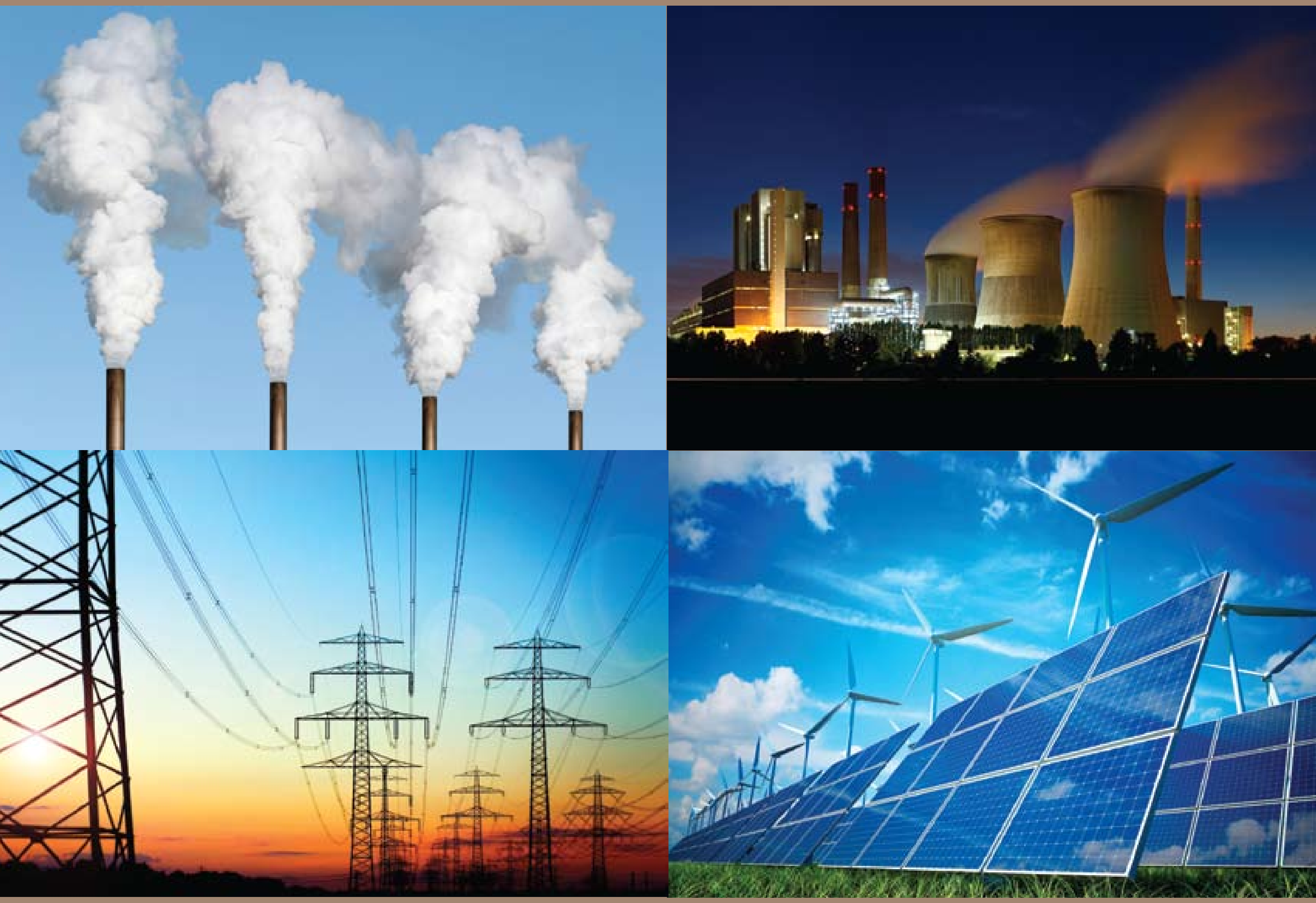
Policy Research Project Report 174

ECONOMIC AND REGULATORY CHALLENGES AND OPPORTUNITIES FOR US-MEXICO ELECTRICITY TRADE AND COOPERATION



LBJ Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin

Lyndon B. Johnson School of Public Affairs
Policy Research Project Report
Number 174

Economic and Regulatory Challenges and Opportunities for US-Mexico Electricity Trade and Cooperation

Project directed by
Alejandro Ibarra-Yunez, Ph.D.

A report by the
Policy Research Project on
Electricity Trade and US-Mexico Cooperation
May 2012

The LBJ School of Public Affairs publishes a wide range of public policy issue titles. For order information and book availability call 512-471-4218 or write to: Office of Communications, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin, Box Y, Austin, TX 78713-8925. Information is also available online at www.utexas.edu/lbj/pubs/.

Library of Congress Control No.: 2012940006
ISBN: 978-0-89940-792-0

Printed in the U.S.A.

Cover design by Doug Marshall
LBJ School Communications Office

Policy Research Project Participants

Students in Alphabetical Order

Nora Ankrum, B.A. (English), The University of Texas at Austin; experience in journalism and energy industry analysis

Lun Dai, B.A. (English), Sichuan International Studies University; experience and interests in logistics and renewable energy

Dyan Knapp B.S. (International Studies), Michigan State University; certified to operate surface ship propulsion plants, US Navy

Alejandro Márquez-Márquez, B.A. (International Politics and Foreign Policy), Georgetown University

Claire McEnery, B.A (Anthropology and Spanish), The University of Virginia; specialty in international development

Daniel J. Noll, B.A. (Government), The University of Texas at Austin; experience in energy as research assistant at the UT Energy Institute

Oscar Padilla, B.A. (Finance), The University of Texas at El Paso and Tulane University; experience in public project evaluation

Marcus W. Pridgeon, B.A. (Accounting) and MSc (Ethics and Leadership), Stephen F. Austin State University; specialty in electric distribution, transmission, and generation utilities

Timothy Regal, M.A. (English and Italian), The University of Texas at Austin; experience and interests in economic analysis, business climate/ issues analysis

Kaye Schultz, B.A. (Economics, Psychology), The University of Virginia; interests in economic analysis to energy policy

Amin Shams-Moorkani, B.S. (Industrial Engineering) and MBA, Sharif University of Technology, Tehran, Iran; experience in project management of the automotive and oil industries

Michael Simpson, B.A. (History), Stanford University

Bradley J. Smith, B.A. (Psychology), Texas A&M University; experience and interests in energy resources, sustainability and political economy

Josef Varga, B.A. (International Studies), Texas A&M University

Austin Woody, B.A. (Accounting, Political Science), University of California at Santa Clara; experience in project management, finance, non-profit organizations

Project Director

Alejandro Ibarra-Yunez, Ph.D., Professor of Economics and Public Policy and Chair, Economics of Networks and Regulations, EGADE Business School, Tecnológico de Monterrey, Campus Monterrey; Visiting Professor/Researcher, LBJ School of Public Affairs, The University of Texas at Austin (academic year 2011-2012)

Table of Contents

List of Tables

List of Figures

List of Acronyms

AC	Alternating Current
AS	Ancillary Services
ASP	Ancillary Service Provider
BTU	British Thermal Unit
CAISO	California Independent System Operator/ California ISO
CCAG	Climate Change Advisory Group
CEC	California Energy Commission
CEGB	Central Electricity Generating Board (USA)
CENACE	Centro Nacional de Control de Energía
CENTREL	Organisation for the Synchronous Interconnection of the Electric Power Systems of the Czech Republic, Slovakia, Poland, and Hungary with the UCTE Power Systems
CERA	Cambridge Energy Research Associates
CFE	Comisión Federal de Electricidad
CNE	Comisión Nacional de Energía (Chile)
COFECO	Comisión Federal de Competencia, also called CFC (Mexico)
COFEMER	Comisión Federal de Mejora Regulatoria (Mexico)
CONAPO	Consejo Nacional de Población (Mexico)
CPUC	California Public Utility Commission
CRE	Comisión Reguladora de Energía
CREZ	Competitive Renewable Energy Zone(s)
CUSFTA	Canada-US Free Trade Agreement
D	Distribution (company)
DC	Direct Current
DOE	Department of Energy (USA)
EIA	Energy Information Administration (US)
EILS	Current Emergency Interruptible Load Service
EIS	Emergency Interruptible Service
EPA	Environmental Protection Agency
EPAct	Energy Policy Act

ERCOT	Electricity Reliability Council of Texas
EU-ETS	European Union Emission Trading Scheme
EWG	Exempt Wholesale Generator
FERC	Federal Energy Regulatory Commission
FIT	Feed-In Tariff
FPA	Federal Power Act
FPC	Federal power Commission
FTRs	Financial Transmission Rights
G	Generators
GATT	General Agreement on Tariffs and Trade
GATS	General Agreement on Trade in Services
HHI	Herfindahl- Hirshman Index of Concentration
IAEA	International Atomic Energy Agency
INEGI	Instituto Nacional de Estadística y Geografía (Mexico)
IOUs	Investor Owned Utilities
IPPs	Independent Power Producers
ISO	Independent System Operator
LAERFTE	Ley para el Aprovechamiento de las Energías Renovables y el Financiamiento de la Transición Energética
LCOE	Levelized Cost of Energy (US calculation of renewable energy by DOE)
LFC	Luz y Fuerza del Centro (Mexico)
LFCE	Ley Federal de Competencia Económica (México)
LORS	California Environmental Quality Laws, Ordinances, Regulations, and Standards
LSE	Load-Serving Entity (also called LS)
LSPEE	Ley del Servicio Público de Energía Eléctrica
LTFTRs	Long Term Financial Transmission Rights
MOUs	Municipal Owned Utilities
MW	Megawatt (capacity)
MWh	Megawatt hours (power)
NAEWG	North American Energy Working Group
NAFTA	North American Free Trade Agreement

NEMS	National Energy Modeling System
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Council
NIETCs	National Interest Electric Transmission Corridors
NORDEL	Organization of Nordic Power Cooperation (Norway, Sweden, Denmark, and Finland, also called NORD POOL)
NPCC	Northeast Power Coordinating Council (New York and Canada)
NREL	National Renewable Energy Laboratory
OECD	Organization of Economic Cooperation and Development
OFGEM	Office of Gas and Electricity Markets (GB and Wales)
O&M	Operation and Management (expenses).
PAN	Partido Acción Nacional (Mexico)
PEMEX	Petróleos Mexicanos
PGCs	Power Generation Companies
PJM	Pennsylvania, New Jersey, and Maryland Interconnection
PM	Power Marketer
POEMS	Policy Office Electricity Modeling System (USA)
POISE	Programa de Obras e Inversiones del Sector Eléctrico
POLRs	Provider of Last Resort
PPAs	Purchasing Power Agreements
PRD	Partido de la Revolución Democrática (Mexico)
PRI	Partido Revolucionario Institucional (Mexico)
PTC	US Federal Renewable Electricity Tax Credit
PUCT	Public Utility Commission of Texas (also written TPUC, and PUC)
PURPA	Public Utility Regulatory Policies Act
PX	Power Exchange
QFs	Qualifying Facility (in ERCOT)
QSEs	Qualified Scheduling Entities
RECs	Renewable Energy Credits
REPs	Retail Electric Providers (also called R)
RES	Resource Entity
RFTS	Registro Federal de Trámites y Servicios
RIAs	Registro de Impacto Administrativo

RPS	Renewable Portfolio Standard
RTO	Regional Transmission Operator
SARE	Sistema de Apertura Rápida de Empresas (México)
SC	Scheduling Company
SCT	Secretaría de Comunicaciones y Transportes (Mexico)
SEMARNAT	Secretaría del Medio Ambiente y Recursos Naturales (Mexico)
SEN	Sistema Eléctrico Nacional
SENER	Secretaría de Energía (Mexico)
SHCP	Secretaría de Hacienda y Crédito Público
SIEPAC	Sistema de Interconexión Eléctrica de los Países de América Central (Central American RTO)
SIN	Sistema Interconectado Nacional (Mexico)
SMD	Standard Market Design
SUTERM	Sindicato Unico de Trabajadores Electricistas de la República Mexicana
TDSPs	Transmission and Distribution Service Providers
TO	Transmission Organization (similar to a TRANSCO)
TRANSCO	Transmission Company
TSOs	Transmission System Operators
UCTE	Union for the Coordination of the Transmission of Electricity (formerly UCPTE) in Western Europe: Austria, Belgium, France, Germany, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Switzerland.
UNCTAD	United Nations Conference on Trade and Development
UN-DESA	United Nations Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Office for International Development
WECC	Western Electricity Coordinating Council
WTO	World Trade Organization

Foreword

The Lyndon B. Johnson School of Public Affairs has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month policy research project, in the course of which two or more faculty members from different disciplines direct the research of a small group of graduate students of diverse backgrounds on a policy issue of concern to a government or nonprofit agency. This “client orientation” brings the students face to face with administrators, legislators, and other officials active in the policy process and demonstrates that research in a policy environment demands special talents. It also illuminates the occasional difficulties of relating research findings to the world of policy realities.

This publication presents the results of a policy research project conducted during the 2011-2012 academic year that examined challenges and opportunities of binational cooperation in electricity connections, trade, and investment, applied to the US-Mexico region. The students researched the different market structures of this industry in North America, where Mexico has a vertically integrated state-owned utility Comisión Federal de Electricidad (CFE) that operates in a shadow national market with independent power producers and close to 700 permits for non-utilities’ generation. The US connects with Mexico with two principal entities: the Electrical Reliability Council of Texas, or ERCOT, independent from the federal regulator FERC, and the Western Electricity Council of California or CAISO-WECC.

The curriculum of the LBJ School is intended not only to develop effective public servants but also to produce research that will enlighten and inform those already engaged in the policy process and the emerging market and binational issues. The project that resulted in this report has helped to accomplish these tasks.

Finally, it should be noted that neither the LBJ School nor The University of Texas at Austin necessarily endorses the views or findings of this report.

Robert Hutchings
Dean
The LBJ School of Public Affairs

Acknowledgments

The Policy Research Project was partially funded by Grupo Xignux and SEISA from Mexico. The Tecnológico de Monterrey freed the project director of time to conduct the research project. The LBJ School of Public Affairs provided funds for Alejandro Ibarra-Yunez' stay in Austin during the academic year 2011-2012.

The Policy Research Project benefited from visits and lectures to the research team by Bill Bojorquez (Vice-President of planning at Hunt Energy and formerly at ERCOT), Mike Cleary (Chief Operating Officer) and John Dumas (Director Wholesale Market Operations), both from ERCOT, and gracious contacts obtained from Laura Doll (ERCOT, now at CAISO).

Funds allowed for three field work trips by selected students during the course of the research project. The first one took place in October 2011 to El Paso to attend the Border Energy Forum on renewable energies, organized by the Texas General Land Office (Soll Sussman) and Comisión Federal de Electricidad (CFE) from Mexico.

Then selected students made a field trip to Mexico City in January 2012, where lead by professor Ibarra, they held meetings at the Secretary of Energy (SENER) with Luis Arias Osoyo; the Mexican Energy Regulatory Commission (CRE) with Israel Hurtado, Rubén Flores García, Alejandro Peraza, and Marco Antonio González; CFE's Florencio Aboytes (Vice-President, Power System Planning); CFE's Tomás Valdés (interruptible tariffs); and the Competition Commission (COFECO) with Benjamín Contreras (electricity advisor to the Commission) and Ali B. Haddou. They also met with CFE's National Center for Energy Control's (CENACE) Eduardo Meraz (Vice-Director), Manuel Alanís, Nemorio González, and Martín M. Vivar. Finally, the team benefited much from a visit to Dr. Juan Rosellón, professor at CIDE and a world expert.

A trip was made by another selected group of students to Washington, DC, in February 2012 to both attend the 2012 National Electricity Forum and also hold fieldwork meetings at the Mexican Embassy with Antonio Ortiz Mena and José Luis Paz; the Federal Energy Regulatory Commission (FERC) with Keith O'Neil; and to the Department of State's Bureau of Economic Energy and Business Affairs, with Mathew McManus. They also met with Andrew Selee and Christopher Wilson at the Woodrow Wilson Center for Scholars. We would like to acknowledge and thank all the people interviewed for this project (see Appendix A for list).

In Austin, insights by Professors Chandler Stolp and Robert Wilson contributed to the focus and organization of the research effort. Lucy Neighbors helped with templates and Lauren R. Jahnke helped with the editing and formatting.

Chapter 1. Introduction: Setting the Stage for International Electricity Integration

by Alejandro Ibarra-Yunez

Abstract

This introductory chapter sets a global framework of electricity trade and international integration, from converging domestic policies in Nordic countries and continental Europe to Central Europe and other international regional markets towards a deep legal and regulatory convergence. Trade in electricity is argued to increase reliability and security at the same time that states relinquish part of their control attributions towards international pools and markets. The chapter shows that electricity can share the characteristics of an essential resource to a country, to be protected, with the concept of being a tradable good or service. As a framework for analysis, it then shows that the insufficient US-Mexican set of interconnections makes this market an outlier *vis a vis* other heavier trading areas and investment projects, and this offers great opportunities to increasingly share a common policy vision and joint physical interconnection strategies. One important lesson from heavier trade and investment markets across the world is the separation between transmission and generation, not necessarily the property of the modern electricity markets by the state or private interests.

1.1 Setting of the Research Framework

Constrained transmission electricity lines are a typical aspect of restructured electricity markets. For the past 15 years or so, electricity has transited from vertically integrated utilities under government ownership and management to the opening up of competition in generation for exclusive sale to the incumbent under long-term contracts (sole buyer model). More recently although in an asymmetric manner across the world, regulatory incentives to expand transmission investments under stressed infrastructure arising from demand and also from renewable sources of energy have characterized some economies, while in others full unbundling, vertical separation of transmission from generation and trade, are typical. A wide mix of market structures makes research in the various systems relevant. Moreover, even if a new market for electricity is now apparent in Europe and in the Americas, connected systems and trade have been rather incipient but call for a profound analysis, not only of the alternative non-market, transitional, and market dynamics, but also of the stakeholders and political interests in an industry that is critical for economic development. This Policy Research Project addresses this key issue applied to the linkages and connections between Mexico and the United States, mainly in the sub-regional levels of Texas-Mexico and California, given the experiences in other international cooperative infrastructures.

When the North American Free Trade Agreement (NAFTA) was launched in 1994, trade liberalization and investment in the energy sector in Mexico were constrained because oil was excluded from the agreement, but electricity deregulation and opening up is contained in Chapter 6 of NAFTA. Chapter 6 applies both to trade in "energy goods" and "measures related to investment and the cross-border trade in services associated with those goods." Tariffs on electricity goods and services (as well as petrochemicals also under Chapter 6) were totally phased out in 1998, and national treatment measures for cross-border investment have been warranted (Horlick, Schuchhardt, and Mann, 2002). Chapter 9 refers to standards, while Chapter 10 of NAFTA applies to the environment and environmental converging standards. Additionally, Chapter 11 is dedicated to foreign investment liberalization, protection, national treatment provisions, and related measures including disputes. According to the cited authors, Article 605 (a) to (c) establishes that parties may not impose export restrictions if they reduce the proportion of the total supply made available to the other NAFTA parties, below the level of the preceding three years or other agreed period; or set a higher price on exports to another NAFTA country than on domestic sales and disrupt normal supply channels or alter the normal mix of energy products. Article 605 only applies between the US and Canada because Mexico entered a reservation in Annex 605 such that limitations on the use of export restrictions shall not apply between Mexico and the other NAFTA parties.

Now, according to the Mexican Public Utilities Law, called Ley del Servicio Público de Energía Eléctrica (LSPEE) that became operational in 1993, electricity is separated between utilities (as a public good/service exclusively provided by the vertically integrated parastatal Comisión Federal de Electricidad or CFE), and non-utilities, that can entail private investment interests under the following alternatives. First, there are the Independent Power Producers (IPPs) under long-term contracts with incumbent CFE and also considered utilities that provide electricity flows from their investments in exclusivity to CFE (IPPs in Mexico are defined differently from their US counterparts; see corresponding section below). Second, there are private investors or investment grouped interests of generating non-utilities for self-supply (auto-generation), for self-supply from combustion processes derived from industrial gases, or co-generators. Then, the law allows permits for export and also for import of electricity if interested parties request corresponding permits. This means that a firm that holds a permit, for say, co-generation, cannot be involved in export or import, unless it requests the corresponding permit in Mexico, hence no piggy-back permits are allowed, which differs from the US state of regulations (CFE Annual Report 2010; CRE interview, January 10, 2012; Ibarra-Yunez 2008a).

To have an ample framework for a detailed analysis in the research project, the American regulation establishes that the exports of electricity from the United States to a foreign country are regulated by the United States Department of Energy (DOE) pursuant to sections 301(b) and 402(f) of the Department of Energy Organization Act (42 U.S.C. 7151(b), 7172(f)) and require authorization under section 202(e) of the Federal Power Act or FPA (16 U.S.C. 824a(e)). Because of the provision of public interest in transmission of electric flow to a party of a third country or jurisdiction, sales of electricity in interstate commerce or exports of electricity in the United States are regulated by FERC, although not prohibited if jurisdictional consumption is guaranteed and satisfied. Imports are not regulated in the US or Canada, but need a permit in Mexico

Moreover, the federal authority has jurisdiction of transmission entities that carry or participate in interstate commerce, but not on generating facilities, transmission, and distribution activities in intra-state commerce. For this reason, among other regulations, there are regional regulated interconnects with few links and trade (EIA 2011).

Given the main listed provisions does not totally explain the almost null electricity trade at the sub-regional level, between Texas ERCOT and Mexico (taken as one integrated market), mainly in asynchronous, direct current DC manner; and a more integrated synchronous DC and AC (alternating current) connects between Baja California in Northwestern Mexico and California (Baja California is part of the US Western Electricity Coordinating Connection or WECC). Turning electricity from a public good towards a tradable good has rendered benefits in more integrated systems in the world, such as Nordic countries, Western Europe, but also Canadian provinces with the United States, in terms of reliability and security for the systems, but also because it has included open access to better technologies and sources of energy that move prices downwards and extend electricity sourcing strategies to private, mostly industrial, users. Additionally, Canadian energy carries the renewable and green tag as a complementary good/service for regional US markets to reach green objectives (Goodman 2010).

Systems that prefer staying as islands with few interconnections opt for it predicating better control over reliability and security of energy, and not to depend on third parties. However, electricity connections can be observed in layers of degree of commitment and control, in a similar fashion than foreign direct investment flows of various levels of control/commitment, extending from minority shares, to shelter programs, to joint ventures, majority shares, and in the extreme wholly-owned subsidiaries (UNCTAD 2008, 2010).

A first layer can be analyzed mostly in cases of emergencies. ERCOT or WECC have entered into emergency connections with CFE of Mexico that has supplied electricity to the north in an asynchronous way, using DC connectors. Both in situations of extreme freeze and extreme heat that occurred in Texas in February and July-August of 2011, CFE was able to provide backup electricity, but without long-term contracts. For example, in the case of the deep freeze in Texas in February 2-4, 2011, the climate front moved to Mexico after three or four days of the backup supply, for which CFE stopped the supply across the US-Mexican border to cover local demand (interview with Cleary in Austin, Texas, and with Aboytes in Mexico City).

In the case of Baja California, emergencies in California or south of the border have been possible in a more integrated way, since the Mexican Baja state is part of WECC and has no problems compulsorily connecting with CFE across the peninsula, because it operates separate from the rest of the Mexican grid. CFE has a signed long-term contract with San Diego Gas and Electric and Southern California Edison, of 220 MW with a firm Purchasing Power Agreement (PPA) since 1984 (interview with Mr. Arias, January 9, 2012). So a second level of integration is to invest in deeper connects, again, for back-up services, both north and south of the California border but where electricity flows are more continuous and day-to-day, with both DC and AC connectors. Thirdly, a more cooperative infrastructure development could be ensued in parallel across the borders, where the two systems are not planned to be integrated but costs of infrastructure expansion are allocated in each country, such as in some parts of Canada that then invests in connections (Goodman 2010). This could be a case of cooperation in national investment projects while keeping them independent but where ancillary services and convergence of wheeling and price practices are shared. A related case is the possibility to have a trading interest across the border for which a subsidiary has installed capacity in the partner country for supplying or mostly importing and marketing (given regulatory restrictions in exporting), but this needs unbundling of the grid operator. This has been possible in Quebec, Ontario, and British Columbia with US states or regional markets. Finally, there is a case of energy pools and integrated systems where the critical problem is gaming of shared projects by partners that could have incentives to renege their share of a transnational project expansion costs (Laffont and Martimort, 2005).

After presenting the research objectives and framing the institutional setting, this introductory analysis is organized as follows. The next section analyzes how markets are organized and what incentives and challenges are critical as lessons for a more integrated North American electricity market. It emphasizes policy and price structures. Then markets in Europe are presented that have increased links and trade, along with institutional changes that tend towards trans-national policy decisions. The following section analyzes and frames ERCOT in Texas and how it differs or has similarities with WECC and the California ISO and market. Then the chapter concludes with the various topics and particular investigations to be presented in the rest of the report of the research teams.

1.2 Organization of Electricity Markets and Incentives to Trade

The Mexican Utilities Law (LSPEE) passed in 1993 has allowed for many private generation possibilities, to now represent around 36% of total generation with a forecast to reach 45% of total power production in 2015 (SENER 2011). However, given political times and structural weakness by the secretaries of energy in both Mexico and the United States, corresponding infrastructure expansion has not been evident in both policy plans and reality.

There has even been discussion as to whether there exists an energy policy in North America that maintains clear aims at reaching levels of carbon emission reductions, with clean energy sources, and where generation projects are endogenous with transmission expansion and even demand load management (Pineau, Hira and Froshauer 2004). Contrary to an apparently clear energy strategy, a business as usual (BAU) position has been generally taken as a reality by both researchers and market participants. For example, Braun (2011) evaluates the division of competences by legal instances for the European Union around foreign policy related to technical innovation and developing of long-term supply relations, the environmental aspect of shared energy policies, and competition aspects. If addressing these issues is postponed or international commitment is not granted, then the BAU result faces politics rather than welfare and innovation.

On other technical approaches, Laffont and Martimort (2005) emphasize the possibility of parties to extract rents and renege to cooperation in transnational public goods projects. Independent and Regional Systems Operators (RTOs) ERCOT, WECC/ CAISO, and the Mexican CENACE—Cenace is a division of CFE in charge of electricity dispatch and system operator in less than independent ways—follow their BAU position from argued uncertainty in opening up to other supplier organizations, a case of transaction cost economics that set boundaries of a firm, in this case the RTOs.

With the above, the market organizations and incentives to trade differ across borders. Indeed, electricity is a special product/service because it cannot be stored economically, and its delivery requires a grid where connections exist at the same time across all participants. However, demand varies widely from hour to hour of the day, from days, seasons, and years, so generating capacities need to adjust immediately and synchronously with demand of power. Additionally, reserve capacity is needed to meet peak demand, balancing consumption and generation to meet frequency, voltage, and stability constraints. Since demand for electricity is very inelastic, then prices fluctuate starkly within a day (Stoft 2006).

For the above reasons, trade between all stakeholders in this industry (generating companies, suppliers, distributors, traders, customers, and the transmission system operators), has evolved from a centralized command-and-control system such as Mexico's to wholesale bilateral markets through power pools and exchanges. In the case of trans-border markets, Bieleki (2004) has defined three trading models: a single buyer model such as Mexico; open access or third-party model (qualified users in Europe and some parts of the US and provinces in Canada), and regulatory provisions for non-discriminatory access to the grid by any producer and market player. Finally, one can observe power pools or wholesale power exchanges such as is the case in Nordic countries.

The Definition of Participants Varies across Markets

According to the Mexican law, utilities are concentrated in a sole producer and consumer, the parastatal CFE, and what in a very unique contractual format, subcontracted private utilities of more than 35 MW capacity for exclusive sale to CFE that are called Independent Power Producers, similar to what occurred in ERCOT when vertical integration existed and IPPs would sell to the grid operator in 1995.

Mexican IPPs can be and actually are affiliated with foreign energy corporations, and operate as subsidiaries of their parent companies in Mexico under permits from the regulator CRE. Total IPPs reached 28 by end 2011 (there were 22 in 2008). Examples of such utilities are Iberdrola, Union Fenosa, Electricite de France-Tractebel, Mitsubishi, and General Electric. As can be deduced, IPPs in Mexico sense have taken advantage of NAFTA's foreign investment protection and its corresponding Chapter 6 regarding trade of goods and electrical services (Ibarra-Yunez 2008b).

Other generating or marketing participants in the Mexican setting are auto-generation (491 permits in 2011, down from 563 in 2008); co-generation (67 permits in 2011, up from 57 in 2008); importer permits (29 permits in 2011 versus 37 in 2008); exporters (5 permits only both in 2011 and 2008); and small production (6 permits). In total, there were 670 regulated permits or licensed players or groups in 2011, with total capacity of 28,893 MW, and with an estimated investment of US$ 33.7 billion in 2011, according to official data from CRE (2011).

In contrast, the definition in ERCOT of the various participants in the market makes use of the Senate Bill 7 (SB7) of 1999 that liberalized wholesale and required that all Investor Owned Utilities (IOUs) be unbundled into three kinds of companies (affiliation has been allowed): power generation company (PGCs), retail electric providers (REPs), and transmission and distribution service providers (TDSPs), at the same level in a vertically unbundled market. ERCOT then became an independent, unbundled Service Operator (ISO). PGCs whose aims are wholesale can be affiliated with REPs to provide both wholesale and retail electricity to consumers in a competitive market, for which ERCOT only concentrates in being the passive system operator. The PGCs *cum* REPs have produced long term contracts and have driven the restructured market. This *joint* figure was not promoted in California's CAISO, for which frictions existed between wholesalers and retailers (and their regulators) in the crash of 2001 (Wolak 2005).

REPs and PGCs are not regulated if they operate inside the ERCOT market (it encompasses Texas, so no FERC regulation for interstate commerce applies). Now the TDSPs are regulated by the Public Utilities Commission of Texas (PUCT) and are required to offer open access to any supplier, under equal and non-discriminatory conditions. So far no parallelism exists of this figure in Mexico's CENACE that connects all generating players but could restrict access. The PUTC sets the rates for transmission and distribution services under different pricing mechanisms, so again there is a stark difference in ERCOT with the Mexican setting (see below).

Before further deregulation, all customers were served by IOUs (in their three types), plus what the US law names Municipally Owned Utilities (MOUs), and also Electric Cooperatives or Co-Ops, but these have few if any retail customers; they account for 11.2% and 13% of sales (ERCOT 2011).

For ERCOT, IOUs access the grid with no discrimination, but other participants exist in the market, called *resources* (Baldick and Niu 2005). One such optional market participant is called a Qualifying Facility or QF that can be a private interest or a group of producers, while another is called a Load-Serving Entity (LSE). In this sense, the PGCs for wholesale are the equivalent to the Mexican IPPs, and do not own transmission or distribution facilities. QFs are considered in this analysis similar to the Mexican co-generators, self- or auto-generators that sell to themselves and also provide their electricity to the grid. QFs, LSEs, and REPs are what in the Mexican laws and regulations are considered non-utilities. Under US federal and state laws an Independent Power Producer is a non-utility generator that is not a regulated, and differs in its definition in Mexico.

All Mexican business figures are subject to regulation: CFE as the incumbent parastatal is under the oversight of the Secretary of Energy and the Treasury, whereas the regulatory commission CRE oversees all private permits, including the IPP figure. In short, the Mexican regulations depend much on property rights that allow for private investment (domestic and foreign) in generation for defined non-utilities, while the IPP in Mexico is a subcontracted regulated utility for exclusive sale to CFE. Their investment of US$15 billion in 2011 (up from a level of US$7.2 billion in 2008) represents 44.5% of the total investment by private permits. Some challenges for more integration between CFE and ERCOT along the US-Mexican border can be inferred to arise from competition incentives in the north in a new market (full restructuring only took place in 2010), and vertical integration and monopoly/monopsony power in the south, with competition in the margins by *permit holders* of non-utilities.

Since there is not a true market but an integrated system in Mexico, electric services provided directly to customers can only exist under the co-generation, auto-generation permits, small-scale self-supply (less than 1 MW), and import permits that allow for private interests to form so-called Specific Objective Contracts or Contratos de Objetivo Específico, which are part of the CRE permits. They calculate their loads as a group and generate according to cost plans and residual energy sold to CFE. In the case of ERCOT, Load Serving Entities or LSE provide services directly to customers that can encompass REPs, QFs, MOUs, and Co-Ops under diverse contracts, conditions, and schedules, under wholesale "protocols" by ERCOT (Baldick and Niu 2005; Ibarra-Yunez 2008b).

Other participants in the ERCOT market structure are power marketers and aggregators, who do not own facilities but buy and sell electric energy at wholesale, typical of an unbundled market. They get authority by FERC on rates and by the PUCT as registered marketers or aggregators. In sum, all the retailing part of ERCOTs market structure (LSE, Marketers, Aggregators, and REPs) is not replicated in its Mexican counterparts. Wholesale in Mexico is guaranteed by both the CRE permits and the incumbent CFE power purchasing agreements. Moreover, given the vertically integrated incumbent in Mexico, bilateral, market-driven, or regulatory-driven prices and contracts are spelled out by a series of agencies, instead of by ERCOT in the Texas case.

To close this section, the difference in market architecture and structure of participants creates various origins of transaction costs and costs of binational coordination, but allow for connections and links between the binational space, with a true ISO in Texas and retail competition. Industrial and commercial consumers are however similar in their electricity needs in both sides of the border. While CFE serves 35 million customers, ERCOT serves around 22 million. ERCOT capacity for 2010 reached around 77,000 MW, while Mexico's CFE reached around 60,400. ERCOT manages 37,000 miles of transmission, while CFE has 30,630 miles (SENER 2011; ERCOT 2011).

The Pricing Structures as Critical Elements across Systems

In order for the market to clear and reach efficient equilibria, price structures vary across a spectrum that covers transmission, congestion, wholesale, retail, ancillary services, and load. Even though the Texas market largely faces bilateral tariff rates among all participants, there are transactions that are carried out by ERCOT-administered spot market (the balancing market). All Resources, LSEs and aggregators, called Qualified

Scheduling Entities in general or QSEs, submit schedules and load to ERCOT who "must run" and accommodate the flows. Participants can schedule their transactions without ERCOT denying transmission services. In case of congestion, then ERCOT has recently implemented a nodal clearing price. Inter-zonal (now nodal) costs of congestion are directly charged to market participants, but intra-zonal ones are charged to retailers on a load-ration share basis. In order for participants to avoid price fluctuations in contracts and balancing, a bid-based day ahead and real-time market, centrally dispatched, has been created. Other day-ahead and spot tariffs are also applied for Ancillary Services (AS) that maintains the system reliability and security. Services are provided by the participants or pay ERCOT for it to provide them itself by auctions.

The recent implementation of nodal market is predicated by reasons to: (a) allow for reduced congestion costs by wholesalers; (b) improve transparency in the day-ahead market; (c) respond faster to system volatility in the dispatch every five minutes; and (d) better allocate locational resources, and open infrastructures for new renewable generation, payable by node. Ancillary or reserve services by ERCOT are also divided into up-or-down dispatch, responsive reserve tariff, and non-spinning reserve dispatch and tariffs. Finally, in order for consumers to make strategic decisions regarding production programming in times of high price volatility, ERCOT also administers voluntary disconnections by demand in what are known as interruptible contracts. This adds new enhanced players in the energy market, on the side of consumers or load management participants. All the above array of contracts, prices, wholesale tariffs, push to reflect various levels of costs and capacity utilization, as analyzed by Wilson (2002).

In Mexico, prices are organized as follows and are much influenced by the regulated ones set by both the Secretary of the Treasury (SHCP), CFE, and CRE for non-utilities. First for IPPs under long-term 20-year contracts with CFE, power sold to CFE in exclusivity has implied Purchasing Power Agreements or PPAs that include a double contract price to IPPs, one that is a proportional rate to the firm's capacity made available to the single buyer incumbent (part of their committed capacity contracts), and another that covers the variable costs incurred for energy produced and dispatched by CFE (Ibarra-Yunez 2008a; Maurer and Barroso 2011). Against such power flow, CFE-CENACE charges transmission costs to all private participants, that consist of the sum of infrastructure use-plus transmission losses (at voltage, month, and zone), and published administrative costs (by voltage and distance).

Secondly, for all other auto-generators, co-generators, small-scale producers, and in general for all permit holders that sell excess power to CFE, CENACE sets spot and day-ahead prices to be paid that arguably cover the incremental cost of expanding generation capacity, but the incentive is small and conditioned by the ceiling or upper limit of generation (capacity less than 20 MW). Additionally, all permit holders must offer power in case it is needed in emergencies by CFE for public service using a wheeling tariff set by CFE in a bilateral manner or what is called *take-or-pay* (part of their PPAs by voltages). When demand is higher than ready-use energy, the contract has involved both economical tariffs, and also auctioned flows *ex ante* (the permit holder firm is required by law to inform 15 days ahead of time the quantity and target price expected to be delivered on a daily basis). CFE must acquire up to 90% of power flows. The permit holders must assure that delivered energy must not vary more than $\pm$10% of deliverables program. In case of higher variation, CFE sets lower prices called "automatic and non-notified" energy (85% of total auctioned price by region, monthly days, and hours such as minimal, base, and maximum load tariffs). As one can conclude, there is some sort of a shadow market as a step towards a full-fledged spot, day ahead, and auctioned market (Ibarra 2008c).

Thirdly, back-up wheeling tariffs exist for co-generators to start their power plants, charged by CFE. The price is set at a fixed rate if low voltage, and at price per KWh if high voltage. On all non-utility generation, there exist interruptible contracts, but permit holders have made minimal use of them in the past (Interview with CFE, January 2012). Finally, for renewable energies, CRE established in 2008 an overall call for proposals under a promoted modality of "open season." The specific law is called Law for Renewable Energy and Financing of Energy Transition, or Ley para el Aprovechamiento de las Energías Renovables y el Financiamiento de la Transición Energética (LAERFTE), that offers a type of "feed-in tariffs" for all permit holders (CRE 2011).

Trading Opportunities

Electricity trade faces the following driving forces: economic efficiency and arbitrage, security in supply, and environmental issues. The above have to gain against autonomy and independence arguments for a grid operator. On the first account, it is sometimes cheaper and more efficient to open interconnections (DC are more expensive than AC, but are preferred when used mainly for emergency backups), than to maintain reserve margins through investments in more capacities. Then, it is economically sound to manage asymmetric prices and buy where congestion is low and/or demand load faces asymmetric peak-loads, such as a region that encounters stronger winters or summers, or hour of day differences to apply peak shaving.

Regarding security of supply, an importer can take advantage of fuel type differences or a wider energy portfolio (Zenon and Rosellón 2010). At the same time, competitive elements are added to the power industry under transition. Finally, as it is the case of US importers in California, there are considerations of imported clean Canadian electricity to reach environmental objectives (Goodman 2010). As already argued, all these generate comparative advantage positions that drive increased trade. Against this argument, there are political and strategic positions in favor of independence and autonomy by systems operators such as ERCOT in Texas, to be little dependent but being able to rely on excess capacity or infrastructure south of the border. Less evident is this reason in California system operator CAISO (KEMA Inc. 2008). In the case of Mexico, CENACE, the system operator from CFE, plans its expansion with little or no international connections, arguably out of inertia (interviews with CENACE, and CFE programming, January 2012).

1.3 Experiences in Other Markets and Lessons Derived

The consideration of vertically integrated monopolies prevalent in past decades has changed dramatically in the last 20 or so years, beginning with deregulation and unbundling in Great Britain and Wales in 1989 (creation of the Office of Gas and Electricity Markets OFGEM), and nowadays with most markets unbundled, although not necessarily in private interests. This consideration is critical in the case of Mexico, where proposals for deregulation by the executive since 1997 have reiteratively faced votes against deregulation in Congress, with the wrong argument of risk of privatization for which the electric industry has lagged behind counterparts elsewhere in the world. This is very evident in the oil industry that has not become a public enterprise but has remained a state-owned enterprise (PEMEX and its divisions such as PEMEX-Gas) being a fiscal cash machine for the federal government, but an element of distortion in the energy panorama in Mexico, and a source of international frictions since NAFTA (Weintraub 2007). The following table shows the evidence in a selected group of countries regarding unbundling, rather than privatization.

Table 1.1
International Reference of State-Owned Enterprises, vs. Mixed Enterprises and Private Firms in Electricity, with and without Unbundling
(Generation and Transmission)

State-Owned Enterptrises		**Mixed Property Enterprises**		**Private Firms**	
Integrated	Vertical unbundling	Integrated	Vertical unbundling	Integrated	Vertical unbundling
Hungary	France	Island	Brazil	Denmark	Argentina
Luxemburg	Norway	Portugal	Austria	Netherlands	Chile
Russia	Czech Rep.		Australia		Finland
Paraguay	Switzerland		Hong Kong		Japan
Mexico	South Korea		Indonesia		Peru
	Honduras		Colombia		Spain
			Central America (SIEPAC)		UK
			Canada		USA

Source: Author’s generation with data from International Energy Agency IEA (2005, 2011).

As can be evidenced, most markets have increasingly faced unbundling as a driving force towards both more competition, and also more pressing challenges of coordination of market participants. Each country however, faces its own market and regulatory challenges. However, the most salient cases can be observed in Europe. Selected cases have inserted at least the following into their regulatory compacts:

1. Obligations to provide non-discriminatory access to competitive segments;

2. True unbundling of the transmission segment (sometimes along with distribution) that includes accounting, administrative, and operative unbundling;

3. Opening of electric dispatch and wholesale market, both driven by regulated prices in some cases, and market driven transmission rights in others (see Rosellón, Myslikova, and Zenon 2011 for the PJM market);

4. Integration of qualified user, among some consumers such as big industrials (others have also included all retail residential); and

5. Increasing cooperation in transmission capacity and international links.

According to Hogan, Rosellón, and Vogelsang (2010), despite liberalization efforts in Europe, the markets in Europe and Eurasia remain rather fragmented. For example, in 2000, inter-regional trade in Europe consisted of around 2% of generation in the continent, excluding intra-regional trade (Bieleki 2004). Since Europe is partitioned into neighboring blocs, some are synchronous such as Central and Western Europe (called CENTREL AND UCTE), and some have separate synchronous grids, such as Scandinavia NORDEL and Central Europe CENTREL. UCTE encompass Austria, Belgium, France, Germany, Greece, Italy, Luxemburg, Netherlands, Portugal, Spain, and Switzerland, which trade around 160 TWh among themselves. In Southern Europe, trade reaches 23% of total generation, whereas CENTREL (encompassing the Czech Republic, Hungary, Poland, and the Slovak Republic), faces 10% exchanges. One key explanation is lack of agreements on sharing costs of transmission expansion across Transmission Systems Operators (TSOs), and another is lack of arbitrage and asymmetric export charges and compensation charges for transmission to make prices converge. Net flows basically go from east to west in a chain of countries.

It is not clear whether systems are modeled as star-like connections in bilaterals, or as meshed ones, as has been studied for example by Balaguer (2011), Joskow and Tirole (2005), and Wang, Zhou, and Botterud (2011), where the emphasis is on the bidding for allocation of electric net flows. It could be the case that absence of clear price mechanisms scare away participants and countries in international trade and investment.

The lack of more tradable flows of electricity can partly be explained, as argued above, by the idea of operators to remain self-sufficient and assure security of supply, but can also find an explanation in transaction costs or inertia. The consequence would be that TSOs or ISOs would over-invest in excessive reserve capacity, up to around 20% in the case of ERCOT in 2010, to around 40% in Mexico's CFE in the same time (interviews with respective executives of these two operations). The same regional operators plan to reduce reserve margins to 13.5% in ERCOT and 12% in CFE by 2013 and 2014, respectively, such that mothballing (closing) generation plants and restructuring generation from renewable sources would be implemented with no transmission expansion pressures. However, some electricity load corridors face congestion. Such is the case of the San Diego area, Imperial Valley and two northward corridors in

California, and the Houston, Dallas-Fort-Worth, or Texas Valley areas in Texas (KEMA 2008; Interview with Bill Bojorquez, October 6, 2011).

Another reason of low transmission across regions or countries is the cost of transmission over long distances and transmission losses, in addition to the fact that new generation tends to be located close to consumption centers. Hence transmission not only is sub-optimally invested, but is also subject to allocation of payments or rents, a phenomenon analyzed in investment but regulated markets by Matsuyama (1990), where the investor conditions its expansion plans to a government shield, in case there are no clear rules regarding non-incumbent owned investments in transmission complementary lines from generation to the high voltage connector. So over-investment can result from self-reliance motifs in excess reserve allocations, while under-investment could arise from conditioning investments to regulatory shields.

A third explanation is that given asynchronous connections, as is observed in all US-Mexico connections except for Baja California and Guatemala-Belize, DC cable links are expensive and used for high transit capacities and small distances for which day-to-day trade opportunities dilute. They are justified however, by the fact that control of a contract area is simpler in DC current than synchronous AC links that face the loop-flow problem where electricity flows through the line of less resistance rather than contract lines. Thus more involvement in cooperating or sharing of projects can divert efforts towards more integration, and an indicator of commitment could be the amount of AC connections across borders versus DC ones, other things being equal.

Still another problem in international trade in electricity (gas has resolved the issue) is the existence of monopolies and exclusivity of rights, where the transmission operator could discriminate against the access of another party, or charge high and discriminatory tariffs for delivery, and if vertically integrated, could prefer its own generating-transmitting capacity rather than renting it out, or an “empire-building motive.”

In all, trade in electricity flows shows an incipient performance, as shown in the following Tables 1.2, 1.3, 1.4, and 1.5 by region, but where there exists short to medium potential for increased electricity trade capacity seems to be under-utilized and price differences give rise to trade benefits. The tables present domestic production and imports and exports, with no reference to sources of generation. Countries within a regional connection are grouped together for observation both at the country participant and within a regional connection.

In comparison North America seems an outlier from comparative European connections and country participants in those regional markets who are heavier traders overall. Flows are measured by country, so it is not totally possible to analyze if flows exist within the regional markets or inter-regions. However, according to Montravel (2004), a total of 63 GVA of interconnection capacity existed between European regions in 2004, around 10% of total generating capacity. In comparison, Ibarra-Yunez (2008a) found Canada-US interconnection of around 5% of Canadian capacity in 2008.

Table 1.2
Trade in Electricity in Europe by Regional Connection: UCTE
(GWh in 2010)

Country	Domestic Production (1)	Imports (2)	Exports (3)	2/1 (%)	3/1 (%)
Austria	68,291	19,745	17,528	2.9	2.6
Belgium	95,531	12,404	11,842	13.0	12.4
France	547,821	37,101	66,600	6.8	12.2
Germany	580,849	42,960	57,918	7.4	10.0
Greece	57,048	8,516	2,573	14.9	4.5
Italy	287,013	45,761	1,817	15.9	0.6
Luxemburg	4,539	7,280	3,216	160.4	70.9
Netherlands	110,109	15,584	12,809	14.2	11.6
Portugal	51,781	5,812	3,192	11.2	6.2
Spain	287,766	5,169	13,514	1.8	4.7
Switzerland	66,248	33,401	32,882	50.4	49.6

Source: International Energy Agency EIA, statistics, electricity table 2010, and author's calculations, consulted at http://www.iea.org/stats/index.asp. Total domestic production in UCTE totaled 2,156,996 GWh, with total imports of 233,733 GWh, or 10.8% of total production, and exports of 223,891 GWh, or 10.4% of total production.

Table 1.3
Trade in Electricity in Europe by Regional Connection: NORDEL
(GWh in 2010)

Country	Domestic Production (1)	Imports (2)	Exports (3)	2/1 (%)	3/1 (%)
Denmark	36,662	10,599	11,735	28.9	32.0
Finland	77,035	15,717	5,217	20.4	6.8
Norway	123,740	14,671	7,125	11.9	5.8
Sweden	149,282	14,931	12,851	10.0	8.6

Source: International Energy Agency EIA, statistics, electricity table 2010, and author's calculations, consulted at http://www.iea.org/stats/index.asp. Total domestic production in NORDEL totaled 386,679 GWh, with total imports of 55,918 GWh, or 14.5% of total production, and exports of 36,928 GWh, or 9.6% of total production.

Table 1.4
Trade in Electricity in Europe by Regional Connection: CENTREL
(GWh in 2010)

Country	Domestic Production (1)	Imports (2)	Exports (3)	2/1 (%)	3/1 (%)
Czech Rep	79,470	6,641	21,591	8.4	27.2
Hungary	34,845	9,897	4,702	28.4	13.5
Poland	143,592	6,310	7,664	4.5	5.3
Slovak Rep	25,278	7,334	6,292	29.0	15.0

Source: International Energy Agency EIA, statistics, electricity table 2010, and author's calculations, consulted at http://www.iea.org/stats/index.asp. Total domestic production in CENTREL totaled 283,185 GWh, with total imports of 30,182 GWh, or 10.7% of total production, and exports of 40,249 GWh, or 14.2% of total production.

Table 1.5
Trade in Electricity in North America
(GWh in 2010)

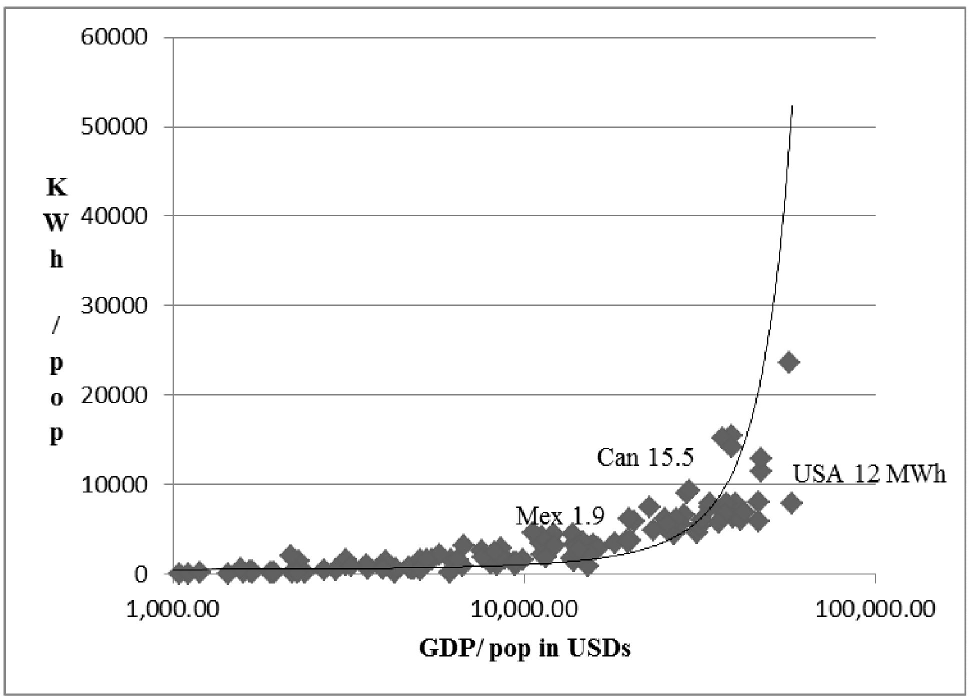
Country	Domestic Production (1)	Imports (2)	Exports (3)	2/1	3/1
USA	4,164,681	41,503	22,795	1.0	0.6
Canada	579,497	18,631	44,817	3.2	7.7
Mexico	256,319	397	1,348	0.2	0.5

Source: International Energy Agency EIA, statistics, electricity table 2010, and author's calculations, consulted at http://www.iea.org/stats/index.asp. Total domestic production in North America totaled 5,000,497 GWh, with total imports of 60,531 GWh, or 1.2% of total production, and exports of 68,960 GWh, or 1.4% of total production.

Also, some smaller countries such as Luxemburg or Switzerland in UCTE, or Denmark in NORDEL, or Slovak Republic in CENTREL, relatively depend more on imports if their production base is conditioned by economies of scale. However, such conclusion would not apply for Mexico, for example. Across European connects, electricity seems to flow from east to west, and from Germany and France to the south and west. Trade balances (exports minus imports) do not necessarily have a capacity to penetrate other markets and many examples show balanced bilateral trade. In sharp contrast, Canada resembles France or Germany in its flows, but it stands out as a net exporter. From the tabular analysis, Mexico strongly stays un-connected. Of the above tables, the heaviest traders (both ways) are Luxemburg and Switzerland in UCTE, Denmark in NORDEL, and the Slovak Republic in CENTREL. Heavy importers in the tables are Greece, Italy, Finland, and Hungary, while the stronger net exporter related to domestic production is the Czech Republic.

The more closed-down markets again seem to be the USA and Mexico but there seems not to be a justified correspondence of this situation, related to a high correlation between the size of an economy (in GDP per capita) and the generation/consumption capacity that would imply more integration of electricity markets. Figure 1.1 evidences the high and increasing correlation between GDP per capita (in PPP dollars for 2010), and net generating capacity per capital for the last data available from the IEA (2011).

Figure 1.1
World net per capita Electricity Consumption and per capita GDP
2010, Purchasing Power Parity Dollars



Source: Author’s generation with data from WB economic indicators 2011, and EIA 2011.

1.4 State of Markets in North America

Electricity as a transition industry needs policy changes over time, but at least some of the following aspects are evident across the world: (a) a move towards open access and market-driven pricing rules; (b) separation between generation and transmission; (c) rulings regarding wholesale trade, either using incentive regulation or transmission marketable rights or FTRs; and (d) some incentive mechanisms for transmission expansion. According to Rosellón and Weigt (2011) and Rosellón, Myslikova, and Zenón (2011), both market-oriented and regulation-oriented strategies are possible, but not all interconnection efforts have reached the above four conditions, mainly conditions (b) and (d). In the case of Canada, provincial development and supply have moved with different levels of restructuring.

For example, Manitoba does not allow for retail sales in competition (though it exports to the Great Plains US states), while other provinces allow for large industry qualified users both inside their markets and within the United States. This is the case of Alberta and British Columbia with the US Western Connection WECC; Quebec and New Brunswick with the East Interconnection and the US regional RTO called NPCC. Ontario has a totally liberalized market inside and with it is interconnect with the US region RFC in the Eastern Interconnection. The US FERC has mandated that RTOs oversee transmission interconnections in competitive markets. Canada adheres to FERC rules. Main high voltage links exist in Quebec with the US Northeast; between Ontario and Michigan, New York, and Pennsylvania; between Manitoba and the US Midwest; and between British Columbia and the Pacific Northwest and California. According to the Canadian Electricity Association (2010), there are more than 74,600 Km, equivalent to more than 46,900 miles of high voltage (higher than 230 kV) international transmission lines, where more than 50% are AC of 230 kV or higher.

A form of business integration is through the so-called marketing licenses. In the case of Mexico, connections of high voltage exist in the Tijuana-Mexicali areas with the Southern California CAISO (San Diego-Mesa Otay and Tijuana, Imperial Valley), and in the Juarez-El Paso border. For its part ERCOT relies and seeks asynchronous DC connections not only with Mexico but with other regional markets in the United States. Main connectors are the following, covering from west to east: Eagle Pass (36 MW), Laredo variable frequency transformer (100 MW), and McAllen-Sharyland (150 MW). Also, connections to the north (Dallas-Fort-Worth area) of 220 MW with Oklaunion, and to the east at Monticello (Swepco and Entergy) of 600 MW, complete ERCOT's links.

Table 1.6 shows the various levels of deregulation and unbundling of the different Canadian provinces, voltage for long-distance transmission, and state of trading indicators. This completes the overall framework of North American electricity challenges.

1.5 Similarities and Differences between the US and Mexico: ERCOT and CAISO/WECC

The two systems operators that have connections with Mexico are the California ISO that was created in 1998 and ERCOT that began operating in 1995, with full unbundling starting in 2002. The two systems are similar in population served and capacity generated that is monitored and managed. However, in the case of California, non-utilities are concentrated geographically in the north whereas the ERCOT generating park combines utilities and non-utilities, as was described in a previous section, throughout the part of the state under ERCOT's control. Additionally, CAISO within the Western Interconnection WECC extends beyond the state of California and monitors transmission capacity of 14 western states, plus British Columbia and Alberta, and part of northern Mexico. Hence, it must follow wholesale production under FERC surveillance while retail is not regulated, as opposed to ERCOT's promotion of having wholesalers and retailers to be integrated with no surveillance of FERC in electricity trades within Texas.

Another important difference is that in CAISO there is a Power Exchange in charge of scheduling and setting market clearing prices in day ahead and hour-ahead operations.

Table 1.6
Canada's Utilities and Transmission Points and Trade, Comparison with Mexico, 2009

Province	Number of Utilities	Year became Wholesale Comp.	Retail Comp.	Trans-mission status	KV of Inter-connection	Trade
Alberta	4 (co-gen)	1996	Large industrials	Investor-owned companies (ISO)	500 kV + 135 kV (2) also via BC	Marketing licenses
Ontario	2 (nuclear)	2002	Yes	Vertically semi-liberalized	345 kV (2)+ 230+ 120+ 115	
British Columbia	1 (hydro), plus other non-utilities	1996	Large industrials	Vertically semi-liberalized (state)	500 kV (2)+ 230 (2)	All West and California
Quebec	1 (hydro)	1997	Large industrials	Vertically integrated	765 kV + 120 (2) + 450+ 120 (2)	New England and NY
Manitoba	1 (hydro)	1997	No	Vertically integrated	500 kV + 230 + 230 (2)	
N. Brunswick	1	2003	Large industrials	ISO	345 kV (2) + 230 (2) + 345+ 345+ 138 (2)	Maine and NY
Mexico	1 plus other co-gen	2002 with law adjustments	No	Vertically integrated	230 kV + 200+ 115+ 138 (2)+ 136 (2)+ 400 kV planned for Guatemala	Calif., West and South Texas

Source: Author's generation with data from NEB (various reports); for Mexico, CRE.

Both ISOs have in their mandates transmission security, dispatch, and ancillary services. However, the regulatory framework seems to be of minimalist stance in the case of ERCOT, while the California ISO intervenes more. Table 1.7 summarizes the main differences between the two systems.

Table 1.7
Similarities and Differences between ERCOT and CAISO, 2012

ERCOT	CAISO
Intervenes in planning and scheduling of transmission only in congestion events	Plans and sets scheduling of transmission, and coordination in bilaterals
Power exchanges are private bilaterals and not regulated	Power exchange is active and separated from the ISO
Coordinates measures to alleviate congestion	Same as ERCOT
Monitors operation of power systems to ensure enough reserves and ancillary services	Congestion management
No operation of Financial Transmission Rights; Reforms more in steps.	Financial Transmission Rights are active and monitored by the ISO; CAISO's activities are complex and launched rapidly from beginning
Nodal pricing began in Dec. 2010, with ERCOT increasing congestion monitoring; Congestion corridors measured in northern Houston and San Antonio areas	Locational marginal cost pricing; Congestion areas in northern, central, and southern California
System operation reliability, stability, price alignment, successful monitoring of customer switching	System is more complex and with higher control levels, reliability, with some past issues
Promotes and coordinates transmission expansion; ERCOT has grown its 320 kv+ around 21% between 2002- 2009	Monitors transmission expansion that grew 7% between 1997 and 2007 (320 kv+)
Consumer orientation is part of ERCOT mandate; No FERC supervision of a Standard Market Design (SMD), it can be changed in the future; Follows "best practice"	Consumer orientation is somewhat loose in CAISO mandate; Part of this reason is argued that provoked the 2001 electricity crisis

Source: Author's generation with information from CAISO, ERCOT, NERC reports; Baldick and Niu (2005); Tierney (2008); Wolak (2005).

1.6 Conclusions and Content of the Report

This introductory chapter is complemented in Chapter 2 with the description of generation participants in the markets of both sides of the US- Mexico border, along with the analysis of the types of regulated permits and the different definitions of independent power producers that result from the asymmetric market designs. The report then presents an analysis of main issues that pose both challenges and opportunities for deeper cooperation. Chapters 3-5, on demand for electricity, the transmission grid status, and challenges for deeper integration of the differently defined markets, analyze and present finding on the new trends in demand and load management and interruptible tariff differences, trends in demand by the four US and six Mexican border states, and the state of the transmission grids and cooperation alternatives.

Chapters 6 and 7 analyze not only the legal and regulatory settings in both countries, but also the political economy and institutional background for the internal distribution of regulatory competences and endowments, as part of the study of areas of bilateral cooperation. One of these two chapters concentrates on Mexico, while the other focuses on the United States and on the system operator Electricity Reliability Council of Texas, or ERCOT.

Chapters 8 and 9 concentrate on analyses of supply challenges to the binational electric systems. One chapter presents the alternative agent-based methodologies to theoretically ground an analysis of transmission expansion and connections, and presents a simulation exercise that proves benefits of interconnection in reducing congestion and wholesale prices, and increasing availability and reliable supply of power, but also shows that welfare enhancing market expansion might need to create additional incentives to transmission operators on both sides of the US-Mexico border. The final chapter focuses on analyzing the emerging and important renewable markets, and its challenges for incentive mechanisms and government policies.

References

Balaguer, J. 2011. Cross-border Integration in the European Electricity Market. Evidence from the Pricing Behavior of Norwegian and Swiss Exporters. *Energy Policy* 39: 4703-4712.

Baldick, R. and H. Niu. 2005. Lessons Learned: The Texas Experience. In James M. Griffin, and Steven L. Puller (eds.). *Electricity Deregulaton, Choices and Challenges*. Chicago University Press.

Bieleki, J. 2004. Electricity Trade: Overview if Current Flows and Infrastructure. In Janusz Bielecki and Leklaku Geboye Desta (eds.), *Electricity Trade in Europe. Review of the Economics and Regulatory Challenges*. The Hague. Kluwer Law International

Braun, J.F. 2011. *EU Energy Policy under the Treaty of Lisbon Rules-Between a New Policy and Business as Usual.* European Policy Institutes Network Working Paper EPIN-No. 31. November.

CFE. 2010. Comisión Federal de Electricidad Annual Report 2010. Mexico DF. Retrieved November 20, 2011, at http://www.cfe.gob.mx.

ERCOT. 2011. 2010 Annual Report. Retrieved January 9, 2012, at http://www.ercot.com/news/presentations/2011/2010_Annual_Report.pdf.

EIA. 2011. Energy Information Administration Official Energy Statistics. Retrieved November 2, 2011, at http://www.eia.doe.gov.

Goodman, R.J. 2010. Power Connections: Canadian Electricity Trade and Foreign Policy. *Canadian International Council Energy Report*. No. 1 (June). Retrieved September 3, 2011, at http://www.onlinecic.org.

Hogan, W., J. Rosellón, and I. Vogelsang. 2010. Toward a Combined Merchant-Regulatory Mechanism for Electricity Transmission Expansion. *Journal of Regulatory Economics* 38: 113-143, DOI 10.1007/s 1149-010-9123-2.

Horlick, G., C. Schuchhardt, and H. Mann. 2002. NAFTA Provisions in the Electricity Sector. Commission for Environmental Cooperation. Montreal. Background Paper #4.

Ibarra-Yunez, A. 2008a. Estudio de Campo de los Jugadores Eléctricos Actuales y Formas Contractuales [Field Study of the Present Electricity Players and Contractual Forms], Comisión Federal de Competencia/ OECD Mexico 2008.E.06.

Ibarra-Yunez, A. 2008b. Puntos Críticos en el Modelo Eléctrico Mexicano Mixto [Critical Aspects in the Mexican Mixed Electricity Market], Comisión Federal de Competencia/ OECD Mexico 2008.E.05.

IEA. 2011. International Energy Agency Statistics by Country/region. Retrieved November 2, 2011, at http://www.iea.org/stats/index.asp.

Joskow, P. and J. Tirole. 2005. Merchant Transmission Investment. *The Journal of Industrial Economics* LIII (2): 233-264.

Laffont, J.J., and D. Martimort. 2005. The Design of Transnational Public Good Mechanisms for Developing Countries. *Journal of Public Economics* 89: 159-196.

KEMA Inc. 2008. Challenges and Opportunities to Deliver Renewable Energy from Baja California Norte to California. Consultant Report CEC-600-2008-04.

Matsuyama, K. 1990. Perfect Equilibria in a Trade Liberalization Game. *The American Economic Review.*

Maurer, L.T.A., and L.A. Barroso. 2011. *Electricity Auctions: An Overview of Efficient Practices*. Washington, DC. The World Bank.

Montravel, G. 2004. European Interconnection: State of the Art 2003. In Janusz Bielecki and Leklaku Geboye Desta (eds.), *Electricity Trade in Europe. Review of the Economics and Regulatory Challenges*. The Hague. Kluwer Law International.

Pineau, P-O., A. Hira and K. Froshauer. 2004. Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA. *Energy Policy* 32: 1457-1475.

Rosellón, J., Z. Myslikova, and E. Zenon. 2011. Incentives for Transmission Investment in the PJM Electricity Market: FTRs or Regulation (or Both?). *Utilities Policy* 19: 3-13.

Rosellón, J. and H. Weigt. 2011. A Dynamic Incentive Mechanism for Transmission Expansion in Electricity Networks: Theory, Modeling, and Application. *The Energy Journal* 32 (1): 119-148.

SENER. 2011. Secretaría de Energía *Prospectiva del Sector Eléctrico 2010-2025*. Mexico, D.F. Retrieved November 22, 2011, at http://www.sener.gob.mx.

Stoft, S. 2006. Transmission Investment in a Deregulated Power Market. In F. Leveque (ed.). *Competitive Electricity Markets and Sustainability*. Cheltenham: Edward Elgar Publishing Ltd.

Tierney, S.F. 2008. ERCOT Texas's Competitive Power Experience: A View from the Outside Looking In. White paper by the Analysis Group. October. Boston.

UNCTAD. 2010. *World Investment Report: Investing in a Low Carbon Economy*. Geneva. Retrieved March 28, 2012, at http://www.unctad.org/en/Docs/wir2010overview_en.pdf.

UNCTAD. 2008. *World Investment Report: Transnational Corporations and the Infrastructure Challenge*. Geneva. Retrieved March 28, 2012, at http://www.unctad.org/en/Docs/wir2008_en.pdf.

Wang, J., Z. Zhou, and A. Botterud. 2011. An Evolutionary Game Approach to Analyzing Bidding Strategies in Electricity Markets with Elastic Demand. *Energy* 36 (5, May): 3459-3467.

Weintraub, S. (ed.) 2007. *Energy Cooperation in the Western Hemisphere, Benefits and Impediments*. Washington, DC. Center for Strategic and International Studies Series.

Wilson, R. 2002. Architecture of Power Markets. *Econometrica* 70 (4, July): 1299-1340.

Wolak, F. 2005. Lessons from International Experience with Electricity Market Monitoring. World Bank Policy Research Working Paper No. 3692. June.

Zenon. E. and J. Rosellón. 2010. The Expansion of Electricity Networks in North America: Theory and Applications. Munich Personal RePEc Archive Paper No. 26470 (November). Retrieved October 1, 2011, at http://mpra.ub.uni-muenchen.de/26470/.

Chapter 2. The Structure of Utilities and Non-Utilities in North America, and Regional Players

by Alejandro Ibarra-Yunez

Abstract

This chapter analyzes the asymmetries in market design between Mexico and regional interconnections in the US, ERCOT in Texas and CAISO in California, regarding the market spaces apparent for suppliers of utilities and non-utilities on both sides of the border. Many stakeholder power producers are critical players for electricity markets, where electricity producers could use their market power to restrain supply, while the transmission and distribution part of the market could underinvest to artificially create high-priced congestion. The nature of unbundled versus integrated systems is studied, typifying the multiple parts and players in this increasingly restructured market. The study delineates all licensing characteristics on both sides of the border, regarding power producers as legal and administrative elements of transaction costs, applied to Independent Power Producers (IPPs), auto-generators, and co-generators. It also presents other players in unbundled markets such as retailers, distribution, ancillary service providers, schedulers, and qualifying facilities, among others in the US, that create a complex market but offer many strategic opportunities.

2.1 Introduction

Traditionally the operation of electricity systems in the world assumed a vertically integrated firm or regional set of firms that integrated generation, transmission, and distribution. A justification existed in economic theoretical terms that the vertically integrated firm was a natural monopoly, with high economies of scale in all segments and cost subadditivity, meaning that only the integrated firm will produce at lowest average costs than unbundled ones (Mas-Colell, Whinston, and Green 1995). However, given advances during the 1980s mainly in technology, noteworthy in thermal generation processes, a strong evidence emerged of competitive markets in generation, access, retailing, and overall trading that called for a deep revision of regulatory processes across the world (Armstrong, Cowan, and Vickers 1994; Hunt 2002; Jamasb and Pollitt 2005; Joskow 2002; Spiller and Tommasi 2005; Stern and Cubin 2005; Wilson 2002).

Historically Chile began deregulating the industry in the 1970s, which called for unbundled parts of the industry and separation of what can be called utilities and non-utilities, or electricity generation as a public versus non-public good, where competition was begun under regulatory oversight (Beato and Laffont Eds 2002). A summary characterization of Chile's inclusion or market forces included: (a) listing state-owned enterprises in their stock markets, or capital democratization; (b) operational, financial, and administrative separation; and (c) sale to private interests via auctions. Similar procedures occurred in the United Kingdom in the early 1980s, but no capital democratization occurred as a first step. Other countries in the world followed the described dynamics. After experience with about 20 years of deregulation, they have shown better economic efficiency and performance by the process of unbundling competitive parts while maintaining regulated monopoly transmission and some distribution, without resorting to massive privatization (Ibarra-Yunez 2011).

This point is critical to settings such as Mexico, where deregulation has remained a rather politically charged process that has placed the country as non-competitive and with many welfare distortions. After the Zedillo Administration package passed and rejected by the Mexican Congress in 1999, other proposals during the Fox and Calderón Administrations (from 2000 onwards) have faced setbacks in congress from arguments against privatization that were never part of the various proposals for reform. If only political strongholds understood the welfare objective of unbundling and deregulation, with evidences from across the world, a much better market picture would occur. In spite of all the regulation hurdles Mexico has faced, the Ley del Servicio Público de Energía Eléctrica (LSPEE), or electricity law, was passed in 1992 and liberalized generation and trading under regulated non-utility permits below 20 MW of capacity, for auto-generation and co-generation in private hands, small production, and imports and exports. These private activities are overseen by the Comisión Reguladora de Energía (CRE) created in 1995 that also oversees the so-called Productores Independientes de Energía (PIEs) or Independent Power Producers (IPPs) with capacity permits of higher than 30 MW for exclusive sale of electricity to the incumbent parastatal CFE, as is described in Chapter 1. Beginning in 2008 a so-called “open season” was called to promote and incentivize private generation of renewable energies, mostly wind, bio-mass, and recently solar (SENER 2011).

The distribution of permits is at the end of 2011 as follows: 491 auto-generation permits, 67 co-generation ones, 28 IPPs, 29 import permits, and 5 for export. Total is 619 permits under CRE jurisdiction. Private investment stands out at around US$33.704 billion in 2011, double the US$16.270 billion invested in 2008, which gives an idea of the attractiveness of this semi-liberalized market, where private investment seems to be complementary, non-rivalry of the incumbent CFE and its transmission arm CENACE (See Chapter 1 and next section).

As for the United States, the overall national system has operated as segmented and regionally separated systems, where traditionally utilities were vertically integrated firms, either as investor-owned or IOUs, municipal-owned utilities or MOUs, and rural cooperatives. The passage of the Public Utilities Regulatory Policy Act or PURPA in 1978 opened the market for Independent Power Producers or generators for the energy market, at the same time that Independent System Operators or ISOs were created, first as part of utilities and then by Orders 888 and 889. In 1996, open access under transmission-only ISOs was created to operate the flows and administer energy balances in the region or area of their operation. A wholesale and retail market began where the Federal Energy Regulatory Commission (FERC) regulates wholesale markets and interstate commerce, while retail is free or overseen by the states’ public utility commissions (Joskow 2005). According to the Bureau of Labor Statistics (2012), there are 8,048 electrical utilities or IPPs under the tag Producing Generating Companies (PGCs), creating around 405,000 jobs. As for non-utilities, EIA data shows that there are around 1,738 in 2008, mainly auto-generators and co-generators, established under PURPA as Qualifying Facilities or QFs. The amount of investment in generation has reached around US$900 billion to $1 trillion in 2009-2010 (EIA 2011).

One problematic area is the predictability of prices that make generation profitable at close to congestion, but where the transmission capacity and prices paid for supply delivery are not clear for the generating companies of both utilities and non-utilities. For this reason in deregulated systems there are challenges to determine optimal investments in power capacity. For example, low wholesale prices could postpone generating plant expansions or launch new generating projects. This has occurred in Texas at the same time that demand can reach record levels, such as on abnormally hot or cold days. Also, generating plants that are broken down or mothballed are incapable to respond at short notice in case of emergencies. At the same time, proposals to increase retail prices for consumers have faced strong opposition among the citizenry, for which generation expectations are strongly affected by this set of circumstances. This chapter reviews theory, institutional settings, and empirics from the point of view of generation and its determinants on both sides of the US-Mexican border, given the alternative market and regulatory architectures. The next section is devoted to the analysis and the governance structure that frames Mexico producers. The following section takes account of the US power producer, and then concentrates on markets in Texas within ERCOT and in California within the CAISO market. The chapter then concludes with an analysis of risks and opportunities.

2.2 Supply Market Architecture: Mexico's Case

Concentrating on foreign Independent Power Producers or IPPs in Mexico, the Mexican law of 1992 allows for them to participate in larger than 30 MW projects for exclusive sale to incumbent CFE. From 22 permit holders in 2008, in 2010 there were 28 of those investments, concentrated in Spanish projects by Iberdrola, Unión Fenosa, and Gas Natural México (the latter acquired the assets of The French EDF Internacional subsidiary in 2008), with 34.3%, 17.2%, and 14.2% of MW name-plate capacity of all IPPs in 2010, respectively (65.8% of total foreign investors in this market). Mitsubishi reduced its participation from 18.5% in 2008 to 12.3% in capacity for 2010 (Mitsui Corporation has maintained one project in the state of Yucatán, with a participation of 4.2%, so the total Japanese stake is 16.9% of the total). US investors include InterGen with 8.9% of participation and AES with 4% (total of only 12.9%). The Canadian TransAlta has two permits and participates with 4.4%.

Given the nature of Mexico's legal framework for IPPs as facing an exclusive buyer CFE in a "build-operate-own" model with power purchasing agreements offered for a period of 20 years, the market for IPPs is semi-concentrated, according to regulation practice (Church and Ware 2001). The calculated Herfindahl-Hirshman concentration index is 2,418 points in 2007 and 2,146 in 2010, a change of 408 points of reduced concentration. According to Mexico's competition law (Section 4 of the Competition Commission "Resolución en que se da a conocer el método…"), higher than 2,000 points in the HHI or an increase of 200 points in a relevant period are considered elements to conclude that a market is concentrated. Hence, the IPP bilateral market in Mexico could be considered a concentrated one.

In a related and relevant matter, investment is estimated by the Comisión Reguladora de Energía (CRE 2012), to be USD$ 15 billion in 2011, double the level from 2007. A first thought about these specific permit holders under the surveillance of CRE is that given their power in similar fashion of California's experience with power games by generating interests, there is a risk of undersupplying the market to pressure prices upwards (Joskow 2003; Wilson 2002). However, since final prices are exogenous to market forces in Mexico (they are set by the Secretary of the Treasury SHCP and Secretary of Energy's proposal), such a behavior would be muted.

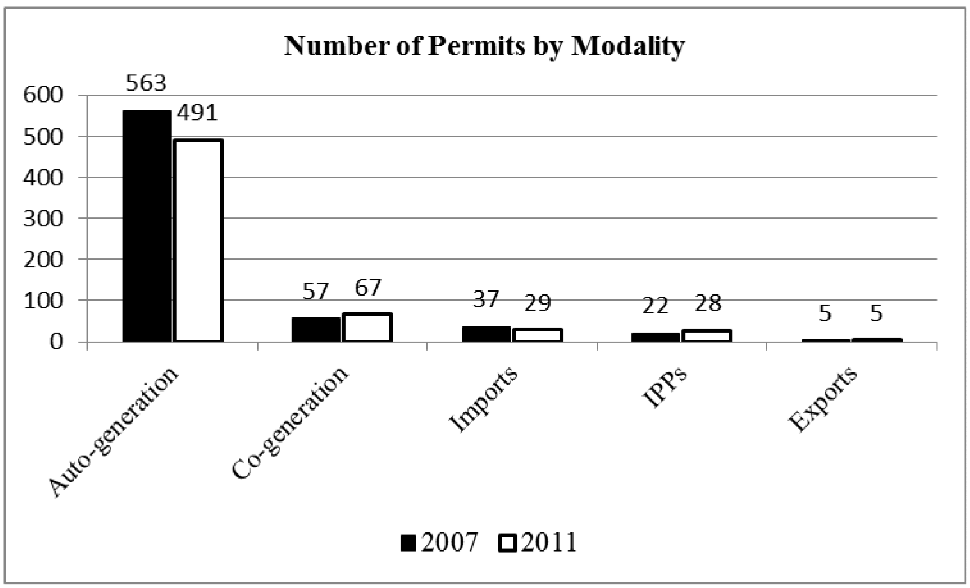
On the other hand, given the sole buyer framework, gaming could arise rather from restricted access rights to the national grid set by the Energy Control Center, CENACE, which is the Transco within CFE, or by charging monopoly rents by CFE to IPPs, in its transmission rate formulas. So far, long-term purchasing power agreements, PPAs, have made the semi-market coordination efficient and stable, with few conflicts. Moreover, prices between IPPs and CFE are *ex ante* programmed to increase stability, even if contracts are realized in bilateral form rather than in an energy *pool* or market (Ibarra-Yunez 2008a). One key aspect frequently argued as a precondition for deep interconnections is the price mechanism, to be set in transparent form and arising from both regulated prices in the hands of the regulator (in this case CRE), and market prices at the zone, or better, node, close to marginal cost. This has been the main argument in papers such as Hogan (2002), Hogan, Rosellón, and Vogelsang (2010), and others where merchant models of electricity are compared with regulated markets, mainly assuring that both transmission and generation are stable and efficient parts of the market.

On the part of the transmission networks in Mexico, they face a challenge to modernize them and improve backbones, mainly nowadays where renewable sources of energy are located farther from consumption centers and where there is the question of how to fund grid expansion. In the case of CFE, budgetary sources set a limit to expansion, even if between 2005 and 2010, these federal allocations have increased but used not for either expansion of the Sistema Eléctrico Nacional SEN from CENACE or generation (Martínez-Chombo 2010). This could also impel the incumbent CFE to overcharge for sunk costs of the grid, affecting IPPs profitability (transmission rights costing).

Additional to IPPs, the Mexican regulation allows for auto-generation (self-supply), co-generation, small-scale supply, and permits for imports and exports under CRE's regulation. At present, there are 491 auto-generation permits (down from 563 in 2007); 67 co-generation permits (up from 57 in 2007); 29 import permits (down from 37 in 2007); and 5 export ones, low figures in contrast to other markets. However, these permits are not a low figure regarding investments, since a calculation by CRE shows US$11.8 billion for auto-generation in 2011 (up from US$5.2 billion in 2007), US$3.6 billion for co-generation (up from US$2 billion), and US$2.5 billion in export activities (up from USD$ 1.4 billion in 2007), with a total permitted capacity of 28,893 MW in private producers, both utilities and non-utilities. The following three graphs summarize the distribution of private investment activities in Mexico.

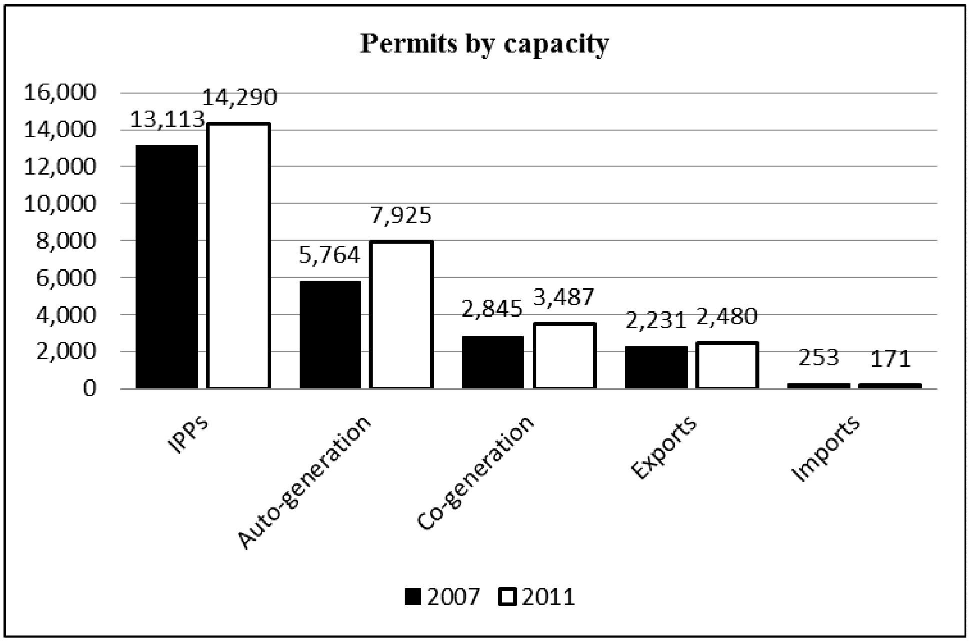
Finally, given a shadow market rather than a true open market in Mexico, the present analysis has separated the permit holders between those that form the so-called Specific Objective Contract Partnership permits for peak shaving only from permits that have implied a sort of internal market and sale of residual energy to CFE via PPAs. From co-generation permits, 20.1% show this characteristic while 5.5% of auto-generation permits show it, although in terms of the latter's capacity it is 63.3% that is traded (Ibarra-Yunez 2008b). In summary, there seems to be an implicit and mixed market in Mexico to the limit of the regulatory framework. The next section reviews the permit frameworks of operation themselves.

Figure 2.1
Distribution of Permits in Mexico (Number)



Source: Author's generation with data from CRE.

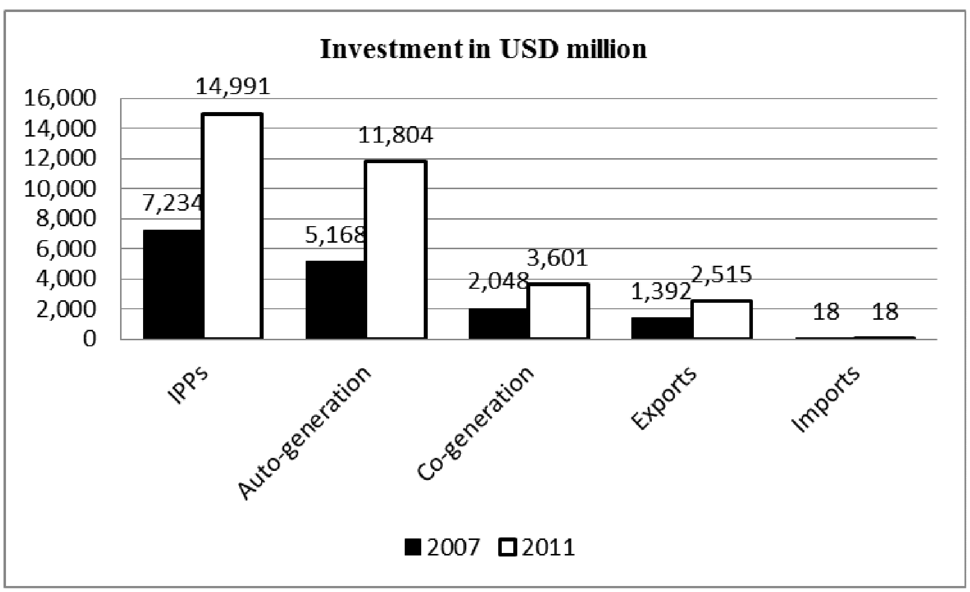
Figure 2.2
Distribution of Permits in Mexico (in MW capacity)



Source: Author's generation with data from CRE.

Note: As can be seen, total private authorized capacity reached 28,893 MW in 2011.

Figure 2.3
Distribution of Permits by Investment



Source: Author's generation with data from CRE.

Note: Total estimated investment by December 2011 reached US$33,704 million.

2.3 Analysis of Permit Characteristics in Mexico and Players

This section spells out the characteristics, aims, and limits of the private sector permits to generation activities in Mexico, both of utilities (IPPs) and non-utilities (rest of permits).

IPPs

For the case of IPPs, the following are the critical elements for investors to gather all requirements under CRE's jurisdiction:

1. Proof of existence under public and commerce registry and formally constituted as a resident company in Mexico. Note that all IPPs have foreign companies as main stockholders, but where US companies are present only marginally with no apparent reason.

2. Programs, designs, constructions, and all activities needed to operate generating facilities within a time schedule set by the permit solicitor, along with all technical specifications about main transformers, switches, and other links to assure supply to the SEN system, also following CENACE technical specifications.

3. Contracts and capacity commitments of electricity generation (technical maximum and real capacity in MW).

4. Purchasing power agreements associated with CFE (in MWh offered in different tiers, from day-ahead markets, to economic reserves, to non-scheduled).

5. Specifications of the types of technologies to use and all requirements of gas, fuels, and water usage, and other things for operation and emission norms.

6. Once operations are initiated, the permit holder must inform CRE quarterly of the type and volume of fuels used, quantity of generated electricity, and fixed charges for capacity, O&M (operation and maintenance) and the variable charges for O&M, by fuel and ramping up.

7. Get from CFE all property rights of land, land use, and discharges.

Co-Generation Permits

In all cases, this research found that main co-generation permit holders are associations of industrial companies that use part of the heat and gasses from industrial processes for private interchanges and public sales of excess electricity to CFE. They need to solicit a registry into a trade figure called *Sociedad de Objeto Específico* to CRE (Specific Object Partnership). One critical point is that CFE has a say in the conditioning of costs of congestion to CFE's grid of the SEN, but without a market mechanism. Most co-generation processes use vapor recuperation for industrial and mining projects. Noted is the concentration of projects for industries in the glass and cement sectors, food and beverages, textiles, petrochemicals, metal-mechanics, hotel services, and municipalities into lighting projects (Ibarra-Yunez 2008b). Many industrials are active co-generators in discontinuous electrical off-grid activities, with CFE contracting of non-peak load services and where base supply to ramping up electricity for own use is around 15% of demand. Co-generators can enter into PPAs with the incumbent CFE for the sale of excess flows of electricity.

Recent co-generation projects also have included use of renewable energies (biomass). The rules established by CRE for permits is shown next, where solicitors must establish:

1. Proof of existence under public and commerce registry and formally constituted as a resident company in Mexico. Under this modality, all permit requests have included a group of industrial or mining partners.

2. Capacity to install and the distribution by all partners of the production, conduction, transformation, and delivery of generated electricity (sales within partners is not regulated).

3. Planned location for the co-generating plant(s), with its technical description that include the type of technology, annual estimated generation, self-consumption, and use of inputs.

4. Building and construction program and schedule of initial operations, after testing, and disposable excess energy to CFE.

5. Obligation to supply energy in case of public service requirements and emergencies.

6. Adherence to the rules of dispatch of the SEN (porting).

7. Responsibility for risks under all circumstances when conditions of co-generation supply change. The permit holder(s) are responsible for the property rights and rights of way.

8. Permit holders must accept "associated purchase contracts" before CFE (PPAs).

9. The permit holder must quarterly inform CRE and CFE of its operations.

Under the PPA with co-generation, CENACE and CFE establish a programmed auction using *ex ante* prices, or else establish as the purchase price for excess, the so-called automatic price, with tariffs dependent on capacity and by KWh. On its part, CFE establishes charges for access to the grid by KWh, plus charges for operation and maintenance and also ramping up in a regulated type of market (Hogan 2002, Vogelsang 2001). During the investigation, one risk voiced by co-generating permit holders is the red tape when the partnership invites new firms or firms leave the partnership such that a whole new permit solicitation is required by CRE. Another risk is the nature of the access tariffs to the integrated grid. Finally, a last important risk is the lack of a clear sharing rule for infrastructure expenses by private investors, since transmission and distribution is by law, monopolized by the incumbent CFE state corporation.

Auto-Generation Permits

There were 491 permits of this category at the end of 2011, down from 563 in 2008 (CRE 2012), mainly because some permit holders have decided to increasingly depend on CFE supply given a recently capped price established by the federal government in 2009 after the US recession hit Mexico's economy. It is also possible that some permit holders for self-supply ceased to renew permits, such as Pemex or retailers. Most auto-generation permits also allow for a group of companies to share the auto-generation project for bilateral, not regulated prices, under the referred Specific Object Partnerships. Most auto-generation permits do not imply sale of excess electricity. However, around 40 (roughly 10%) of permit holders, mainly larger installed capacity permits to the limit of their 20 MW allowance, do sell excess electricity as non-utilities, similar to Qualifying Facilities, or QFs, in the ERCOT market (presented in a next section). Second to IPPs, this modality has implied the second largest capacity installed with more than US$11 billion invested. Private participation in here is rather important, noting that after analyzing all permits in Mexico, companies appear in more than one modality (e.g., IPPs plus auto-generation permit, co-generators plus auto-generators, IPPs and import permits). In order to participate in more than one activity, the investor must secure different permits, not being allowed to use permit pancake strategies. The following list shows the characteristics of the contracts where permit solicitors must guarantee:

1. Proof of commercial existence under public and commerce registry and formally constituted as a resident company in Mexico. Under this modality, all permit requests have included industrial or mining partners but also retailers and other members of the partnership.

2. Capacity to install and the distribution by all partners of the production, conduction, transformation, and delivery of generated electricity (sales within partners is not regulated).

3. Authorized capacity to install, and distribution of maximum consumption by each permit member.

4. In case it is needed, the list of additional partners in the planned expansion of the permit holder. Sales to non-members of the permit are prohibited by the regulation.

5. Technical description that includes the type of technology for installation, annual estimated generation, self-consumption, and use of inputs.

6. Building and construction program and schedule of initial operations, after testing, and disposable excess energy to CFE, according to Arts 36 (I, numeral b), and 36-bis of the LSPEE.

7. Obligation to supply energy in case of public service requirements and emergencies against the received payment from the PPA contracts.

8. Adherence to the rules of dispatch of the SEN (porting), in the point of connection. It is possible that electricity demand could be larger than excess supply, for which the contract can be subject to automatic economic supply or reception via auctions.

9. Responsibility for risks under all circumstances when conditions of generation supply change. The permit holder(s) are responsible for the property rights and rights of way.

10. Permit holders must accept "associated purchase contracts" before CFE.

11. The permit holder must quarterly inform CRE and CFE of its operations.

According to analysis of the governance structure of auto-generators in Mexico, the permit holder should inform 15 days in advance if it prefers auction supply, specifying quantity and price to offer at daily delivery, up to the grid capacity as the ceiling supply. CFE, according to the Mexican regulation, must acquire a minimum of 90% of this supply, while the permit holder is responsible that electricity supply stays within 10% of variation with respect to power delivered to CFE. In case of non-adherence, then CFE would acquire excess supply as non-notified automatic delivery, at a price 85-90% of the offered one, depending of the thermal efficiency of the power producer. There are various tariffs for wheeling that depend on the use intensity (base load, medium load, peak load), mainly for high consumption tariffs (HS).

Auto-generators in Mexico seem not to distrust the reliability of CFE supply. However, ramping up generation is subject to purchase of electricity to CFE of 15% of backup energy. Partners in the contracts can save such 15%, and up to around 27% of energy costs from non-backing up. Auto-generators would benefit if tariffs and put versus call purchasing options were done in a true market, as is the case in WECC-CAISO and ERCOT.

Import and Export Permits

Under the LSPEE, importer permits are granted for exclusive use of permit holder partners, and electricity cannot be subject to resale (Art. 72(II)). If Mexico faced a true market with an unbundled structure (Transco, ISO, and qualified users), import permit-holders could evolve towards a figure similar to the one seen in the US or Canada called a broker or marketing company (Griffin and Puller 2005; Goodman 2010). In such cases, importing partnership groups can self-supply or resell as market complement, but in Mexico incumbent CFE and the system operator CENACE (part of CFE) under present regulations prohibit such parallel market without CFE or CENACE participation. It is for the market architecture reason in addition to potential wholesale price risks and subsidies that are difficult to predict that Mexican import permit holders are so few and have played a marginal role until 2011. The above does not apply to the incumbent CFE that can extend links and connected ports.

For example, as is presented in other chapters, SENER (2011) shows that there are nine high voltage (400 kV- 230 kV) connectors to the US market, plus one with Belize and one with Guatemala. Connections exist between Baja California with California at Tijuana-Otay Mesa and La Rosita-Imperial Valley, with 800MW available for power and energy markets with the north on a permanent basis (Baja as shown elsewhere is part of the Western Electricity Coordinating Council, WECC). Additionally, there are two connectors used for emergencies in the El Paso region (Diablo, Texas, with Paso del Norte Mexico, and the Azcárate connection with Reforma in Juarez), with capacity of up to 200 MW and medium voltage links of 115 kV. With the Texas ERCOT, there are emergency links and asynchronous DC interconnections in Eagle Pass, Laredo, Falcon, Frontera, Sharyland-Mcallen, and Brownsville-Military Rd. These linkages range from 138 kV lines to 230 kV lines, and have capacity for trading of up to 580 MW and growing. Finally, the connectors to Belize and mainly with Guatemala in recent times shows capacity of up to 200 MW for and to the Central American market with high voltage transmission of 400 kV (Belize connects with Mexico permanently also, at lower voltages and where capacity can reach 40 MW). Finally, plans to increase investment in transmission capacity concentrate in California, Reynosa-Matamoros with the Texas Lower Valley, and Guatemala (SENER Prospectiva 2011).

On their part, exporters in Canada are promoted in three tiers as (a) exporters of physical electrons from renewable sources of energy, mainly from hydro, but also wind or nuclear; (b) research and advice in engineering of new technologies and smart grids; and (c) development of clean energy business services. Contrary to a simplified intervention in Canada, export permits in both the US and Mexico are restricted by federal regulations to guarantee domestic supply in the US and economic viability and transmission stability in Mexico, respectively, before granting aspiring exporter companies with the corresponding licenses or permits.

The Mexican law and regulation under LSPEE allows exports from co-generating activities, IPP activities, and any small production activities to be destined for external markets. However, permit holders of co-generation or other should secure a separate exporting permit, increasing the transaction costs for the non-CFE generators. Additionally, the type of interconnection carrier contracts and the distribution of infrastructure expansion rates between CFE and a private party is critical. As can be deducted, incentives for export between Mexico and the US are restricted at the level of the market architecture, in addition to other non-economic and procedural reasons (Ibarra-Yunez 2011).

To close the section, it is important to note that transporting or ramping services (wheeling) by CFE has increased at an average rate of 8.9% per year, except for zero increases in 2008 and 2009. This evidences a *de facto* merchant model in Mexico in the transitional market architecture.

2.4 Supply Market Architecture: the US Case and Main Players

After the passage of the Public Utility Regulatory Policies Act of 1978 (PURPA), the formerly integrated although sparsely organized US market faced generating capacity to be updated and changed, to be consistent with various players in different layers of the market. In the end of the 1970s, Section 210 of the PURPA created an arrangement called a Qualifying Facility or QF to promote new players and reduce the US fossil fuel dependency after the oil shock of the '70s. A QF had to have 50% or less ownership by a utility, plus it was required that technology diversification was used, such as co-generation or a generator using renewable energy. Companies could own more than one QF and diversify by location. From the end of the '70s to well into the '90s, most generation was produced by vertically integrated utilities.

Then the regulator FERC triggered a new type of producer: the so-called "exempt wholesale generators," or EWGs, to make it not compulsory that utilities were owned by a holding company. With this plan, wholesalers could be separated from retailers and promote more competition. In 1996, FERC passed Order 888 that required all investor owned utilities (IOUs) that owned transmission lines to open them for all generating facilities in a non-discriminating manner. Additionally, any wholesale producer (QFs, EWGs, IOU or any power generating company or PGCs) after passing a test of lack of market power could price its electricity at market prices instead of at a regulated rate of return, or cost-based caps, thus liberalizing the market (Badlick and Niu 2005; Steinhurst 2008; Wolak 2005).

Utilities then had to create independent corporations in charge of transmission: the ISOs and regional RTOs, to determine new ways to set access procedures and charges, as well as acting passively (ERCOT) or actively (CAISO) to set wheeling charges, wholesale at intrastate levels with FERC regulation, and promoting retail competition, at least for those that were non-incumbent. To understand unbundling dynamics in the US, most incumbent utilities were pressed to divest the generation capacities, similar to the former experience with telecommunications, by selling to another party, or creating affiliates owning former integrated assets (Beato and Laffont 2002).

Other stakeholders in the US electricity market, embraced by federal and state legislations and sets of rules, complete the panorama. From the generation part of the market, the QFs and EWGs discussed above, as well as the allowances for the power generating (non-utility) companies or PGCs, were created mostly as divestitures of existing generating plants by utilities and also as transfers of utility plants to unregulated affiliates and new generating plants (Joskow 2005). These entities are allowed to remain affiliated up to 5% of share ownership by utilities or other entities (Baldick and Niu 2005). Accordingly, around 34% of generation was produced by non-utilities in 2002 and 39% in 2011, while the comparative figure is roughly 33% in Mexico for 2009 (SENER Prospectiva 2011).

The PGCs operate as wholesale providers similar to Mexico's definition of IPPs, and are regulated. Additionally, the divested retail electric provider REP (this entity is not regulated if it operates within the state boundaries) defined in ERCOT, along with a transmission and distribution service providers, or TDSP, complete the set of the three unbundled IOUs (Baldick and Niu 2005).

In an unbundled market with retail and wholesale prices and auctions, other stakeholders are important players that do not have s similar entity represented say, in Mexico. These are the distribution companies or more generally the Load Service Entities, or LSEs, along with Marketers and Aggregators that do not need to own power facilities.

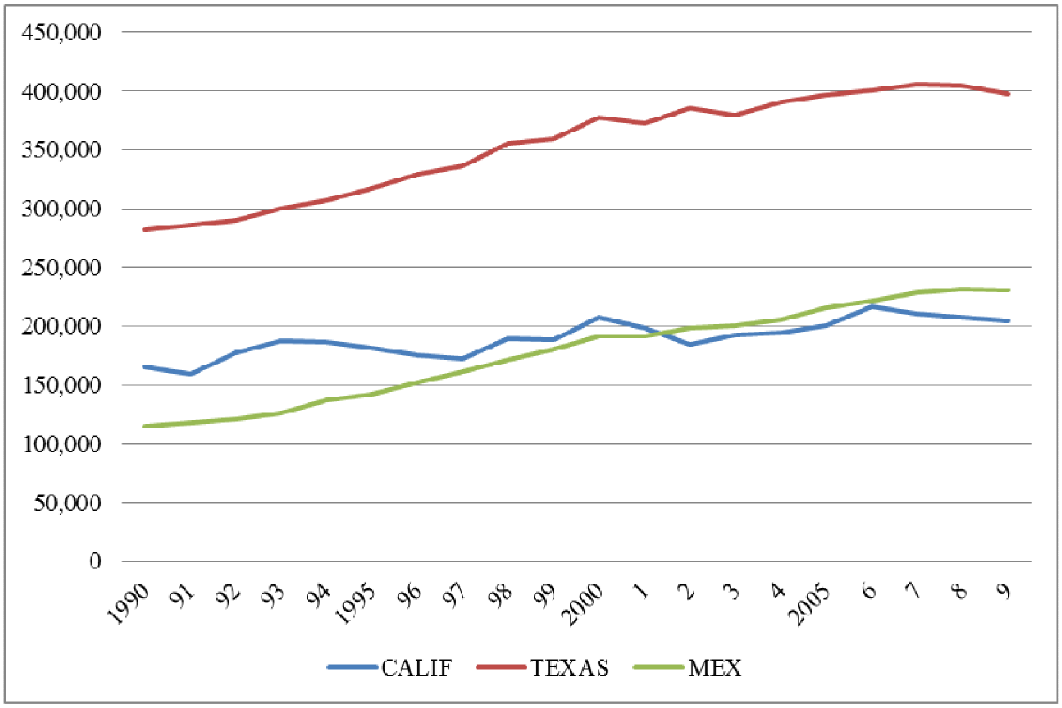
Table 2.1 shows the sizes of the systems of interest for the current research analysis: the California system operation (CAISO), the Electricity Reliability Council of Texas (ERCOT), and the integrated national Mexican operation (CFE).

Table 2.1
Comparison of the US and Mexico Systems of the Research Project, 2010

	CAISO	ERCOT	CFE
Installed Generation (MW)	57,124	63,025	60,440
Transmission Lines (miles)	25,526	40,500	31,187
Population served	30 million	23 million	34 million
Planned Reserve Margin (operational %)	15	13.75%	13%
Ave. Annual Load weighted price/ MWh	$39.91	$26 - $170 (7pm)	$12
With fuel adjustment	$33.95	n.a.	n.a.
Renewable % of total MWh (2009, 2010)	11	15.1	3 (wind) 14.2 (wind and hydro)

Sources: Author's generation with CAISO data set, ERCOT data set; SENER (2011) Prospectiva del Sector Eléctrico 2010-2025.

Figure 2.4
Total Net Generation in GWh: California, Texas, and Mexico
1990-2009



Source: Author's generation with CAISO data set, ERCOT data set; SENER (2010) Prospectiva del Sector Eléctrico 2010-2025.

2.4.1 Main Stakeholder and Player Participation and other Market Governance Activity

The previous sections have spelled out differences between Mexico and part of the relevant US systems CAISO and ERCOT, regarding generating players. Now, it is necessary to create a framework of the market design and its various players. With this in mind, there are different roles other stakeholder participants play in the unbundled market. Specifically, Srivastava, et al. (2011), have studied the distribution of competences between at least the following players.

- Generators (of all types and proprietorship structures described above) [G].

- Power Marketers that become active participants the more unbundled is the market. In Mexico permit holders enter into bilateral non-regulated exchanges both with incumbent CFE and among their "off-grid" partnerships, rather than operating in a power market. However, CFE definition of firm energy supply now works through the system operator CENACE with auctions. Power marketers can be active or passive across countries and regions [PM].

- Power Exchanges, as market clearing mechanisms, that exist in some markets but not in others (they exist in the California CAISO, but not in ERCOT) [PX].

- Transmission owners, similar to the defined TDSP above, that can be closely related to overall definition of Transcos [TO].

- Scheduling coordinators that generally do not own facilities; they are separated from power exchanges or pools. They generally are also separated from the system operators and of Transcos. Both CAISO and ERCOT have such a business figure. For ERCOT, scheduling coordination and power exchange activities are merged and part of the same operation so that a question is what section plays a leading role: power exchanges with a secondary role of scheduling, or scheduling with a minor role of PX [SC].

- Ancillary Service Providers are fundamental to a vertical unbundling, because they supply support services to reliability of the power system. Some system operators allow for ancillary services, mainly through traded rights in spot and forward markets, to be part of power exchanges AS-PX such as in CAISO, while others can be part of the Independent System Operator activities, or AS-ISO. For example in Texas, the ISO (ERCOT) provides the ancillary services. Moreover, there is no PX in Texas, giving the ERCOT ISO the leading role that has been considered a successful story of arbitraging and operations, and where ancillary services are critical [AS].

- Retailers [R] and Distribution service providers [D] complete the map of participants. Under the retailing figure, ERCOT defines Load Service Entities, or LS, as the D of the map, while marketers and aggregators form the R, that also seems clear to encompass the so-called retail electric provider, REP.

The alternative market design models of stakeholders and players have arisen in the US from legal and regulatory designs, and also from pragmatic allocation of power among the different participants and how regional regulators have envisioned their own markets both from its inception to accommodate agents' interests and origins of power, in a typical case of multi-principals and multi-agents in game theory and the theory of incentives (Laffont and Martimort 2005).

As for the Mexican case, CENACE, the Mexican System Operator, was planned since the beginning of the decade to be separated from CFE and become a true ISO. Congress voted against many executive reform proposals since the Zedillo administration of 1994-2000, passing through the Partido Verde, the PRD, PAN party proposals, and executive proposals of the following Fox Administration (2000-2006) and the present administration of Pres. Calderón of 2006-2012 (Ibarra-Yunez 2011).

In the research project visit to Mexico City in January 2012 to CFE, CENACE, the Energy Regulatory Commission (CRE), and the Secretary of Energy (SENER), the research team members gathered that given political times, no changes are foreseen during 2012 to reforms in the sector, although CENACE high administrators argued that they operated in market clearance operations and wheeling services, as if a true (although a shadow) market existed, with daily and fortnightly auctions for system access and tariff setting.

2.4.2 The California Market

The market ISO began operations as a non-profit organization in January 1, 1998, to secure reliable and secure energy to about 30 million California state residents. CAISO is part of the Western interconnection WECC that extends from Baja California in northwest Mexico to British Columbia in Canada, and is subject to federal oversight by FERC regulation. CAISO provides dispatch of energy and transmission access services and ancillary services to balance the market hourly and daily (through frequency regulation, spinning and non-spinning reserves, and replacement reserves to anticipate changes in demand or plant outages). The SC provides the balance schedules of delivery to the ISO, while an unbundled PX creates the spot market for electricity and schedules trading and market clearance in financial markets. All IOU power producers must bid generation to the PX, but own the transmission grid that is operated by CAISO since March 31, 1988, when it assumed all the transmission control of investor owned generators. To put the California market in perspective, dispatch has a separated PX operation not seen in Texas ERCOT, but generators are much more vertically integrated in CAISO than in ERCOT. Los Angeles and Sacramento County are not covered by CAISO.

Much has been written about market and regulatory failure in California's electricity market in 2000 and 2001. Among the main research references are Bompard, Ma, Napoli, and Jiang (2006); Borenstein (2000); Borenstein, Bushnell, and Wolak (2002), Gilbert, Neuhoff, and Newbery (2004), and noteworthy Joskow (2001, 2003, 2005, 2008); and Joskow and Kahn (2002).

However, some aspects of the example of market and regulatory failure have become lessons for restructuring in other parts of the world and within the United States. Since it is not the objective of this chapter to delve into California's complex market and regulatory hurdles, only salient points are presented next after analyzing them for lessons in deeper integration of binational markets. However, measures taken seem to respond to the aim of reducing retail prices. At the same time not all structural problems faced by wholesalers, retailers, and unregulated transmission contracts were in place that faced new open access and "price to beat" contracts for cost recovery (Joskow 2001). The California case can show the following lessons:

1. Markets where private interests play a greater role than a well-defined mechanism of transition and where players at least do not lose is prone to failure as the new "market" is tested in its operation. For example, it is reported that the California Public Utility Commission (CPUC) sent commissioners to England and Wales that were persuaded of their model instead of studying the particularities of players in CAISO. The point is especially important in the wholesale market and its institutions ISO and PX.

2. Separating the ISO from the power exchange in charge of scheduling day-ahead and daily hourly trading can create problems of information and reliability for generating companies supplying information and trading position to the PX with interested objectives of creating tying or conditional sales. This is a topic often addressed in game theoretical industrial organization as market failure potential. All utilities in California and the main, very powerful, IOUs must trade power and energy in the PX. Moreover, in the California price crisis in 2000-2001, the PX took hourly day-ahead supply and demand bids and "stacked up" to have aggregate demand and supply curves for electricity, so that prices not only increased because of conditioned sales by powerful incumbents but by design of the regulation applied by the PX.

3. When various oversight mechanisms are independent for operational reasons, such as the ISO and the PX in California, propensity to face moral hazard problems and overall information asymmetries increases. Such was the case in 2000, when critical lack of coordination was more evident in congestion periods and its management. According to Joskow (2001), flaws were clear in the congestion management system around the "protocols" for investment in interconnection and transmission for new generators (in California IOUs were three concentrated ones), real time balancing markets, ancillary services, and day-ahead and real time market clearance. These are aspects of unbundled electricity markets, mainly around congestion periods of days, weeks, or seasons, that could make others reject deregulation altogether. The California experience has postponed many restructuring plans across the world, including coordinated binational and trinational efforts in North America. The lack of coordination in critical congested periods gave rise to above expected prices over marginal costs.

4. Moreover, given excessive prices over costs in stressed and congested periods, main concentrated generators saw an opportunity to withhold capacity during stressed periods to squeeze the markets, so that price increases were a strategic result of conduct (Borenstein, Bushnell, and Wolak 2000).

5. When the ISO is passive, with low power to change incentives, strategic conduct by suppliers moves the market referee (the ISO) to not being able to regulate market clearance mechanisms of more costly sources of energy, nor to impel producers to increase reserve margins in anticipation of unbalanced growth between demand and supply, or price caps to interested conduct by powerful players.

6. Regarding retail markets, California established choice of customers over their service provider, but if they did not choose one, they would be serviced by the local utility at a regulated final price of around $65 per MWh for up to four years. This price cap or fixing over retail prices provokes two effects: insufficient "churn" and market discipline; and the measure disincentivizes both investment in power plants and servicing the market with firm supply, so that utilities buy power in more volatile local markets, increasing their market and price risks. This

can be somewhat overcome with power flows from other regions, in this case the northwest US and Canada, and other southwest or Mexican suppliers.

7. Oversight by FERC, when implemented in a light manner and reactive way, made the federal regulator face diminishing returns in regulatory power and strained the policy relationship between federal and state oversights (Estache and Martimort 2005; Joskow 2001). This element has been frequently minimized but plays a critical role in other interconnections (ERCOT follows) and federal oversight reputation. For example, Joskow emphasizes that after FERC's new price mitigation rules were applied to California in mid-December 2000, after four months of wholesale price hikes, the result was to see prices soar to around $400 cents per MWh. With such an effect and price freezes, all utilities in CAISO reached insolvency at the end of 2000.

8. Spot prices do not work well or are insufficient mechanisms when supply is tight and demand is inelastic, so that long-term contracts under competitive conditions are guaranteed. This fact is not totally resolved even nowadays, between CAISO and other sources in the WECC, including Canada and Mexico. In the case of ERCOT, as will be seen, forward and financial securities are part of that market that has been applauded as beneficial to all players.

After the California crisis of 2000-2001, measures were taken that now place CAISO and that market in better position, in addition to its aggressive strategies towards renewable energies. First, the PX was merged into CAISO for the ISO to become an active agent and market balancing authority in day-ahead markets, as well as congestion in order to increase reliability. It also increased its oversight of available capacity obligations, financial transmission rights for clearer transmission planning and for generators to hedge transmission congestion (see Hogan, Rosellon, and Vogelsang 2010). This congestion management is a critical element for reliable energy markets.

Finally, CAISO is now active and final-word regulator in ancillary services and interruptible contracts, mainly after California began implementing its green energy aims.

2.4.3 ERCOT and the Texas Market

The Electric Reliability Council of Texas (ERCOT) is the independent, not-for-profit system operator that administers, by its original design and governance structure, the part of the Texas grid that is not synchronous with the Eastern or Western Interconnections, so that interference by federal oversight, through FERC, is minimized and the system becomes independent and autonomous, although it follows and adheres to FERC's principles called the Standard Market Design (SMD). This includes the following attributes: (a) all transmission access operations under transparent and non-discriminatory rules; (b) congestion management; (c) long-term rescue adequacy; (d) market monitoring and intervention; (e) demand and response management implementation and coordination; (f) ancillary services; and (g) follow "best practice."

ERCOT has existed since 1970 as a reliability council under the standards set by the North American Electric Reliability Council (NERC) to facilitate work by utility producers, non-utilities, and other non-facilities based actors in the industry, as is described above. Its council and board of directors are members of all stakeholder groups. ERCOT, by operating within Texas (not trans-state), falls not under FERC jurisdiction but on the Public Utility Commission of Texas (TPUC) under Texas laws and regulations. In comparison with CAISO, ERCOT has evolved over a longer period where the participation of all sector actors makes this system a compact one. Moreover, part of ERCOT's success, as expressed by its directors and others in the industry interviewed for the research project, is predicated in the representation of interests of all industry agents.

Since 2000, ERCOT's mandate by the PUCT and the Texas Legislature is to develop rules for wholesale prices of electricity (called protocols), unbundle all generation and other, from transmission, where beginning in 2001, ERCOT merged all infrastructure under itself to become the single "control area" or ISO. ERCOT nowadays has to access all generation by utilities, non-utilities, renewables sources, and accommodate all activities of this true unbundled, competitive market.

Through its mandate, ERCOT has built over 8,500 miles of transmission circuits from 1999 to 2010 and approximately 2,300 miles of 345 kV circuits to interconnect areas of high wind in the western part of the state, after mandated by the legislature to include those under the Competitive Renewable Energy Zones or CREZ sent by the PUCT in 2009. With this, Texas became a leading state in renewable generation (ERCOT 2011).

ERCOT separates the market participants as follows: first, there are entities performing the functions of a qualified scheduling entity (QSE) that are involved in the bidding of marketable energy and ancillary services; load serving entities (LSE) that sell at retail to customers when they have the choice option; and resource entities (REs) or transmission/distribution service provider (TDSP). Additionally, there are the competitive retailers or CRs and LSEs that compete to sell electricity to final customers when they have a choice, and the providers of last resort, or POLRs, that are distributors when customers do not have a choice (ERCOT 2011). Power exchange and ERCOT as an ISO jointly perform market clearing at wholesale and retail, somewhat different from CAISO.

The market clearing activities within ERCOT are classified as:

1. Bilateral market in a bid-based pool in day-ahead prices (it is different from pools where demand is considered fixed).

2. Balancing energy market with ERCOT playing a passive role and letting loads and resources to transact with each other and where the ISO oversees the clearing of congestion to keep reliability in the system, nowadays at more than 8,000 nodes (formerly in zones), at different daily hour schedules. Within the balancing market, there are requests by ERCOT of unit-specific bids, out-of-merit energy, reliability-must-run units, and non-spinning reserve energy. All of the above are market-based settlements to maintain the system reliably.

3. Congestion management that includes re-dispatch to relieve transmission congestion, price management at base and peak periods of congestion, allocating of re-dispatch costs, and congestion rent for the ISO.

4. Ancillary services market, to further maintain the system reliable and secure. Each market participant must provide AS based on its historical load, as Baldick and Niu (2005) stress, in scheduled form, such that AS must be offered first by low cost power produced, and then offered in increments from other sources of power that are more expensive.

5. Capacity adequacy, so that participants coordinate to install capacity that involves paying for own activities in each production chain link, additional to a sharing rule of payments for impacted external links (Willems 2000). This activity has proven to liberate the tensions between overproduction in generation and transmission congestion or need to invest in expansion, such that new generation, say from, biomass, or geothermal co-generators share additional transmission investment needs with the transmission providers. Also in capacity adequacy one determined and plans for reserve margins.

6. Generator interconnection policy, such that instead of generators paying upfront for transmission enhancements, new generation pays first for interconnection only, and only if needed, shares costs of upgrading the networks.

7. Market power mitigation. After the 2000-2001 California watershed, and UK experiences with the exercise of market power in its England-Wales area, the PUCT established bid caps of $1,000/MWh for energy, and $1,000/MW per hour of capacity as a way to reduce potential exercise of market power (Bompard et al. 2006).

8. Load response, such that load and demand participants voluntarily opt to reduce consumption or stop the load after price signals, receiving compensation. One such type of load response is interruptible contracts while another is the provision of re-dispatchable energy by other market participants such as QSEs, REs, and POLRs (see Chapter 3 in this report).

ERCOT has been much commended for its observance of a transparent, representative, and open market mechanism and system that keeps its operation distinctively independent from federal oversight. However, as seen in this section, many stakeholders playing a set of complex market activities could make the system difficult to track and evaluate its efficiency and welfare characteristics. One concern is that separated bidding processes between AS, spinning and non-spinning reserves, and load and congestion prices could increase price volatility, reduce hedging capacities by stakeholders, and result in diminished benefits for final consumers (Joskow 2008). Additionally, reliability of services has seen episodes of stress and events that call for increased interconnections and management of them, such as with Mexico's CFE or to the other two connections with Oklahoma and Arkansas (Tierney 2008).

However, Texas' electricity market has evolved from a transition period after 2001 to a fully competitive market in 2008, and beginning in December 2010, a market with disaggregation at more than 8,000 nodes rather than zones. As a result, prices have decreased by more granular load markets, as well as nodal costs became around $31 million cheaper by launching the nodal market in the course of the first 10 months of experimentation, between December 2010 and September 2011, except for the extreme load months. As for spinning reserve costs, nodal ones became more expensive than zonal (Cleary and Dumas presentation November 2011). As for the market design lessons, ERCOT implemented wholesale and retail competition at the same time, differently than many other transitional markets including CAISO, where retail price freezes or rate caps were applied for default customers.

2.5 Conclusion

This analysis presents the nature of utilities (CFE parastatal vertically integrated incumbent and privately held subsidiaries IPPs), and privately invested non-utilities in Mexico overseen by the CRE, and their legal and regulatory needs and requirements as a first exercise. It then compares the size of the Mexican, Californian, and Texas electricity markets, and the different experiences of CAISO and ERCOT as two control centers that maintain access points with Mexico. The complexity of the players and stakeholders gives the analyst an idea of the difficulty in increasing depth of interconnected systems, but at the same time, the analysis also shows that complex markets such as CAISO but most importantly ERCOT in Texas can function as successful stories of a problematic and adjusted California system and a totally de-regulated one in Texas with much potential to include new players (notably renewable sources of energy on one side, and end consumers on the other extreme).

The deep and active participation of REPs, PGCs, QFs, TDSP, LSE, and marketers, in both CAISO and ERCOT nowadays, should instead of scaring policymakers from taking decisive steps toward deregulation, make them aware that transition periods take time but where all stakeholders should participate, as it has been evidenced mainly in the ERCOT success story. And it shows that market design is crucial as well as the detailed planning of all aspects of the restructured market where new rules and practices are included in steps. Finally, both the FERC and NERC authorities are important players along with state ones, as is the case of California; and adherence and even surpassing rules (such as the SMD) by ERCOT along with its own legislative process and state regulator PUCT.

References

Armstrong, M., S. Cowan, and J. Vickers. 1994. *Regulatory Reform: Economic Analysis and British Experience*. Cambridge. The MIT Press.

Badlick, R. and H. Niu. 2005. Lessons Learned: The Texas Experience. In James M. Griffin and Steven L. Puller (eds.). *Electricity Deregulation Choices and Challenges*. Chicago. University of Chicago Press.

Beato, P. and J.J. Laffont (eds.) 2002. *Competition Policy in Regulated Industries: Approaches for Emerging Economies*. Washington, D.C. Inter-American Development Bank.

Bompard, E., Y.C. Ma, R. Napoli, and C.W. Jiang. 2006. Assessing the Market Power Due to the Network Constraints in Competitive Electricity Markets. *Electric Power Systems Research* 76: 953-961.

Borenstein, S. 2000. The Trouble with Electricity Markets: Understanding California's Restructuring Disaster. *Journal of Economic Perspectives* 16(1): 191-211.

Borenstein, S., J.Bushnell, and F. Wolak. 2002. Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market. *American Economic Review* 92(5, December): 1376-1405

Borenstein, S., J. Bushnell, and F. Wolak. 2000. Diagnosing Market Power in California's Deregulated Wholesale Electricity Market. University of California Energy Institute Working Paper *PWP- 064*. August.

Church J. and R. Ware. 2001. *Industrial Organization: A Strategic Approach*. Boston. McGraw Hill.

CRE. 2012. Data on Mexican non-utility permits. Retrieved January 10, 2011, at http://www.cre.gob.mx.

EIA. 2011. Official Energy Statistics from the US Government. Retrieved December 9, 2011, and February 8, 2012, at http://www.eia.doe.gov.

ERCOT. 2011. Long-term Study Interim Report. Retrieved April 8, 2012, at http://www.ercot.com/content/committees/other/lts/keydocs/2011/LONG_TERM_STUDY__INTERIM_REPORT_Volume_1.pdf.

Estache, A., and D. Martimort. 1999. Politics, Transaction Costs, and the Design of Regulatory Institutions. The World Bank Working Paper No. 2073. DOI 10.1596/1813-9450-207.

Gilbert, R., K. Neuhoff, and D. Newbery. 2004. Allocating Transmission to Mitigate Market Power in Electricity Networks. *Rand Journal of Economics* 35(4): 691-709.

Griffin, J. M. and S. L. Puller. 2005. A Primer on Electricity and the Economics of Deregulation. In James M. Griffin and Steven L. Puller (eds.). *Electricity Deregulation Choices and Challenges*. Chicago. University of Chicago Press.

Goodman, R. J. 2010. Power Connections: Canadian Electricity Trade and Foreign Policy. *Canadian International Council Energy Report No. 1*. June. Retrieved September 3, 2011, at http://www.onlinecic.org.

Hogan, W. 2002. Electricity Market Restructuring: Reform of Reforms. *Journal of Regulatory Economics* 21: 103-132.

Hogan, W., J. Rosellón, and I. Vogelsang. 2010. Toward a Combined Merchant-Regulatory Mechanism for Electricity Transmission Expansion. *Journal of Regulatory Economics*. Published online on June 23, 2010, DOI 10.1007/s11149-010-9123-2.

Hunt, S. 2002. *Making Competition Work in Electricity*. New York. Wiley.

Jamasb, T., and M. Pollitt. 2005. Electricity Market Reform in the European Union: Review of Progress Toward Liberalization and Integration. Center for Energy and Environmental Policy Research *WP 05-003.* University of Cambridge.

Joskow P. L. 2005. The Difficult Transition to Competitive Electricity Markets in the United States, in James M. Griffin and Steven L. Puller (eds.). *Electricity Deregulation Choices and Challenges*. Chicago. University of Chicago Press.

Joskow, P. L. 2008. Lessons Learned from Electricity Market Liberalization. *The Energy Journal*. Special Issue. The Future of Electricity: Papers in Honor of David Newbery: 9-42.

Joskow, P. L. 2003. Electricity Sector Restructuring and Competition: Lessons Learned. *Latin American Journal of Economics* 40: 548-558.

Joskow, P. L. 2002. Electricity Sector Restructuring and Competition: A Transaction Cost Perspective. In Eric Brousseau and Jean-Michel Glachant (eds.). *The Economics of Contracts: Theories and Applications*. London. Cambridge University Press.

Joskow, P. L. and E. Kahn. 2002. A Quantitative Analysis of Pricing Behavior in California's Wholesale Electricity Market During Summer 2000. AEI-Brookings Joint Center for Regulatory Studies *Working Paper 01-01*. January.

Ibarra-Yunez, A. 2011. Is There an Integrated Electricity Market in North America? Institutional Challenges in Mexico. In Isidro Moralaes (ed.). *National Solutions to Trans-Border Problems?* Surrey. Ashgate.

Ibarra-Yunez, A. 2008a. Estudio de Campo de los Jugadores Eléctricos Actuales y Formas Contractuales [Field Study of the Present Electricity Players and Contractual Forms], Comisión Federal de Competencia/ OECD Mexico 2008.E.06

Ibarra-Yunez, A. 2008b. Puntos Críticos en el Modelo Eléctrico Mexicano Mixto [Critical Aspects in the Mexican Mixed Electricity Market], Comisión Federal de Competencia/OECD Mexico 2008.E.05.

Laffont, J. J., and D. Martimort. 2005. The Design of Transnational Public Good Mechanisms for Developing Countries. *Journal of Public Economics*. 89: 159-196.

Martínez-Chombo, E. 2010. Fuentes de Sobrecostos y Distorsiones en las Empresas Públicas de México [Sources of Excess Costs and Distortions in Mexican Public Utilities]. *Economía Mexicana Nueva Epoca*. XIX (1): 31-89.

Mas-Colell, A., M.D. Whinston, and J. Green. 1995. *Microeconomic Theory*. New York. Oxford University Press

Secretaría de Energía SENER. 2011. *Prospectiva del Sector Eléctrico 2010- 2025*. Mexico, DF. SENER.

Spiller, P. T., and M. Tommasi. 2005. The Institutions of Regulation: An Application to Public Utilities. *Mimeo*. The World Bank.

Srivastava, A.K., S. Kamalasadan, D. Patel, S. Sankar, and K. S. Al-Olimat. 2011. Electricity Markets: An Overview and Comparative Study. *International Journal of Energy Sector Management* 5(2): 169-200.

Steinhurst, W. 2008. The Electric Industry at a Glance. National Regulatory Research Institute- Synapse Energy Economics. November.

Stern, J., and J. Cubin. 2005. Regulatory Effectiveness: The Impact of Regulation and Regulatory Governance Arrangements on Electricity Industry Outcomes. *World Bank Policy Research.* Working paper No. 3536. March.

Tierney, S. F. 2008. ERCOT Texas's Competitive Power Experience: A View from the Outside Looking in. The Analysis Group Inc. *White Paper*. October.

Vogelsang, I. 2001. Price Regulation for Independent Transmission Companies. *Journal of Regulatory Economics* 20(2): 141-165.

Willems, B. 2000. Cournot Competition in the Electricity Market with Transmission Constraints. Working Paper Series No. 2000-4. Leuven. Katholike Universiteit Leuven.

Wilson, R. 2002. Architecture of Power Markets. *Econometrica* 70 (4, July): 1299-1340.

Wolak, F. A. 2005. Lessons from the California Electricity Crisis. In James M. Griffin and Steven L. Puller (eds.). *Electricity Deregulation Choices and Challenges*. Chicago. University of Chicago Press.

Chapter 3. Electricity Demand Management and Pricing

by Marcus W. Pridgeon and Tim Regal

Abstract

This chapter examines demand management (response) in electricity markets and its potential to significantly change the traditional supply-demand relationship within the electric utility industry. It provides a literary review laying out the current state of demand response programs. Specifically, this chapter examines the current demand management programs of the Electric Reliability Council of Texas (ERCOT) and Mexico's Comisión Federal de Electricidad (CFE), including such items as qualification, contractual terms, compensation, and program participation. Finally, this chapter concludes with a discussion of the value of demand response and any possible impediments it may create should the US and Mexico more robustly connect their respective electric grids.

3.1 Introduction

Demand response is almost universally accepted as a valuable tool of Independent System Operators (ISO) in maintaining the reliability of electric systems. Additionally, it has been viewed as a viable and important component in creating price stability in liberalized markets. Although significant technological (equipment) advances have been made over the past century, the basic physics of electrical generation and supply have remained virtually unchanged. Like other commodities, electricity operates in a "supply and demand" business model. However, as accurately noted by Faria (2011), the unique qualities of electricity differentiate it from other commodities in that a balance between supply and demand must be maintained at all moments, and in the inability to store meaningful quantities of electricity. Because of these unusual characteristics, it would seem logical that the supply side of the equation (electric generators or ISOs) would benefit by influencing the demand side of the equation (consumers).

Although demand management is certainly not a new concept, its application is inconsistent across North American power grids. With advancements made in communication, metering, and control technology, the customer appears to be ready and willing to actively participate as a more sophisticated electrical consumer with the intent of lowering cost. For both traditional and technical reasons, the supply side of the equation seems hesitant to fully embrace active participation by consumers. One reason for this hesitancy is the necessity for grid operators to have the ability, with certainty of control and quantity, to increase supply or lower demand as needed to maintain the constant balance needed in the electric grid (Borenstein 2002).

Although much of the current literature and discussion of demand response programs focus on the residential customer, about 60% of electric consumption in the US comes from commercial and industrial users, according to the US Energy Information

Administration (EIA), while it is 65% for Mexico, according to its CFE incumbent integrated company (CFE 2011). Part of the attention stems from the pace and anticipation of innovation, as the development of new technology offers the potential to reshape the electricity market. The 2012 National Electricity Forum focused almost exclusively on the continued evolution of the electricity market with its theme of “Visualizing the 21st Century Electricity Industry.” Advances in smart metering, micro-grids, self-generation via renewable energy, and storability are all engaging and market-altering potentialities. Even small efficiency gains from residential users can yield, over time, significant contributions to curbing peak load demand to the relief of strained ISOs. In ERCOT, for example, a 0.5% reduction in sales due to efficiency gains, a level currently achieved in some states, would lead to a reduction of approximately 3,000 MW of peak load demand over the course of a decade, according to van Welie (2012).

As impactful as residential demand response could become, the lack of demand management programs for the residential consumer in both the Electric Reliability Council of Texas (ERCOT)[1] and the Comisión Federal de Electricidad (CFE)[2] and the size of the industrial and commercial electricity market relative to the residential market suggests that, in order to capture demand management as it exists today, a study of residential demand management would be premature, narrow, and still largely hypothetical.

For many years, large industrial consumers have played the key role in demand response, primarily through interruptible load contracts. Utilities have used these as “reliability” tools. If the consumer were allowed to fully participate in the market, this historically passive side of the industry may possess the potential to have a significant impact not only on traditionally considered reliability, but also on pricing stability.

In order for customers to become more actively involved, two primary elements need to exist. First, technology has to be employed in order to allow the consumer to see, understand, and control its consumption of electrical energy. This technology currently exists and is being employed by large industrial consumers. For smaller consumers, the revolution in technology is well under way with the development and implementation of smart meters. Many utilities are in the process of installing a successive generation of smart meters, each generation with more capabilities than its predecessor. Technological changes have allowed metering to evolve from time-of-use to real-time, and consumers, with real-time price information, have the ability to alter consumption based on these more dynamic signals. In a world of dynamic pricing, these meters need to not only measure usage in granular time increments, but they also must be able to receive (and possibly act) on real-time (dynamic) pricing data.

The second important element in allowing the consumer to fully participate is a liberalized (deregulated) electric market. Unfortunately, North American electricity

[1] The Electric Reliability Council of Texas (ERCOT) is the Independent System Operator and Balancing Authority for 75% of the land area in Texas and 85% of the state’s electric load.

[2] The Comisión Federal de Electricidad (CFE), founded in 1937, is the state-owned electric utility serving the entire country of Mexico.

markets have been slow to embrace, and at times have even retracted from, liberalization. International electricity markets have led the way in liberalization with mixed results. Although the goals of increased efficiency of both production and consumption have not been fully realized in liberalized electric markets, debate continues regarding the reasons for these shortcomings. One area of consensus is the need for more demand management in the balance of supply and demand (Borenstein 2002).

A liberalized market is one that functionally unbundles its generation and delivery components and in which active competition exist in the supply (generation) portion of the industry. Traditionally, electrical energy pricing has not reflected the true "time period" cost of providing electrical energy (dynamic pricing) and thus provided the consumer little incentive to alter its consumption pattern. In liberalized markets, this impediment has been removed. Competitive markets have produced a number of innovative pricing structures which allow consumers, through their action, to control the cost of their electric purchases.

This chapter specifically examines demand response programs in regions of the United States-Mexico border, and more specifically, programs offered by ERCOT and CFE. The study is divided as follows: after describing the setting in both partner electricity markets, the third part analyzes and critically assess the theoretical approaches to demand (load) management. The fourth part, the basis of the analysis, goes into great detail to study demand response pricing, compliance, and regulation in both markets. Part five concludes and sets fundamental propositions.

3.2 The Setting

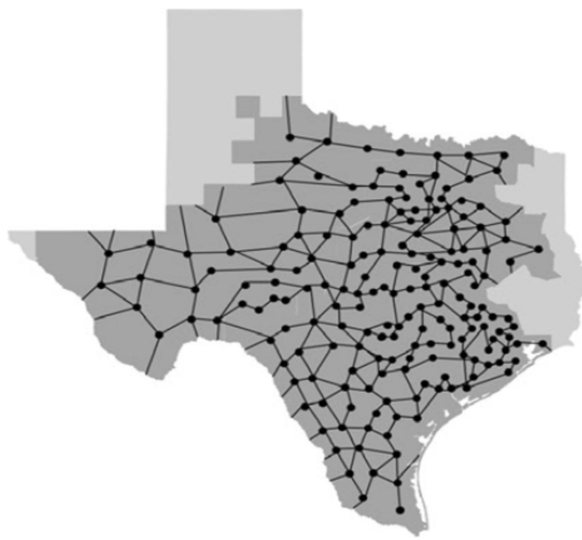
Demand response takes many forms and has been defined in various ways. Both Faria and the United States Department of Energy (DOE) classifies demand response as active consumption changes by end-users based on incentives used to affect both the timing of demand and total use (Faria 2011; Aalami 2010). As noted earlier, residential demand response programs are in their infancy and based more in theory than historical application. Because of this, demand response programs considered in this chapter are those designed to incent (through direct compensation) consumers to alter their consumption patterns to increase system reliability, provide cost stability, or reduce social cost. These existing programs are tailored to commercial and industrial consumers. This is an appropriate focus because as stated earlier, commercial and industrial sales accounted for 60% of total retail sales of 3,899 Terawatt-hours (TWh) in the United States in 2010 (Energy Information Administration 2010). In the case of Mexico, 2010 commercial and industrial sales accounted for 64%[3] of total sales of 186.6 TWh, of which, large industrial sales (Gran Industria) represented 23% of the total sales (CFE 2011).

---

[3] In the CFE Informe Anual 2010, sales to the former Luz y Fuerza were not segregated by rate classification. In determining the CFE's commercial and industrial sales, it was assumed that the rate class distribution of Luz y Fuerza was similar to that of CFE's remaining customer base.

There are multiple US electric Balancing Authorities[4] and Mexican electric regions that line the US-Mexico border. Regarding demand response on the US side of the border, this paper focuses on the ERCOT electric grid. ERCOT was chosen because it is one of three isolated interconnections in the North American Electric Reliability Corporation (NERC)[5] and a single Balancing Authority. Additionally, it is one of the newest, and arguably most advanced, liberalized electric markets in the world. It currently has several active demand response programs. A graphic illustration of ERCOT's service territory is shown below.

Figure 3.1
ERCOT Nodal Market in Texas, 2011



Source: ERCOT (2011).

Although ERCOT currently offers no demand response programs intended to stabilize system cost, there is currently a strong push by consumers for ERCOT to amend its market protocols, which will allow this to occur.

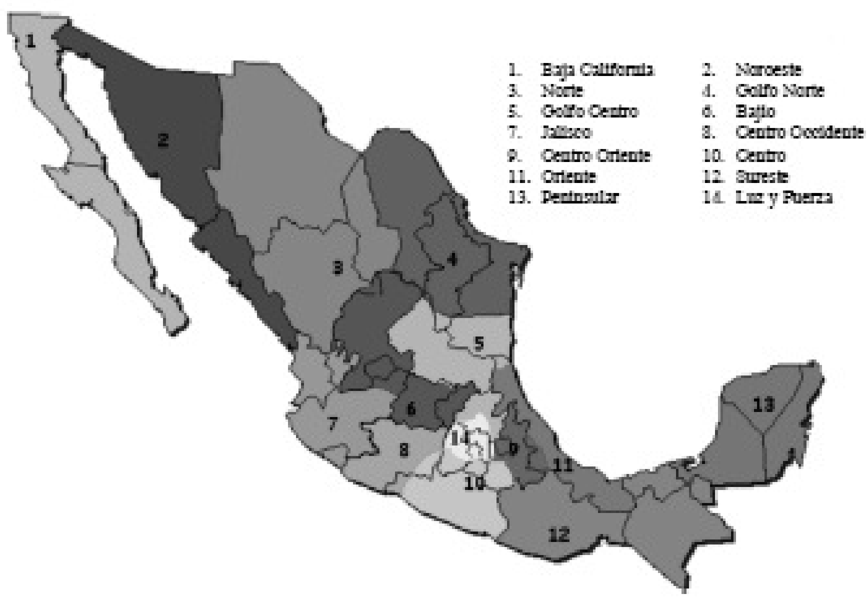
---

[4] Balancing Authority is defined as the responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within the Balancing Authority Area, and supports Interconnection frequency within its area. There are 131 Balancing Authorities in the North American Electric Reliability Corporation.

[5] The North American Electric Reliability Corporation (NERC), certified by the Federal Energy Regulatory Commission, is the organization responsible for ensuring the reliability of the North American bulk power supply system.

On its part, all electric service in Mexico is provided by one parastatal utility, the Comisión Federal de Electricidad or CFE, as is presented above. Consumer classifications, rate structure and rate values are proposed by CFE to the Secretaría de Energía (SENER),[6] which after review forwards them to the Secretaría de Hacienda y Crédito Público (Secretary of the Treasury). The three organizations negotiate any differences with Hacienda having the final say. Hacienda then includes revenue produced by the electric rates in an omnibus budget presented to the Mexican Congress. CFE's rates and rate structure are not cost based, but rather a result of political negotiation. The CFE regions are equivalent to US Balancing Authorities and graphically displayed.

Figure 3.2
Mexico's CFE Zonal Divisions, 2011



Source: Sener (2011), "Propectiva del Sector Eléctrico 2011-2025."

This chapter examines the application of interruptible (demand response) tariffs offered by CFE. As discussed in more detail below, CFE's interruptible program does not limit its deployment to emergency situations. As such, CFE could deploy demand response for economic reasons, but historically has not done so.

[6] The Secretaría de Energía (SENER) was chartered on December 28, 1994, and charged with the authority to lead in the development of Mexico's energy policy.

3.3 Theoretical Framework

Academic literature is almost universal in its view that demand response will have a significant positive effect on both system reliability (its traditional use) and cost stability in liberalized markets. Some studies question, however, the best methods of achieving these end goals and whether demand bidding programs, dynamic tariffs, or a combination of both would be best in a restructured electricity market. Regardless, the great majority of literature enthusiastically acknowledges the potential that demand response possesses.

Demand-side management has traditionally focused on system reliability to the exclusion of cost efficiency, which system operators value highly as a tool to deal with unexpected changes in supply and demand levels (Faria 2011). This focus on reliability has almost solely taken the form of interruptible load contracts, as opposed to time-based rates. According to Cappers (2010), 93% of the peak load reductions from demand response decisions in the US is provided by various types of incentive-based programs. Interruptible load contracts are recognized as a significant reliability tool used by electric grid Independent System Operators. As Fahrioḡlu (2000) states, ISOs can deal with congestion through congestion pricing, quantity rationing, or interruptible load contracts, and when dynamic pricing is lacking, interruptible load contracts work well to relieve congestion concerns. With the right incentives, ISOs can stimulate voluntary participation in demand management programs.

Historically, most interruptible contracts do not distinguish by load characteristic (size, location, ramp rate). As this type of demand response program continues to mature, discussions are surfacing regarding valuing individual loads based on specific characteristics, primarily location. The discussion of locational value of demand response moves away from the traditional view of it being a tool to resolve supply and demand imbalance and into a tool to answer congestion problems. Again, according to Fahrioḡlu (2001), most transmission and distribution problems can be addressed by effective demand management programs. Fahrioḡlu (2000) and Harris (2006) have written extensively about the value of locational demand response, praising its ability to customize interruptible contracts to the particular needs of customers and utilities in diverse settings and situations. In later research where he developed a model to determine the value of demand response by location, he concluded that the value of a contract is related to the location of the customer. Hence a mechanism to incorporate locational attributes is needed. Borenstein (2002) adds to the discussion of locational demand response, but promotes the use of time-based (rate) incentives to address local conditions when system load reductions would fail to resolve the situation. Both Borenstein and Fahrioḡlu agree that letting the market resolve reliability issues is a preferable action, however both acknowledge that there are certain situations where contractual demand response must be available to ISOs, specifically where a serious security constraint occurs (Fahrioḡlu 2000), or where incentives fail to balance supply and demand (Borenstein 2002). Fahrioḡlu's (2001) later work in modeling locational demand response provides clear empirical evidence of its value. He makes it clear that locational contracts should be valued differently considering their ability to provide demand management at high impact locations.

As a reliability tool, the value of demand response is closely tied to a Balancing Authorities' reserve margin.[7] The higher the reserve margin, the less value is assigned to demand response and the lower the reserve margin, the more value is placed on demand response. Demand response can also help system administrators meet reserve requirements and temper the need for additional generation (Borenstein 2002; Fahrioḡlu 2001).

The North American Electric Reliability Corporation notes that planning reserve margins in many regions in North America have significantly increased over 2009 projections due to the economic recession, however several areas such as WECC-Canada and ERCOT will fall below their targeted reserve margins in the foreseeable future (North American Electric Reliability Corporation 2010). The same phenomenon has also occurred to Mexico. The reserve margin in ERCOT is projected to fall below its target of 13.5% by 2012 and as low as 2.15% by 2019, while for Mexico, from a reserve margin that reached even 20% in 2009, the planned reserve margins will be around 13% in 2020 (Electric Reliability Council of Texas 2011; SENER 2011).

Based primarily on reserve margins, demand-side management will have a different value in different parts of North America. As evidence that interest in and the value of demand response fluctuates with electric system needs, whether by increased generation as a result of liberalization or reduce demand as a result of economic downturn, Faria (2011) offers that load management decreased by 32% in the United States between 1996 and 2006 because of weak load management services offered by utilities. He blames the reduction in money spent on load management programs for the decline, citing a 10% reduction in these programs since 1990, and the eradication of the load management programs in 32% of utilities between 1996 and 2004. It is also worth noting, that in a liberalized market, generators have no incentive to promote demand response. Profits are generated by selling electricity and any program that promotes the reduction of consumption contravenes the profit motive. Additionally, scarcity (low reserve margins) drives the cost of power higher, thus increasing the profits of generators. As noted by Loughran (2004), many argue that both wholesale and retail deregulation resulting from the Energy Policy Act of 1992 weakened the incentives to use demand management programs.

As electric markets liberalize, one issue that consumers face is the volatility of real-time (spot market) prices. More emphasis is being paid to the potential for demand response to stabilize spot market prices (Faria 2011). Regarding its importance, a common argument, echoed also by FERC, is that sufficient demand response is necessary to achieve efficient electric market performance (Borenstein 2002). Demand-side bidding has the dual beneficial effect of smoothing price spikes and eradicating market power despite the existence of structural market power (Rassenti 2003).

The fundamental question in incenting consumers to respond to price signals is pricing structure. Just like each electric generator has a unique marginal cost, each consumer has

[7] Reserve Margin is the percentage by which available generating capacity is expected to exceed forecasted peak demand within a Balancing Authority.

a unique financial threshold at which it is willing to reduce consumption. A benefit of an incentive structure, besides enticing participation, is the feedback the pricing structure provides in indicating how consumers truly value electricity, or more precisely, the value of interruptibility (Fahrioḡlu 2000). Unfortunately for ISOs implementing interruptible load programs, the generalized price at which consumers are willing to endure interruption, and thus a baseline for payments in demand-reduction programs, is difficult to pinpoint (Borenstein 2002) .

The primary method of introducing the customer as an active participant in the economics of the market is through dynamic pricing (Postelwait, 2009). As noted by Oren (2001), daily and hourly pricing signals for spot markets are increasing as a result of the electric industries restructuring.

Because of the unpredictability of consumer actions and their effect on the market, some are not comfortable with allowing active consumer participation in electric markets. Penner (2009) surmises that the inevitability of dynamic pricing and real-time consumer response, which would be necessary to reduce peak load, reduce price volatility and increase cost efficiency, is still uncertain. Acknowledging this uncertainly and discomfort, Borenstein believes that dynamic pricing and consumer response would decrease price volatility in wholesale spot markets (Borenstein 2002). Internationally, one of the challenges faced by Great Britain in liberalizing its electricity market was real-time market power exerted by private generators. One reason given for Great Britain's struggle with this issue was its failure to encourage demand participation through interruptible load programs (Rassenti 2003). In a more general sense, Moore (2010) concurs with Rassenti that the failure was not with deregulation itself, but the lack of consumer demand response in reaction to volatile wholesale prices.

Even with the recent advances in technology, the cost of participating in a dynamic market continues to be primarily limited to large industrial users. Penner (2009) addresses the progress made and potential benefits of a continued effort to increase residential demand response to dynamic pricing. Kirschen (2003) discusses some of the obstacles to integrating spot market price sensitivity into demand-side management, chief among them the inability, due to costs and time constraints, of small users (residential and small businesses) to obtain the means of price response mechanisms. Flat or minimally stepped tariffs do not allow for small consumers to signal price sensitivity and initiate active demand response due to the lack of a viable mechanism that allows for such dynamic interaction with price fluctuations and discrepancies (Harris 2006). Even if the cost of technology decreases to a point that small consumers can participate, ISOs are hesitant to allow small consumer participation because of their unpredictability and the idiosyncrasy of consumer behavior. A detailed alternative tariff design study conducted on 1,300 California households concluded that a small portion of households accounted for most of the aggregate demand response (Reiss 2002). Penner (2009) argues that although the emerging technology signals real benefits and progress in creating a more dynamic electricity market through demand response, significant obstacles, perhaps only surmountable over the course of decades, exist.

As can be seen, there is much excitement in electric markets regarding the potential of demand response to become a more significant player in system reliability. Additionally, there is a newfound interest on the part of consumers, primarily because of recent technology developments, to play an active role in their purchase of electricity. However, political, regulatory, economic, and structural barriers remain to be resolved before the full potential of demand response can be realized. The main application to industry and commerce in comparison between ERCOT and the vertically integrated CFE in Mexico, becomes relevant in the following analysis, mainly because of the need for closer price convergence in the foreseeable future, and the importance of industry and commercial development in main border metropolitan areas and interlinked industries of the two trade and investment North American partners.

3.4 Comparison of CFE and ERCOT Demand Response Programs

The overall mindset of CFE and ERCOT, including their views of the value of demand response, are quite different—one being a parastatal organization with a captive customer base while the other is an unbundled competitive market. In CFE's case, the difficulties of system planning are greatly reduced as they control the entire vertical electric utility structure from the generator to the meter and have a captive customer base. This ability to more accurately plan and maintain adequate reserve margins reduce the value of dynamic demand response. Additionally, since the Mexican market is not competitive and lacks any dynamic pricing structure in its retail tariffs, there is no economic incentive for loads to be price responsive. Even with this lack of value placed on demand response, CFE has had for many years two interruptible tariffs.

Conversely, ERCOT, which owns no generation facilities, must rely totally on the market to provide sufficient generation capacity, including an adequate reserve margin. At this writing, one of the major issues facing ERCOT is a dwindling reserve margin. In order to maintain grid reliability over the next several years, ERCOT will be heavily dependent on demand response. Current Emergency Interruptible Load Service (EILS) protocols limits ERCOT's contracts to 1,000 megawatts (MW) with an annual financial cap of $50 million. ERCOT has recently initiated a Texas Public Utility Commission (PUC) rulemaking (PUC Project No. 39948) which would eliminate the 1,000 MW limitation. Participating parties to the rulemaking are further recommending that the PUC eliminate the $50 million financial cap. Both proposals are being made with the intent of expanding participation in the EILS program. The following subsections compare and contrast the interruptible load programs of CFE and ERCOT.

3.4.1 Qualification

CFE's has two interruptible tariffs designated as I-15 and I-30. In order to qualify for tariff I-15, a consumer must have demonstrated a demand of at least 10,000 kilowatts (KW) in either the peak, sub-peak, intermediate, or base period in the three months prior to making application. Additionally, the customer must be able to interrupt its committed load within fifteen minutes of notification. The customer must designate its total load as either firm or interruptible. The interruptible portion must be a minimum of 7,000 KW and a maximum of the average maximum peak during the three months prior to application. All current CFE interruptible customers are served under tariff I-15.

Tariff I-30 is similar to I-15 with the exception that demand demonstration must be at least 20,000 KW and must be interruptible with thirty minutes of notification. The compensation provided by tariff I-30 is considerably less than I-15, most probably because the interruptible notification period is longer. CFE has no customers served under tariff I-30.

Unlike CFE's program which takes the form of rate tariffs, ERCOT's program, because of its competitive market structure, takes the form of a periodic competitive offering process. Retail customers within ERCOT submit competitive offers through a Qualified Scheduling Entity (QSE). The minimum amount of load that may be offered is one megawatt. QSE's may aggregate multiple resources to meet the one MW bid requirement. Such aggregated bids will be considered a single EILS resource. Participants must be able to interrupt their committed load within ten minutes of notification. In the prompt PUC rulemaking noted above, ERCOT is seeking to reduce the minimum offer to 100 KW and to create different class of demand response participation based on differing notification periods.

3.4.2 Term (Contract Period)

With CFE, the interruptible tariffs have a minimum term of one year. If a customer agrees to remain on the tariff for a minimum of three years, its compensation is increased to 1.25 times the standard monthly compensation.

With ERCOT, EILS bids are currently awarded for four month contract periods (February through May, June through September, and October through January). In the rulemaking currently before the PUC, ERCOT is seeking flexibility to create contract terms of differing lengths.

3.4.3 Interruptible Period Categories

CFE designates its consumption categories into three time periods and delineates by weekday/weekend and by season. Baja and Baja Sur categories are different than the remainder of the country. Since no interruptible consumers operate in Baja or Baja Sur, categories for all interruptible consumer areas are defined as follows.

Summer months (defined as the first Sunday in April through the Saturday before the last Sunday in October):

- Monday through Friday:
    - Peak – 8:00 p.m. to 10:00 p.m.
    - Intermediate – 6:00 a.m. to 8:00 p.m. and 10:00 p.m. to midnight
    - Base – midnight to 6:00 a.m.
- Saturday:
    - Intermediate – 6:00 p.m. to 9:00 p.m.
    - Base – midnight to 6:00 p.m. and 9:00 p.m. to midnight

- Sunday:
  - Base – all day

Winter months (defined as the last Sunday in October through the Saturday before the first Sunday in April):

- Monday through Friday:
  - Peak – 6:00 p.m. to 10:00 p.m.
  - Intermediate – 6:00 a.m. to 6:00 p.m. and 10:00 p.m. to midnight
  - Base – midnight to 6:00 a.m.
- Saturday:
  - Intermediate – 6:00 p.m. to 9:00 p.m.
  - Base – midnight to 6:00 p.m. and 9:00 p.m. to midnight
- Sunday:
  - Base – all day

ERCOT defines its contract categories as Business 1, Business 2, Business 3, and Non-Business. It does distinguish between weekdays and weekends, but not seasons. These time periods are defined as:

- Business 1 – 8:00 a.m. to 1:00 p.m., Monday through Friday, except holidays.
- Business 2 – 1:00 p.m. to 4:00 p.m., Monday through Friday, except holidays.
- Business 3 – 4:00 p.m. to 8:00 p.m., Monday through Friday, except holidays.
- Non-Business Hours – All other hours.

3.4.4 Response Time and Limitation on Number of Interruptions

As can be seen in Table 3.1 below, CFE Tariff I-15 participants have 15 minutes to interrupt their committed load once notified by CFE. Participants can only be interrupted once per day, 20 times per year, and any single interruption can last a maximum of six hours.

Table 3.1
CFE Interruptible Tariffs in Comparison to ERCOT

Program	CFE I-15	CFE I-30	ERCOT EILS
Max Time to Interruption	15 minutes	30 minutes	10 minutes
Max Duration / Interruption	6 hours	4 hours	
Max Interruptions / Day	1	1	
Max Interruptions / Year	20	14	
Max Interruptions / Contract Period			2
Max Hrs / Contract Period			8

Sources: Comisión Federal de Electricidad (Tarifas Interrumpibles I-15, 1-30), PowerPoint; Electric Reliability Council of Texas, Emergency Interruptible Load Service, Technical Requirements & Scope of Work, November 20, 2009.

ERCOT EILS participants must interrupt their committed load within ten minutes of being notified. Participants can only be interrupted twice per contract period for a total of eight hours. In the current EILS rulemaking before the PUC, ERCOT is proposing to delete the twice per contract period limitation. Although the new proposed rule continues to contain the eight hour per contract period limitation, it contains a provision that if ERCOT deploys EILS and the grid emergency continues to exist at the expiration of eight hours of deployment, participants must remain deployed until ERCOT lifts the emergency notification.

3.4.5 Demonstration of Compliance

CFE's demonstration of compliance occurs at three different times (immediately before deployment, during deployment, and immediately following deployment) on the day an interruption is deployed.

With ERCOT, retrospectively, through 15 minute load interval data, participants must average the firm plus interruptible committed load for each category during the contract period. By illustration, if during Business Hours 1, a participant declared 10 megawatts of firm load and committed 50 megawatts for interruption, the 15 minute load interval data must average at least 60 megawatts during all Business Hours 1 for the contract period.

3.4.6 Penalty for Non-Compliance

With CFE, if a customer is found out of compliance with any of the three demonstration of compliance standards above, a financial penalty is imposed of six times the monthly compensation. If a second violation occurs within a 12-month period, CFE has the right to suspend service under the interruptible tariff.

With ERCOT, if a QSE fails to meet its obligations under the current protocol, by either failing to demonstrate its committed load during all contract period category hours or fails to meet its load reduction obligations in an EILS deployment event, ERCOT shall withhold all or part of an EILS resource's capacity payment for the contract period and suspend participation in the EILS program for six months.

3.4.7 Limitations on Deployment

CFE may deploy interruptions for any reason, be it emergency, economic, or simply to test the system.

ERCOT may only deploy EILS as part of a defined Emergency Electric Curtailment Plan (EECP) event. EILS may not be deployed for economic reasons.

3.4.8 Participation (Number of Accounts / QSEs)

CFE currently has 18 participating industrial/manufacturing accounts. As can be seen in Table 3.2, energy sales to these participants total 4.3 terawatt-hours which equated to

2.17% of CFE's total energy sales and 10.2% of energy sales to its Large Industrial rate class.

Table 3.2
Mexico's I-15 Contract Distribution by Industry and State 2010

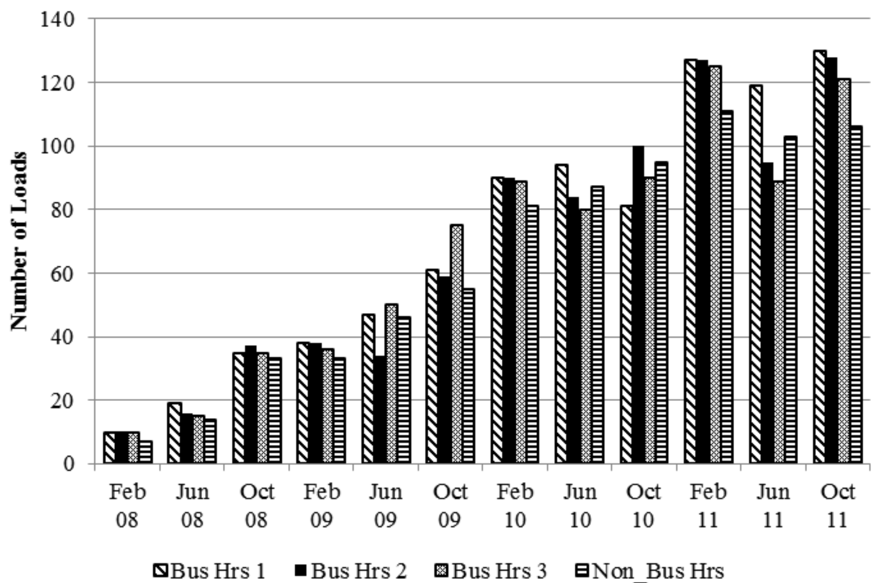
Comisión Federal de Electricidad: I-15 Accounts by State, Industry and Load Factor					
Account	**State**	**Industry**	**Peak KW**	**KWh**	**Load Factor**
1	Nuevo Leon	Paper and Cardboard	11,292	80,362,578	81.24%
2	Coahuila	Steel Manufacturing	77,488	413,002,845	60.84%
3	Colima	Ferrous (Iron) Mining	19,133	137,739,896	82.18%
4	Michoacan	Ferrous (Iron) Mining	14,510	78,159,483	61.49%
5	Colima	Ferrous (Iron) Mining	24,783	141,859,977	65.34%
6	Colima	Steel Manufacturing	17,829	135,583,622	86.81%
7	Morelos	Cement	33,212	213,332,473	73.33%
8	Morelos	Textiles and Threading	15,629	96,888,298	70.77%
9	Veracruz	Basic Chemicals	92,800	604,593,500	74.37%
10	Veracruz	Petrochemical	33,351	188,632,404	64.57%
11	Tabasco	Industrial Gases	18,210	92,969,531	58.28%
12	Estado do Mexico	Chemical Products	16,361	125,903,095	87.85%
13	Guanajuato	Steel Manufacturing	252,295	1,406,080,529	63.62%
14	San Luis Potosi	Cement	30,687	205,289,105	76.37%
15	Puebla	Industrial Gases	16,617	149,082,073	100.00%
16	Jalisco	Petrochemical	13,916	115,569,622	94.80%
17	Jalisco	Electronic Components	12,659	73,920,432	66.66%
18	Jalisco	Plastic Bottles Fabrication	10,003	63,589,568	72.57%
				4,322,559,031	

Source: Comisión Federal de Electricidad (private papers).

Since the inception of ERCOT's program, participating QSEs have increased from approximately 10 in the original contact period to over 120 in the most recent contract period.

The total number of accounts participating peaked in the February-May 2011 contract period at over 900. Participation has fallen by approximately 50% since that time, most probably due to the economic loss suffered by a 28-hour EILS deployment in February 2011.

Figure 3.3
Number of QSE Participants
(Excludes April-May 2011 Special Period)



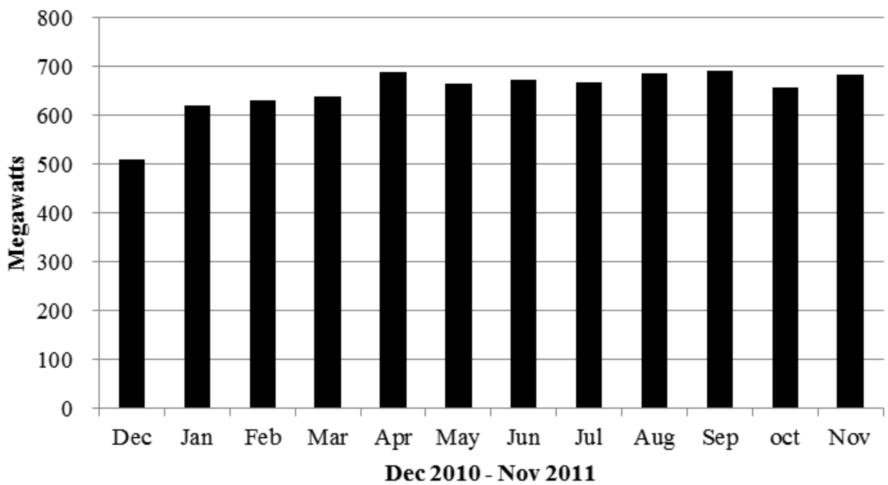
Source: Data from Electric Reliability Council of Texas (EILS Update January 4, 2012).

3.4.9 Load under Tariff / Contract

For the 12-month period ending November 2011, CFE had the following quantities of load designated as interruptible in its three designation periods, as shown in Figure 3.4.

Load participation within ERCOT is somewhat smaller than participation within CFE. However, as shown in Table 3.3, ERCOT's load participations has almost doubled during peak hours from the original offers of 262 MW to over 470 MW during the February through May 2011 contract period. Consistent with the decline in account participation following the February 2011 EILS deployment, load participation in subsequent contract periods has fallen.

Figure 3.4
2011 I-15 Interruptible Load



Source: Comisión Federal de Electricidad (private papers).

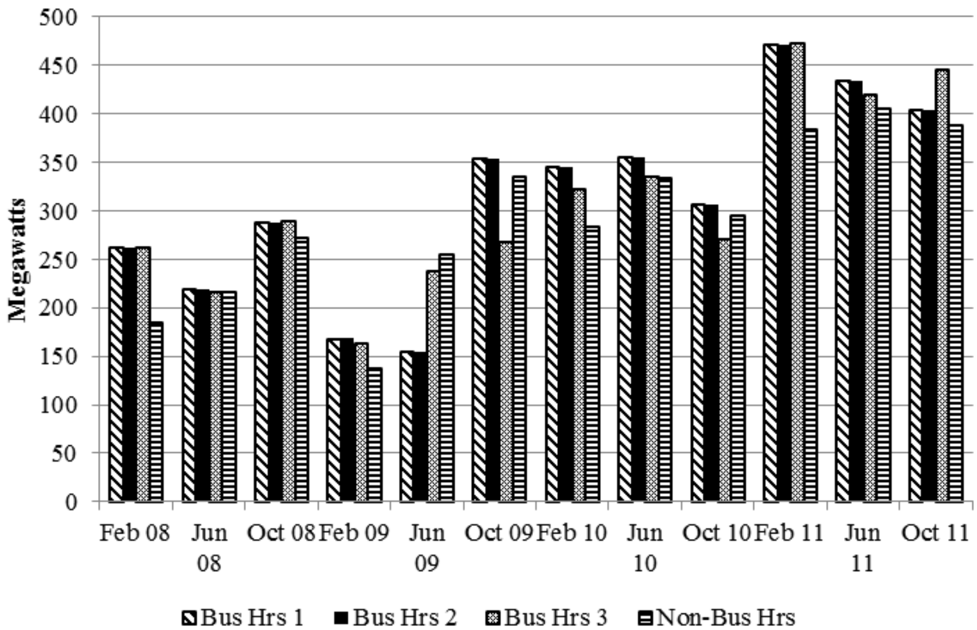
Table 3.3
ERCOT Distribution of Interruptible Contracts

	Megawatts Taken			
	Bus 1	**Bus 2**	**Bus 3**	**N-B Hrs**
Feb 08	262.0	262.0	262.0	185.0
Jun 08	219.0	219.0	216.0	216.0
Oct 08	287.6	287.6	289.5	271.5
Feb 09	168.2	168.2	163.4	137.9
Jun 09	154.7	154.7	237.3	255.6
Oct 09	353.3	353.3	268.0	334.5
Feb 10	345.8	345.8	322.1	283.2
Jun 10	355.8	355.8	335.5	333.2
Oct 10	306.8	306.8	270.1	295.7
Feb 11	470.7	470.7	472.6	384.2
Jun 11	434.1	434.1	420.3	406.0
Oct 11	403.5	403.5	445.3	388.7

Source: Electric Reliability Council of Texas (EILS Update January 4, 2012).

From the data provided above, while the increase of participating QSEs has grown by several hundred percent, the number of megawatts under contract has grown at a much smaller rate. This is most probably explained by the original participants being very large individual accounts, while more recently participating QSEs are aggregators providing much smaller offers in number of megawatts. Graphically, the number of megawatts taken by ERCOT by contract period and category is shown in Figure 3.5.

Figure 3.5
Megawatts Taken
(Excludes April - May 2011 Special Period)



Source: Electric Reliability Council of Texas (EILS Update January 4, 2012).

4.3.10 Compensation

CFE offers two levels of compensation under both Tariff I-15 and Tariff I-30 depending on the voltage level at which the customer receives service. Customers are compensated by a monthly credit on their electric bill. This credit is calculated by a monthly rate times the number of KW designated by the customer as interruptible times the number of hours in the month. The monthly rate is determined by a formula tied primarily to the price of natural gas. A history of the monthly compensation rate of Tariff I-15 for both the voltage levels is shown in Tables 3.4 and 3.5. A graphic representation of the same information is provided in Figure 3.6.

Table 3.4
CFE I-15 Compensation by Tariff Type H-S and H-SL

Tariff I-15 Compensation – Base Tariff H-S or H-SL (US $ / MWh)										
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Jan	$3.00	$3.35	$3.62	$4.40	$5.41	$5.18	$5.76	$5.14	$5.54	$6.08
Feb	3.00	3.26	3.65	4.26	5.32	4.94	5.84	4.85	5.48	6.15
Mar	2.90	3.35	3.68	4.21	5.17	4.89	5.92	4.76	5.68	6.24
Apr	2.92	3.69	3.66	4.10	4.85	4.96	6.14	5.24	5.89	6.44
May	2.99	3.96	3.71	4.22	4.94	5.08	6.28	5.37	5.71	6.54
Jun	3.01	3.86	3.88	4.39	4.99	5.19	6.45	5.25	5.70	6.48
Jul	3.12	3.71	3.97	4.57	5.35	5.37	6.61	5.19	5.69	6.52
Aug	3.25	3.45	4.10	4.72	5.51	5.40	6.78	5.33	5.74	6.28
Sep	3.18	3.44	4.15	4.71	5.40	5.49	6.57	5.19	5.69	5.92
Oct	3.22	3.45	4.12	4.78	5.41	5.65	5.58	5.27	5.88	5.74
Nov	3.33	3.54	4.07	5.02	5.30	5.69	5.34	5.40	5.97	5.77
Dec	3.44	3.49	4.28	5.36	5.31	5.78	5.34	5.51	5.95	5.80

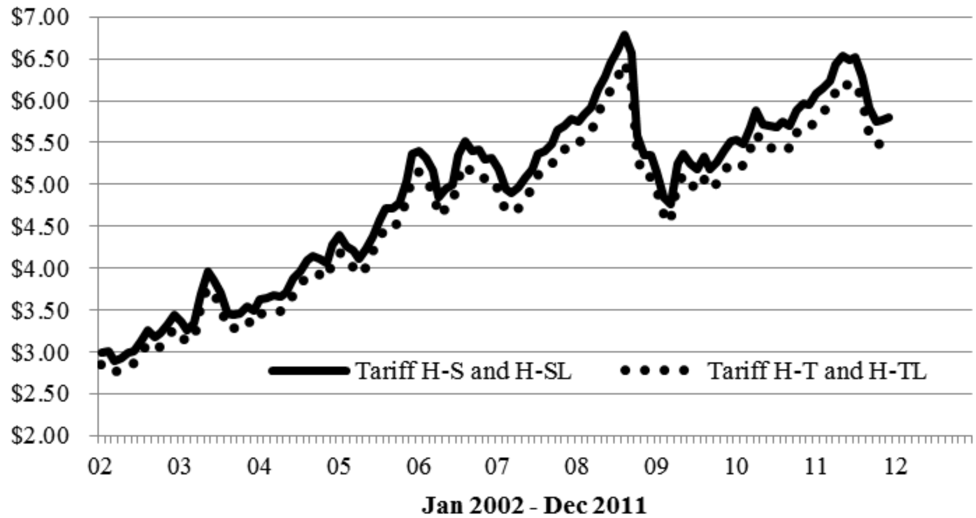
Source: Comisión Federal de Electricidad, at http://app.cfe.gob.mx/Aplicaciones/CCFE/Tarifas/ Tarifas/ Tarifas.asp?Tarifa=I15&Anio=2012&mes=1.

Table 3.5
CFE I-15 Compensation by Tariff Type H-T and H-TL

Tariff I-15 Compensation – Base Tariff H-T or H-TL (US $ / MWh)										
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Jan	$2.86	$3.19	$3.45	$4.19	$5.15	$4.93	$5.48	$4.90	$5.27	$5.79
Feb	2.86	3.11	3.48	4.06	5.07	4.71	5.56	4.62	5.22	5.86
Mar	2.76	3.19	3.51	4.01	4.92	4.66	5.64	4.54	5.41	5.94
Apr	2.78	3.52	3.49	3.91	4.62	4.72	5.84	4.99	5.61	6.13
May	2.85	3.78	3.54	4.02	4.70	4.84	5.99	5.12	5.44	6.23
Jun	2.87	3.68	3.70	4.18	4.75	4.94	6.15	5.00	5.43	6.17
Jul	2.97	3.54	3.78	4.36	5.09	5.11	6.29	4.94	5.42	6.21
Aug	3.10	3.29	3.91	4.50	5.25	5.14	6.46	5.08	5.47	5.98
Sep	3.03	3.28	3.95	4.49	5.14	5.23	6.26	4.94	5.42	5.64
Oct	3.07	3.29	3.92	4.56	5.15	5.38	5.31	5.02	5.60	5.47
Nov	3.17	3.38	3.88	4.79	5.05	5.42	5.09	5.14	5.68	5.50
Dec	3.28	3.32	4.08	5.11	5.06	5.51	5.09	5.25	5.67	5.52

Source: Comisión Federal de Electricidad, at http://app.cfe.gob.mx/Aplicaciones/CCFE/Tarifas/ Tarifas/ Tarifas.asp?Tarifa=I15&Anio=2012&mes=1.

Figure 3.6
Tariff I-15 Compensation



Source: Comisión Federal de Electricidad, at http://app.cfe.gob.mx/Aplicaciones /CCFE/Tarifas/ Tarifas/Tarifas.asp?Tarifa=I15&Anio=2012&mes=1.

ERCOT customers are compensated for each offer accepted on an as-bid basis ($ offer x committed load x hours) for each interruptible contract period category. Individual offers are not made public by ERCOT, but ERCOT does release the total megawatts taken (accepted) and the total dollars paid. From this an average per megawatt-hour (MWh) taken can be determined. A history of the average monthly offers taken by ERCOT is shown in Table 3.6.

Table 3.6
ERCOT Average Tariff Offers

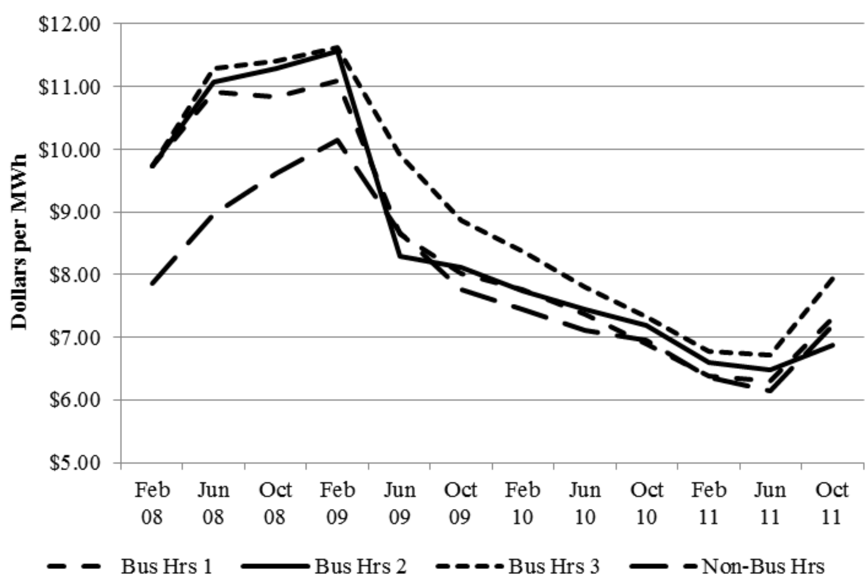
	Business Hours 1					Business Hours 2			
	2008	**2009**	**2010**	**2011**		**2008**	**2009**	**2010**	**2011**
Jan		$10.83	$8.02	$6.90			$11.28	$8.12	$7.19
Feb	$9.73	11.10	7.76	6.39		$9.73	11.56	7.75	6.60
Mar	9.73	11.10	7.76	6.39		9.73	11.56	7.75	6.60
Apr	9.73	11.10	7.76	12.80		9.73	11.56	7.75	13.08
May	9.73	11.10	7.76	12.80		9.73	11.56	7.75	13.08
Jun	10.92	8.64	7.37	6.30		11.07	8.29	7.44	6.47
Jul	10.92	8.64	7.37	6.30		11.07	8.29	7.44	6.47
Aug	10.92	8.64	7.37	6.30		11.07	8.29	7.44	6.47
Sep	10.92	8.64	7.37	6.30		11.07	8.29	7.44	6.47
Oct	10.83	8.02	6.90	7.31		11.28	8.12	7.19	6.87
Nov	10.83	8.02	6.90	7.31		11.28	8.12	7.19	6.87
Dec	10.83	8.02	6.90	7.31		11.28	8.12	7.19	6.87

	Business Hours 3					Non-Business Hours			
	2008	**2009**	**2010**	**2011**		**2008**	**2009**	**2010**	**2011**
Jan		$11.40	$8.87	$7.33			$9.61	$7.77	$6.96
Feb	$9.73	11.62	8.38	6.78		$7.86	10.15	7.44	6.37
Mar	9.73	11.62	8.38	6.78		7.86	10.15	7.44	6.37
Apr	9.73	11.62	8.38	13.58		7.86	10.15	7.44	12.57
May	9.73	11.62	8.38	13.58		7.86	10.15	7.44	12.57
Jun	11.29	9.90	7.81	6.72		8.97	8.66	7.12	6.14
Jul	11.29	9.90	7.81	6.72		8.97	8.66	7.12	6.14
Aug	11.29	9.90	7.81	6.72		8.97	8.66	7.12	6.14
Sep	11.29	9.90	7.81	6.72		8.97	8.66	7.12	6.14
Oct	11.40	8.87	7.33	7.93		9.61	7.77	6.96	7.18
Nov	11.40	8.87	7.33	7.93		9.61	7.77	6.96	7.18
Dec	11.40	8.87	7.33	7.93		9.61	7.77	6.96	7.18

Source: Electric Reliability Council of Texas (EILS Update January 4, 2012).

As can be seen in Table 3.6, one offer must be submitted for the entire contract period (trimester) for each category, thus the accepted offers hold for the entire four-month period. The exception to this was a special offer period for April through May 2011 resulting from the depletion of EILS commitments during a February 2011 EIS deployment. Graphically, the average price paid per megawatt-hour by contract period and contract period category is shown in Figure 3.7.

Figure 3.7
Average Price Paid per Megawatt
(Excludes April - May 2011 Special Period)



Source: Electric Reliability council of Texas (EILS Update January 4, 2012).

3.4 Cost of Program

Table 3.7 shows the total cost to CFE in interruptible credits was $48,327,838 (US dollars) for the 12 months ending November 2011. On average, CFE credited its participating customers $8.227 per MWh for making its load commitment available for interruption. No additional cost was incurred by CFE when an interruption was deployed.

Table 3.7
Comparison of Costs for CFE and ERCOT

	Comisión Federal de Electricidad					Electric Reliability Council of Texas			
	Int Cr $	**MW**	**Hours**	**$/MWh**		**EILS Pmt**	**MW**	**Hours**	**$/MWh**
Dec 10	$3,030,283	523.5	744	$7.780		$1,488,226	295.1	744	$6.778
Jan 11	3,763,711	637.8	744	7.931		1,488,226	295.1	744	6.778
Feb 11	3,888,157	650.7	672	8.892		2,203,682	427.8	672	7.665
Mar 11	3,997,380	658.9	744	8.154		2,203,682	427.8	744	6.924
Apr 11	4,437,222	709.2	720	8.690		2,203,682	427.8	720	7.154
May 11	4,358,567	686.5	744	8.534		2,203,682	427.8	744	6.924
Jun 11	4,362,899	693.0	720	8.744		1,938,057	406.4	720	6.623
Jul 11	4,364,850	688.9	744	8.516		1,938,057	406.4	744	6.410
Aug 11	4,306,320	705.8	744	8.200		1,938,057	406.4	744	6.410
Sep 11	4,090,155	710.5	720	7.995		1,938,057	406.4	720	6.623
Oct 11	3,777,759	677.5	744	7.495		2,182,909	403.1	744	7.279
Nov 11	3,950,545	704.6	720	7.787		2,182,909	403.1	720	7.521
	$48,327,848			$8.227		$23,909,227			$6.924

Sources: Comisión Federal de Electricidad (private papers); Electric Reliability Council of Texas (EILS Update January 4, 2012).

As can be seen from Table 3.7 above, ERCOT made EILS payment to its participating customers in the amount of $23,909,227 for the 12 months ending November 2011. The actual payments were somewhat less based on the individual customer's availability adjustment as noted on Table 3.8. On average, ERCOT accepted offers from participating customers at an offer price of $6.924 per MWh for making their load commitment available for interruption. No additional cost was incurred by ERCOT when an interruption was deployed.

CFE currently has a reserve margin of approximately 22% and as such does not place a significant amount of value in demand response. Conversely, ERCOT is projected to fall below its reserve margin target of 13.5% in the near future and is currently seeking regulatory approval to significantly increase its demand response program. Based on this, convention would follow that CFE would compensate interruptible participants less and have less load under tariff. In fact, the opposite is true. The most probably reason for this phenomenon is the maturity of the two programs. CFE has had interruptible tariffs for several decades. The ERCOT EILS program has only been in existence since 2008. Additionally, the fact that the CFE compensation is formulaic and ERCOT's compensation is determined by competitive offer most certainly plays a part in the difference in compensation levels.

From the inception of the program, ERCOT has taken offers totaling $83,890,558. After availability adjustment totaling $6,114,740, the total cost of the EILS program to ERCOT has been $77,775,818.

Table 3.8
EILS cost to ERCOT

Bus 1	Bus 2	Bus 3	N-B Hrs	Total
$1,070,689	$642,414	$856,551	$2,756,974	$5,326,628
1,438,710	618,204	829,138	3,696,788	6,582,840
1,173,106	778,591	1,056,096	5,197,357	8,205,149
762,703	489,987	637,966	2,620,210	4,510,866
1,026,881	330,875	808,149	4,196,788	6,362,694
1,186,711	705,724	779,708	4,927,827	7,599,971
1,140,394	675,347	906,931	3,944,319	6,666,991
1,301,549	682,965	901,368	4,498,040	7,383,922
720,743	549,267	657,305	4,025,589	5,952,903
1,443,399	887,390	1,237,264	5,246,677	8,814,730
1,329,577	724,626	971,599	4,726,425	7,752,227
1,399,046	681,923	1,158,243	5,492,424	8,731,637
				$83,890,558
		Availability Adjustment		(6,114,740)
				$77,775,818

Source: Electric Reliability Council of Texas (EILS Update January 4, 2012).

3.5 Other Considerations in Demand Response for Electric Supply Chain

Encountering such large sums paid out to participants in both ERCOT's and CFE's interruptible load program, questions of efficiency and effectiveness lead to a consideration of alternative methods of controlling demand. Efficiency standards have been increased and incentive programs have been implemented throughout the United States, and their effects on slowing the growth of, if not reducing, peak load requirements are important to the future of electricity reliability. Self-generation and micro-grids, storage, and smart meters offer equally promising prospects to stem consumer demand. Still in their infancy in conceptualization or adoption, these new technologies will play a still-undetermined role in the future of demand response programs.

Despite their promise for the future, two conditions prevent energy efficiency and the technologies previously mentioned from standing alongside interruptible load programs in the study of effective demand management. First, the uncertainty over the structure of their implementation and their integration into the whole of the electricity industry prevents any real analysis that isn't burdened by conjecture, and thus an unreliable foundation on which ISOs could build executable programs. Second, although costly and at present providing only about 700 MW for CFE and 400 MW for ERCOT, an interruptible load program's value lies in its controllability. As demonstrated by ERCOT's restriction of use to weather emergencies, the priority for ISOs is to control demand when circumstance requires load reduction to sustain the system. Even if ERCOT adjusts its program to match CFE and allows for interruption due to need beyond weather events, the fact that interruptible load programs grant ISOs the power of active demand management make those programs nearly invaluable. Although the reduction to peak needs that new technologies will provide would be embraced by ISOs, their value to demand management, to the true situational needs of system operators, would be limited by their ability to allow for responsive control. Without that control, ISOs are passive players in demand management, and system reliability becomes increasing vulnerable.

3.6 Conclusions

Both CFE and ERCOT have considerable history with demand response programs. The value placed on demand response by the two organizations is significantly different, primarily based on the market structure of each. Although CFE places a lower value on demand response, it has traditionally paid a higher price for having load under control. This may be explained based on CFE's ability to interrupt load for a much broader range of reasons, including economic reasons. It is probably also explained by CFE's compensation rate being formulaic and tied to independent variables.

ERCOT's dwindling reserve margin and its need to maintain grid reliability makes demand response a valuable program. ERCOT is current in the process of seeking greater flexibility from the PUC in order to bring more interruptible load under contract.

The deployment of demand response frees up electric generation to serve more critical needs during times of generation scarcity caused by weather or equipment failure. Like real estate, the "location" of demand response creates much of its value. Demand response loads in western Mexico (Jalisco and Michoacán) would provide very little, if any, grid support to ERCOT because of their remote proximity to the border. Similarly, demand response load in north Texas would be of little assistance to CFE.

Although very little demand response load is currently under tariff in northern Mexico, it does not mean potential participants do not exist. Because of its current generation reserve margin and robust transmission system in northern Mexico, CFE has not promoted its demand response tariffs very much. This may well provide an untapped demand response procurement market for ERCOT if CFE and ERCOT were electrically connected in a more robust fashion. Having CFE demand response capabilities available may well assist ERCOT in the event of equipment failure, however weather-related events will probably tax both grids at the same time, as was the case in February 2011. Although CFE and ERCOT acquire, compensate, and regulate their demand response programs differently, there are no insurmountable barriers in either of their programs that would hinder a greater integration of the two electric grids, and in fact, opportunities may well exist primarily for ERCOT.

References

Aalami, H.A., M. Parsa Modhaddam, and G.R.Yousefi. 2010. Modeling and prioritizing demand response programs in power markets. *Electric Power Systems Research* 80: 426-435.

Borenstein, S., M. Jaske, and A. Rosenfeld. 2002. *Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets.* University of California, Berkeley, University of California Energy Institute, Center for the Study of Energy Markets.

Cappers, P., C. Goldman, and D. Kathan. 2010. Demand response in U.S. electric markets: Empirical evidence. *Energy* 35: 1526-1535.

Comisión Federal de Electricidad. 2010. Informe Anual 2010, Table 3.3.1, 34.

Electric Reliability Council of Texas. 2011. *Report on Capacity, Demand, and Reserves in the ERCOT Region.*

Fahrioglu, M., and F.L. Alvarado. 2000. Designing incentive compatible contracts for effective demand management. *IEE Transactions on Power Systems* 15(4): 1255-1260.

Fahrioḡlu, M. & F.L. Alvarado. 2001. Using utility information to calibrate customer demand management behavior models. *IEE Transactions on Power Systems* 16 (2): 317-322.

Faria, P., and Z. Vale. 2011. Demand response in electrical energy supply: An optimal real time pricing approach. *Energy* 33:5374-5384.

Harris, C. 2006. *Electric Markets: Pricing, Structure, and Economics.* John Wiley & Sons.

Kirschen, D.S. 2003. Demand-side views of electricity markets. *IEEE Transactions on Power Systems* 18(2): 520-527.

Loughran, D.S., and J. Kulick. 2004. Demand-side management and energy efficiency in the United States. *The Energy Journal* 25(1): 19-43.

Moore, J., C.K. Woo, B. Horii, S. Price, A. Olson. 2010. Estimating the option value of a non-firm electric tariff. *Energy* 35: 1609-1614.

North American Electric Reliability Corporation. 2010. *2010 Long-term Reliability Assessment*.

Oren, S.S. 2001. Integrating real and financial options in demand-side electricity contracts. *Decision Support Systems* 30(3): 279-288.

Fox-Penner, P. 2009. *Smart Power: Climate Change, the Smart Grid and the Future of Electricity Utilities*. Island Press, Washington, D.C.

Postelwait. J. 2009. Dynamic pricing and customer behavior. *Powergrid International*. Penn Well Publishing Co., pp. 38-40.

Rassenti, S.J., V.L. Smith, and B.J. Wilson. 2003. Controlling market power and price spikes in electricity networks: Demand-side bidding. *PNAS* 100(5): 2998-3003.

Reiss, P.C., and M.W. White. 2002. Household electricity demand, revisited. *Review of Economic Studies* 72: 853-883.

US Energy Information Administration. 2010. Electric power annual 2010. Retrieved March 6, 2012, at http://www.eia.gov/electricity/annual/.

Van Welie, G. 2012. Getting Serious about Energy Efficiency, Demand Response, Distributed Generation, and Micro-Grids for the 21st Century Electricity System. *2012 National Electricity Forum: Visualizing the 21st Century Electricity Industry*. Renaissance Hotel, Washington, DC. February 9, 2012.

Chapter 4. Consumers and Electricity-Use Trends in the US-Mexico Border Region

by Daniel Noll and Bradley Smith

Abstract

Growth in energy demand and generating capacity is outpacing growth in the transmission and distribution system—a situation that poses real challenges on both sides of the United States-Mexico border. The six Mexican states and four US states that comprise the border region face similar energy issues and constraints to each country as a whole. Decreasing reserve margins and peak demand trends suggest the need to add generating and transmission capacity in both countries—a concern that can potentially be mitigated by increases in electricity trade and power sharing. Electricity grid interconnection can reduce domestic supply concerns and enhance overall grid reliability in addition to yielding environmental benefits through the promotion of renewable source generation. No entity has conducted a study of the entire US-Mexico border region as a single geographic region on the topic of energy use. As a result, this chapter seeks to compile relevant data from various studies to provide a holistic view of the main trends and indicators of importance in the border region. Additionally, it analyzes recent developments in the consumption and demand for electricity in the United States-Mexico border region and its impacts for a North American integration scenario—specifically, within the border states of California, New Mexico, Arizona, Texas, Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas. This analysis finds that an optimized, integrated grid would increase overall grid reliability and induce capital investment in generation and transmission capacity.

4.1 Introduction

Economists widely recognize a positive relationship between electricity consumption and economic growth, as the use of electrical power is ubiquitous in almost every industrial, commercial, and residential activity. As such, statistics on the quantity of electricity being produced and the functions for which it is consumed provide valuable information on the activities in which an economy engages. This information can provide insight into how an economy functions, what industries underlie a state or region's relative strengths or weaknesses, what sectors are experiencing growth (or contraction) over time, and most important to policymakers, where investments must be made to support continued prosperity. This chapter analyzes recent developments in the consumption of and demand for electricity in the US-Mexico border region and its impacts for a North American integration scenario—specifically, within the border states of California, New Mexico, Arizona, Texas, Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas.

A regional analysis of electricity use in the states along the United States-Mexico border is particularly valuable for three reasons. First, the US-Mexico border region contains many high output centers of economic activity. The states of California and Texas rank first and second nationally in total population and economic output. When their output is combined with that of New Mexico and Arizona, these four border states represent 24% of the United States' 2010 Gross Domestic Product (EIA 2011). Similarly the border states of Mexico, while representing a smaller fraction of total population, account for an equally large percentage of total GDP. Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas all rank in the top 11 (out of 31) in terms of economic output, accounting for a combined total just under 22% of Mexico's national GDP in 2010 (INEGI 2010). For businesses involved in manufacturing and other energy-intensive industrial activities, the price of energy inputs is an important factor in the cost of doing business. This creates a strong regional incentive for any policy that might lower electricity prices and provide supply security—two potential benefits of market integration.

Additionally, states in the border region are expected to grow significantly over the next 20 years. According to the US Bureau of the Census, between 2010 and 2030 the populations of Arizona, California, New Mexico, and Texas will grow by 108.8%, 37.1%, 15.4%, and 59.8% respectively. With the exception of New Mexico, all three other states will outpace the national average of 29.2%. Similarly, growth in the Mexican border states is also forecasted to outpace the national average. The population of Baja California, in particular, grew by 39.77% over the past decade and is predicted to continue to grow by 2.31% annually through 2025—almost four times the Mexican national average (CONAPO 2010). This growth has been largely a result of a strong export-oriented manufacturing (maquiladora) base that has thrived since the 1960s and increased its rate of growth after the creation of the North American Free Trade Agreement (NAFTA) in 1994.

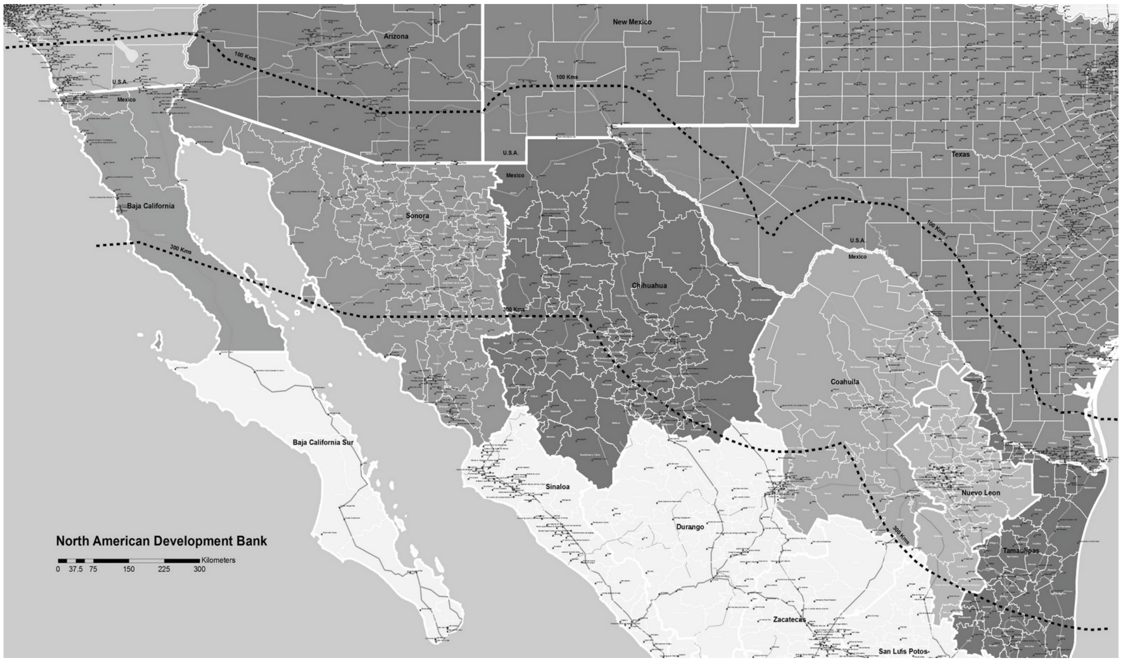
Rapid growth in demand creates significant investment costs and challenges for local and regional power delivery systems that, at least theoretically, can possibly be offset or mitigated through integration. Hughes (1983) notes that as power systems expand out from their urban cores, interconnections among neighboring systems become increasingly common—allowing utilities to form power pools, trade electricity, and share capacity reserves. For regulators and industry stakeholders concerned with maintaining a stable and adequate supply of energy, it is vital that future changes in consumption patterns be forecasted accurately for the requisite planning of capacity additions to occur in a timely fashion. This is especially true when planning structural changes to the power sector (such as in the case of movement towards power system integration) wherein the relative growth and/or size of neighboring markets has substantial bearing on the issues, costs, and distribution of benefits such change may bring. Differences in market structure, natural resource endowment, population growth, or price may affect the allocation of benefits (and therefore justification in allocation of costs) involved in integration.

Third, despite vast differences in market and regulatory structures, the energy sectors of the US-Mexico border region are highly interdependent. Traditionally, this interdependence focused solely on the transport of oil and natural gas. Mexico has long been one of the top three sources of US oil imports, while the gap between Mexican natural gas production and consumption continues to be filled primarily with US imports. Further evidence of this growing interdependence is shown in the increasing number of cross-border pipelines and power lines that have multiplied in recent decades. Between 1990 and 2000 the exchange of oil and electricity in North America both doubled and has since continued to increase (Dukert 2003). At the same time, the natural gas and electricity industries themselves have converged—through mergers, acquisitions, and joint ventures—to create an integrated industry in which low-cost natural gas is the predominant fuel source for new electricity generation facilities. Gradually, the separation of production and delivery systems (in Canada and the United States) has also induced participation by energy marketers active in the trade of energy commodities, according to regional variations in supply, demand, and price. Though a wide range of legal, political, and technical barriers remain, this evidence suggests that the process for North American power sector integration is already irreversibly underway.

Although this chapter focuses on the US-Mexico border region, today's energy systems are integrated over much larger geographic areas. Moreover, the term "border region" has no consistent definition. In 1983, the La Paz Agreement between Mexico and the United States defined the border region as a non-maritime geographic zone extending 100 kilometers (63 miles) on either side of the international boundary (EPA 2012). However, other entities such as the North American Development Bank use an expanded definition of 100 miles into the US land and 300 Km (189 miles) into the Mexican territory for investment purposes (see Figure 4.1).

Energy systems involve complex networks that combine generating units with transmission and distribution services over thousands of miles, and these linkages to larger geographic regions have important consequences for the local provision of electricity. Therefore, this analysis is organized as follows: first, relevant literature is presented on consumption and demand trends within the study region in addition to theoretical contributions to the study of regional electricity market integration. Following that are sections on the structure of the United States and Mexican electricity markets, NAFTA and electricity trade, and recent trends in national energy markets. The remainder of the chapter evaluates the US-Mexico border region and highlights key trends in electricity consumption at the state level. Particular emphasis is placed on the demand characteristics and potential for integration in California and Texas—the two largest energy-consuming states and largest economies in the region.

Figure 4.1
Border Environment Cooperation Commission Border Map



Source: North American Development Bank, retrieved April 5, 2012, at http://www.nadb.org/about/eligibility.asp.

4.2 Review of Available Literature

Supply and demand of electricity, as an essential commodity and public good, are monitored extensively by state and national government agencies, market regulators, financial institutions, and academia. The majority of studies on regional power system integration are descriptive, as opposed to analytic, and focus on characterizing the nature of demand and the implications of its forecasted growth. Several sources for useful data relevant to the subject of this chapter include, but are not limited to, the US Energy Information Administration (EIA), the Electricity Reliability Council of Texas (ERCOT), the North American Electricity Reliability Council (NERC), the California Energy Commission (CEC), the Environmental Protection Agency (EPA), Cambridge Energy Research Associates (CERA), the Center for Energy Studies at San Diego State University, the International Atomic Energy Agency (IAEA), Comisión Federal de Electricidad (CFE), Comisión Reguladora de (CRE), Secretaría de Comunicaciones y Transportes (SCT), Secretaría de Energía (SENER), Secretaría de Medio Ambiente y Recursos Naturales (Semarnat), and other private research centers such as the Electric Power Research Institute (EPRI) in Palo Alto.

The large number of stakeholders in turn gives rise to many studies on the subject that differ in terms of the geographic area included, the historical years analyzed, the future years for which values are predicted, and even which specific indicators are calculated and by what methodology their values are determined. No known entity has conducted a study of the entire US-Mexico border region as a single geographic region on the topic of energy use. As a result, this chapter seeks to compile relevant data from various studies to provide a holistic view of the main trends and indicators of importance in the border region. Forecasts of future energy use are determined through a number of different methodologies that include variables such as economic growth, population growth, weather patterns, new construction of commercial and residential buildings, the impact of energy efficiency and demand-management programs, etc. Many large studies—a such as the Energy Information Administration's *Annual Energy Outlook*, the Mexican Ministry of Energy's *Electricity Sector Outlook*, and California Energy Commission's *Energy Demand Forecast*—take into consideration most, if not all, of these indicators. However, others target a narrower area of interest, such as anticipated demand for renewable energy (Bird et al. 2009) or expected increases in household demand (Rosas-Flores et al. 2011).

Generally speaking, national and statewide analyses tend to focus on broad characteristics(such as population trends and economic outlook, while regional analyses can take a more detail-oriented approach. The San Diego Regional Energy Infrastructure Study (2002), for example, acknowledges increased construction of "larger homes" and "homes that are inland, which require air-conditioning." While this chapter targets a well-defined region, this region is nonetheless large, spanning the borders of four US and six Mexican states. As such, the analysis in this chapter seeks to strike a balance between the two approaches, accommodating both the granularity befitting a targeted study and the wide-angle view appropriate to the region's geographic and cultural complexities. For this chapter, the most important drivers of electricity demand considered are population size and growth, economic performance, and the industries in which an economy is active.

More broadly, the literature on the potential for and implications of regional and transnational electricity system integration can broadly be divided into three main theoretical contributions: (1) literature discussing the impetus behind and barriers to system integration, including technical, political, and economic considerations; (2) literature evaluating the output measures of integration schemes, including developments in physical infrastructure, market mechanisms, and institutional frameworks to accommodate integration; and (3) literature focused on factors influencing an integration process. These include both studies of specific integration initiatives and strategies as well as methodological and theoretical studies pertaining to the technical, legal, economic, political, and organizational aspects of integration. In this context, changes in consumer behavior can become an economic, political, or technical barrier (or rationale) to impede (or catalyze) momentum towards market integration.

The existing and planned interconnections around the world from which empirical evidence has been gathered include Europe's integrated markets (i.e. UCTE, NORD POOL), the Commonwealth of Independent States (CIS, countries of the former Soviet Union), Central America (SIEPAC), Africa's integration efforts (Southern African Power Pool), and Southeast Asia's Greater Mekong Subregion initiative. In 2010, Economic Consulting Associates produced the report "Regional Power Sector Integration" that contains a comprehensive review of the available literature and case studies of the integration experience in the aforementioned regions. What follows are additional contributions relevant to the scope of this study.

A comprehensive assessment of the benefits of regional power system integration is offered by UN-DESA (2005). It finds that although integration is generally welfare enhancing, the distribution of social benefits (and costs) can vary between countries and groups within countries. This analysis extends to the distribution of environmental costs and benefits, and the report concludes with an acknowledgement of the political costs and potential for agency capture to which reform is subject. Sarmiento (2010) describes the state of US-Mexico interconnections and the technical, economic, legal, and political barriers to power sharing. Pineau and Froschauer (2004) provide a comparative analysis of issues facing potential integration in northern European countries, the southern cone of Africa, and North America. They find that the general complementarity of generation fuel sources, peak-load consumption times, physical infrastructure, and relative macroeconomic stability are all key to the shape of the integration process.

Much of the research on international grid interconnection focuses on changes in strategic incentives of electricity generators and how interconnector flows are allocated. Neuhoff and Newbery (2005) demonstrate the effect of moving from separate to integrated markets. They find that integrated markets yield higher welfare outcomes, but that short-run prices may increase if the number of competitors in the market remain low, or if regulators do not coordinate post-integration. Hobbs et al. (2005) analyze the welfare effects of interconnection between markets of equal size. They focus on improvements that arise from two-directional power flows that loosen capacity constraints. While they find that increased interconnections are welfare enhancing, the size of the gain is dependent on the pricing behavior of market participants. Valeri (2008) measures the welfare and competition effects of additional interconnection between Ireland and Great Britain. The study focuses on a case of perfect competition in generation between two countries of different market size and measures the benefits of interconnection due to differences in demand, factor costs, and generation technology. It finds that the main determinant of the size of interconnection needed to achieve integrated markets is the extent to which generation technology differs, and that Ireland realizes greater net benefits due to higher initial wholesale electricity prices.

4.3 Structure of United States and Mexico Power Sectors

The manner in which the generation and sale of electricity is regulated and controlled varies greatly between Mexico and the United States. In the United States, the electric power industry began with vertically integrated electric utilities that maintained ownership of generating units, as well as the transmission and distribution services from which consumers purchased electricity at prices determined largely by input costs. Gradually, this system has been replaced by one in which entities responsible for generation, transmission, and distribution services are separated and wholesale and retail electricity rates are determined by competitive market forces.[8] Complete deregulation, however, has yet to occur in most of the United States. Between 2004 and 2010, the national average price of electricity increased from 7.6 cents per kilowatt hour (kWh) to 9.9 cents per kWh. This increase was attributed largely to increases in fuel costs, but was also the result of the removal of regulated rate caps in states that introduced retail completion. This in turn led many utilities to adjust rates to recover higher transmission and distribution losses and higher wholesale power costs.

As of 2008, only 14 states (generally high cost states, including Texas) have fully deregulated to allow for retail markets in which consumers may choose between competing power suppliers. Attempts at deregulation in other states—and important to this study, the states of California, Arizona, and New Mexico—have been stymied by spikes in retail electricity rates and poor competition that led subsequently to the suspension or amendment of deregulation laws. In 2010, deregulated states paid, on average, 4.4 cents per kWh above rates in regulated states (APPA 2010). The varied nature of market regulation in the United States imposes potential constraints on international negotiations for market integration and power trade with partners such as Mexico, as international grid interconnections involve complex legal negotiations that include national and sub-national stakeholders (UN-DESA 2005). This includes the need to establish unified power purchase and pricing strategies that determine how buyers and sellers of electricity are compensated for power production, as well as for capacity and ancillary services provided over the interconnection. Although Mexico's power sector has perhaps larger barriers to integration in the form of, for example, constitutional exclusions to private participation in the market for electricity production and mainly transmission, distribution, and retail, the variance of regulatory structures between markets and the multitude of actors in the Unites States may have a more important bearing on the course of future negotiations.

IEG (2007) notes the importance of national institutions to lead implementation of integration initiatives (with well understood and defined roles) at the country level, while regional institutions should be used for coordination and support services, such as data collection and dispute resolution. It notes that proper planning and agreement between regulators at the early stages of development is of critical importance to the creation of institutional and market mechanisms to support integration. These include a harmonized regulatory environment, grid codes, and market rules; competitive access to both wholesale and retail markets; and legal agreements on issues such as power purchase agreements (PPAs), liability for supply failure, environmental responsibility, and physical security and operation of the line. This recommendation, however, runs counter to the state of relative autonomy with which US regional transmission organizations and public utility commissions operate. Historically, the US power sector has evolved to maintain distinct and exclusive regional entities for power sharing—a system that has developed regionally so as to minimize its vulnerability to shocks and disruptions such as cascading power outages.

[8] The 1978 Public Utilities Regulatory Policies Act (PURPA) paved the way for an influx of non-utility generators to the market, while the Energy Policy Act of 1992 deregulated the market for transmission (Gándara 1995).

Currently, the delivery of electricity in the United States over high-voltage transmission lines is overseen by 10 industry reliability councils that coordinate the sale and purchase of electric power and operate three major interconnected power grids: the Eastern Interconnected System, the Western Interconnected System, and the Texas Interconnected System. These bulk power systems maintain a network of generating plants, high-voltage transmission lines, and local distribution facilities that operate synchronously within themselves. Since the systems do not operate synchronously with each other, real time power transfers between systems is not possible. The sale and purchase of electricity is based on the day-to-day needs of each system, and operating authorities coordinate purchase agreements to match the real time supply and demand of electricity. This system involves thousands of public and private participants. In 2010, for example, 3,972 electric entities—including publicly-owned utilities, cooperatives, investor owned-utilities, power marketers, and others—participated in the sale of electricity to end-use customers, while 15,228 utilities-owned and independent power producers (IPPs) participated in the generation of electricity (EIA 2011).

By contrast, until 2009 almost all of customers in Mexico received electricity generated and sold by two state-owned companies—Comision Federal de Electricidad (CFE) and Luz y Fuerza del Centro (LFC). CFE is responsible for the generation, transmission, and distribution of electricity across all of Mexico, while LFC was mainly responsible for the transmission and distribution of electricity in the Federal District surrounding Mexico City. In October 2009, all public sales of electricity came under the purview of CFE. Another significant change occurred in 1992 when the Law of Public Service of Electricity (LSPEE) was amended to allow for participation in the generation market by private entities. Since 1993, cogeneration, generation for self-consumption (primarily by large energy-consuming industrial firms), and generation by IPPs became permissible with the stipulation that for the latter, all power is sold directly to CFE. As of 2011, 70.6% of installed capacity in Mexico was owned by CFE, with the remaining 29.4% accounted for by private generators (REEEP 2011). In contrast to the US case, there are 670 permits in Mexico for various types of generators—563 permits for self-supply, 57 co-generation groups, 22 Independent Power Producers, 37 import, and 5 export permits (CFE 2010). Estimated total investment by these private participants reached US$16.32 billion.

4.3.1 NAFTA and Electricity Trade

It is widely acknowledged that industrial, commercial, and residential consumers on both sides of the US-Mexico border can benefit from the trade of electricity. The UN-DESA (2005) report characterizes energy security along six dimensions: energy supply, economic, technological, environmental, social and cultural, and military/security; and it notes that electricity interconnections tend to have associated benefits and costs within these dimensions. Energy trade between any two independent systems can improve reliability and reduce cost through transfers of power for emergency support, reserve reduction and sharing, bilateral purchases and sales, and spot market transactions. Key drivers that create an economic justification for trade include difference in technology and fuels, improved generation asset utilization, differences in daily and seasonal demand patterns, differences between retail tariffs and wholesale prices, and temporal differences between marginal prices in wholesale trade. Load profiles for CFE and ERCOT, for example, display large complementarities due to seasonal variations in peak demand, total energy sales, and load factor. This creates a strong economic incentive to initiative trade by reducing the need and associated cost of building peak load capacity.

The creation of the North American Free Trade Agreement (NAFTA) in 1994 did much to reduce trade barriers and harmonize differences between national treatments of commodity market. NAFTA did not supersede the Mexican constitutional requirement that the federal government own and operate all of Mexico's basic energy resources, but it did include provisions that make it possible for foreign companies to establish and operate electric generation facilities in Mexico. Under the agreement, foreign private companies are permitted to invest in and operate generating facilities for the purpose of cogeneration and self-supply. On their part, IPPs in Mexico must sell electricity to CFE or export electricity to other NAFTA parties, such as for the purpose of supplying US states north of the border (Horlick 2002). The agreement expanded Mexico's Build-Lease-Transfer (BLT) program to permit foreign companies to build electric generation facilities while leasing the construction site, and then to transfer the plant back to CFE before commercial operation (Sweedler 2003). Since full implementation in 2008, NAFTA's provisions concerning natural gas also created the opportunity for US owners of gas-fired power plant facilities in Mexico to introduce competitive gas supplies from US companies.

Trade in electricity between Mexico and the United States already occurs regularly, although the quantity traded is significantly less than has historically occurred between the United States and Canada. In 2009, net purchases of electricity from Mexico accounted for less than 0.01% of total US supply (EIA 2011). Yet, the history of power flows between Mexico and the US reaches back to 1905 when US utilities began supplying small amounts of power to Mexican border towns isolated from transmission linkages. Power began flowing both ways in the 1950s, after which net transfer between the two countries tended to reverse every decade or so (Gandara 1995). From 1996 until 2003, Mexico was a net importer of electricity from the United States (Table 4.1). This trend, however, reversed as new generation facilities in Baja California and other northern states came online, and in 2011 the United States imported 1.3 million megawatt hours (MWh) while exporting 0.6 million MWh (BEG 2006, EIA 2011).

With the exception of power transfers across the California border, international exchanges with Mexico are currently limited to rare emergencies, such as Texas' deep freeze February 2-4, 2011.[9] ERCOT, which manages 85% of the state's electric load, purchased power from Mexico to alleviate the energy shortage. There is considerable interest, however, in increasing the capacity for cross-border transmission, particularly by states enacting aggressive renewable portfolio standards that could be met by wind and solar resources in northern Mexico. California's Renewable Energy Transmission

[9] Over a three-day period, 225 generating units experienced some sort of "unit trip" or other kind of power failure due to extreme temperatures, prompting Texas' independent system operator, the Electric Reliability Council of Texas (ERCOT), to initiate rolling blackouts as supply dropped (Texas Reliability Entity 2011).

Initiative has identified Baja California as one of its most cost-effective and easily accessible potential suppliers (Wood 2010). However, according to the USAID, current plans to expand transmission capacity along that stretch of the border are insufficient; moreover, it is unclear who should pay for such investment, be it the suppliers, the Mexican Federal Electricity Commission, California's Imperial Irrigation District, or a third party (Garrison 2010). According to a report by the Pacific Council for International Policy, lack of a "binational plan for electricity generation or transmission" is a significant barrier to resolving this dilemma (PCIP 2009).

Table 4.1
Mexico Electric Power Foreign Trade 1997-2007 (GWh)

Federal Entity	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Exports											
Chiapas	-	-	-	-	-	-	-	-	1	2	2
Baja California	17	45	31	66	112	164	765	770	1037	1072	1211
Tamaulipas	6	-	-	2	1	-	-	-	-	16	13
Quintana Roo	28	31	100	127	158	180	188	236	253	209	225
Total	51	76	131	195	271	344	953	1006	1291	1299	1451
Imports											
Baja California	406	480	646	927	82	311	45	39	75	514	266
Sonora	3	3	4	4	4	5	5	6	6	6	6
Chihuahua	1101	1022	7	129	235	189	21	2	6	3	3
Tamaulipas	-	2	2	9	6	26	-	-	-	1	2
Total	1510	1507	659	1069	327	531	71	47	87	523	277
Net balance export-import	**-1459**	**-1431**	**-528**	**-874**	**-56**	**-187**	**882**	**959**	**1204**	**776**	**1174**

Source: Secretaría de Energía, 2008. Domestic Electricity Market 1997-2007.

The US-Mexico Bilateral Framework on Clean Energy and Climate Change, established by Presidents Felipe Calderon and Barack Obama in 2009, also recognizes this priority and "aims to increase electricity grid reliability and resiliency in both countries, including of cross-border interconnections" (US Department of State 2011). Beyond simply increasing supply for an importing country while providing a "means of income" for the exporting country, interconnections have been found to reduce prices and increase reliability (Sarmiento 2010). The Border Governors Conference has pointed to "untapped potential for increasing energy interconnections among border communities" and has identified "cross-border energy exchanges" as a priority (BGC 2009).

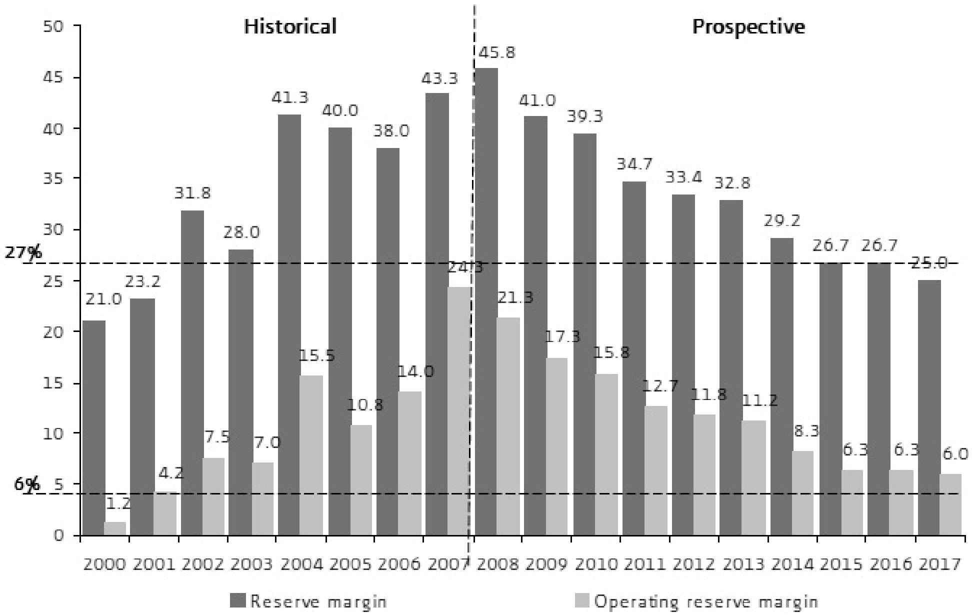
Two key factors limiting the amount of trade in electricity between the United States and Mexico are reliability concerns with synchronous connectivity and legal provisions governing the imports and exports of electricity across the border. Current interconnections between the United States and Mexico offer relatively small capacities and are mostly used for power exchanges in the event of an emergency. With the exception of one interconnection between Eagle Pass and Piedras Negras, all ties along the Texas-Mexico border are asynchronous HVDC interconnections used for emergency support only. Pineau and Froschauer (2004) assess the level of infrastructure integration and determine the current transmission capacity for cross-border electricity export, as measured by total transmission capability over total production capacity, to be 17.13, 2.51, and 2.42 percent for Canada, the United States, and Mexico respectively. The largest share of US-Mexico trade occurs between Baja California and California where two 230 kV ties provide a total capacity of 800 MW.

Numerous laws and network operation reliability standards in Mexico and the United States require local demand to be met first before exportation is authorized. This means that excess generating capacity beyond what is required to meet the internal load requirements of each system must be available for exports to occur. Exports from the US are regulated by Section 202(e) of the Federal Power Act, which requires authorization for the trade from the Department of Energy and that the export action must not impair the operational reliability of the US power system (North American Energy Working Group, 2002). Similarly, imports and exports from Mexico require authorization from CFE or the Energy Ministry with similar restrictions plus additional requirements. For imports, electricity must only be used for self-supply by the party seeking a permit, and in the case of exports, the electricity exported must be the result of cogeneration, independent power production, or small-scale production. Mexico's National Interconnected System (SIN) is expected to maintain a reserve margin well above 27% through 2015, to move to 13% after 2015, giving it ample export potential (Figure 4.2). ERCOT (the Texas interconnection) on the other hand is forecasted to maintain a reserve margin at or below its target level of 13.75%, suggesting a strong incentive for additional trade (ERCOT 2010).

4.3.2 Recent Trends in National Energy Markets

The production and consumption of energy is a major political issue in both the United States and Mexico. The link between primary energy consumption and economic prosperity is well known—growth in population pushes total energy demand upwards, while economic growth leads to an increased per capita consumption in energy. All countries over time have moved towards electrification and, it is no surprise, therefore, that as the world's largest economy the US is also the leading consumer of energy. Policy goals concerning this consumption seek to balance concerns between three competing objectives: national security and the source of energy supplies, the environment and external costs associated with energy use, and the economics of achieving a stable and reliable supply of energy at a low cost. Very few technologies offer solutions that have large benefits along all three competing fronts.

Figure 4.2
CFE Historical and Forecasted Reserve Margin and Operating Reserve Margin, 2000-2017



Source: Comisión Federal de Electricidad, 2007.

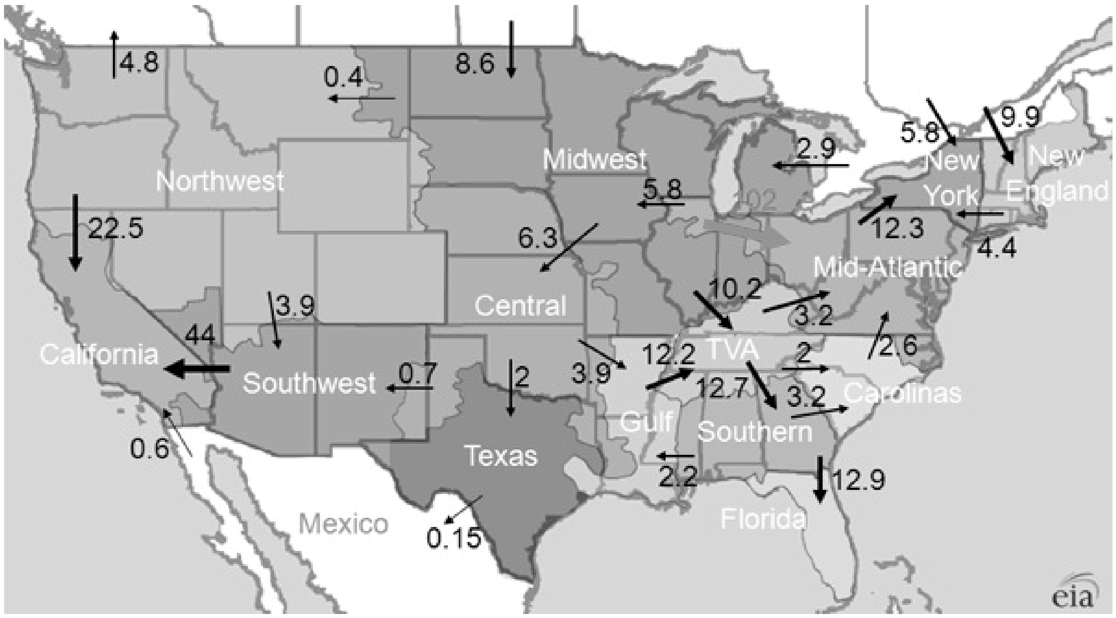
Wind power, for example, has benefits for national security and the environment because it is a domestic source of energy with little to no pollution; however, it is intermittent and relatively expensive. Coal, on the other hand, allows for the cost-effective generation of electricity from domestic sources, but does so with considerable effect on the environment due to air and solid waste pollutants that are emitted. The United States and Mexico rely on a similar mix of sources for their energy supplies, both of which depend predominantly on fossil fuels. While the reliance on fossil fuels carries with it numerous environmental and geopolitical risks, both countries share these risks jointly. This fact highlights the opportunities for collaboration between both governments in the pursuit of solutions to meet these challenges. Conversely, the large potential for wind and solar energy in the region offers the potential to smooth variations in output as generating units across wide geographic zones are tied into a common power pool.

In 2009, the electricity market in the United States was sharply affected by a 2.9% decline in GDP that resulted in reductions in total energy generation of 4.1%—the largest decline in over six decades (EIA 2011). This decline was most heavily influenced by a 9.3% decrease in industrial output that correlated with a 9.1% decline in industrial electricity demand (EIA 2011). EIA forecasts that total US consumption of electricity will experience only modest growth in 2012, primarily from commercial and industrial sectors, while the combination of moderate winter and (forecasted) summer temperatures are expected to drive down electricity sales to residential consumers by 1.2% in 2012. In addition to the economic slowdown, industry expectations over regulatory caps on CO_2 emissions has led to a shift away from investments in coal generation and a movement towards natural gas, which has fewer greenhouse gas emissions. While 40% of national electricity is generated from coal, in 2009 emissions from coal-fired power plants fell by 11%, largely due to a 10.3% decline in coal consumption (EIA 2011). The share of electricity generated from natural gas, by contrast, rose by 4.3% to represent 23% of the national energy mix. The combination of new future environmental restrictions and low near-term natural gas prices has led to a surge in investments in natural gas power plants, which account for 48% of planned capacity additions for 2011-2014 (EIA 2011). Meanwhile, the generation of electricity from renewables, particularly wind, has increased dramatically over the past three years, fueled in party by renewable portfolio standards that have been introduced in 29 states.

Since 1990, interregional trade by investor-owned utilities and cooperatives has increased by 216% and 51% respectively (EIA 2011). The impetus for this change stemmed from an unanticipated operational impact of the Public Utility Regulatory Policies Act of 1978 (PURPA), which was designed to improve energy efficiency through the expanded use of cogeneration and by creating a market for electricity from unconventional sources. However, by encouraging nonutility power generation and making it easier to market these outputs on a wholesale basis, the law led to significant operational changes and the creation of a competitive market. While the majority of electric power in the United States is served by local generators, trade between regions shows a tendency for power to flow south in North America. California is the largest net importer of electricity, receiving 25% of its supply from the northwest and southwest regions (see Figure 4.3).

Mexico, by contrast, operates a much smaller market for energy in terms of capacity and total consumption. In 2008 Mexico's installed capacity was 57.8 GW and it consumed 202 billion kWh of electric power—about 5% of US totals (SENER 2008). While residential and commercial customers consume the largest shares of electricity in the United States, the industrial sector is the main power consumer in Mexico. In 2007, it accounted for 59.1% of total sales, while residential and commercial sectors represented 25.4 and 7.4%, respectively. The total sale of electricity in Mexico has grown by an average rate of 4.5% since 1995, far faster than growth rates in the rest of North America or Western Europe for the same period. This consumption varies by region, with the states of Sonora, Nuevo Leon, Jalisco, Distrito Federal, Mexico, and Veracruz as the largest consumers. High temperatures and large industrial consumption have driven growth in the northwest states of the country at higher rates than the national average (see Chapter 8 for congested zones/nodes between Mexican and US border states and corridors).

Figure 4.3
Annual Net Power Flows among Regions in North America, 2010
(million megawatt hours)



Source: US Energy Information Administration, based on Federal Energy Regulatory Commission (FERC) Form 714 Data.

4.4 Overview of the US-Mexico Border Region

The six Mexican states and the four US states that comprise the border region face similar energy issues and constraints to each country as a whole. Policy concerns over power sector adequacy in the border region, however, is more immediate given that population growth in the region exceeds national averages and this trend is expected to continue over the next decade. Demand for electricity in the northern Mexico border states is expected to increase an average of 6.5% per year, compared to 5.6% for the rest of the country (CFE 2010). As a whole, the population in the 100 km defined zone on each side of the border grew from 6.9 million people to just over 13 million people between 1983 and 2005 (EPA 2012). The most recent population projections for the region—also reported in the 2005 State of the Border Region report—estimate that the region's population will grow to between 16 and 25 million people by 2030. Ninety percent of the border population resides in 15 paired, interdependent sister cities, while the remaining 10% live in smaller tribal and indigenous communities or in rural areas. Over 40% of the region's population resides in the California-Baja California region, which is home to the major border cities of San Diego, Tijuana, and Mexicali.

These increases in expected demand will require investments in new and upgraded infrastructure to handle the generation, transmission, and distribution services needed to serve the growing populations. In particular, a large share of new capacity is planned for high efficiency natural gas power plants that will require additional investments in the pipelines and pumping stations necessary to carry fuel supplies. The EIA predicts a shift in residential demand "to warmer regions with greater cooling requirements," while at the same time demand for clean sources of energy in particular will be driven by renewable portfolio standards (RPS) adopted at the state level. Texas, for instance, aims to reach 10,000 megawatts by 2025, while California recently expanded its renewables target to 33% by 2020, the most ambitious RPS in the country.

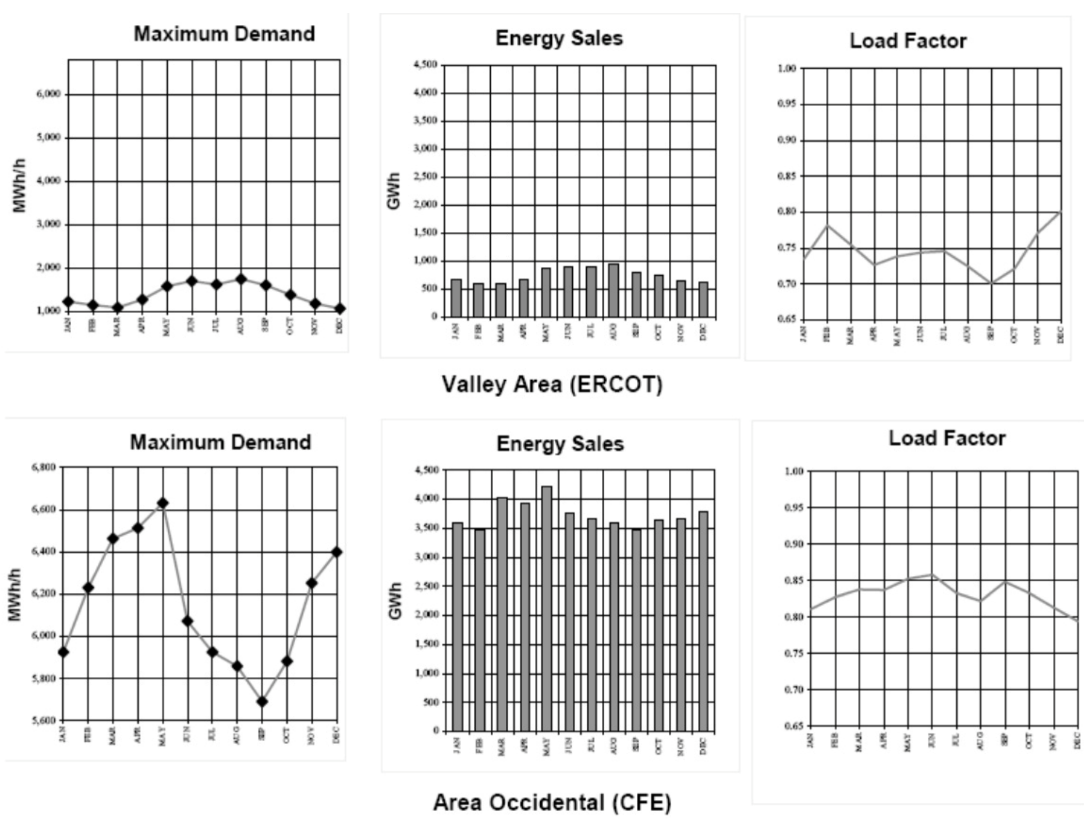
Various studies have identified enormous potential for renewable energy generation in Mexico. A report published by Mexico's Secretary of Energy estimates that "[w]ith an average solar insolation of 5 kWh/m^2," the country's potential for development of solar energy is among "the highest in the world" (Torres Roldán et al. 2006). President Felipe Calderón has specifically acknowledged California's growing demand for renewables and "committed his administration to increasing the opportunities for solar power in Mexico" (Wood 2010). Mexico's natural abundance of wind also presents untapped opportunity, with an estimated potential of 40,000 megawatts of wind power (Cancino-Solórzano 2010). A study prepared for the California Energy Commission puts the estimate for Baja California alone at 10,000 MW (Karin et al. 2008).

Before the economic recession of 2008, the border region economy had boomed for a long time in large part because of its trade relationship with Mexico and Canada under the North American Free Trade Agreement (NAFTA). The northern border states of Mexico had, in particular, experienced dynamic growth. Between 1993 and 2006 the Mexican economy overall had an average growth of 2.9%, whereas the northern border states exhibited a growth rate of 4.1%. Baja California, Chihuahua, and Nuevo León showed the most rapid growth during the period.

The border region continues to serve as the principal base for industrial output in each country. In both Mexico and the United States, the combined border state GDPs in 2006 were equivalent to approximately one-fourth of total national GDP (25% in Mexico, 23.7% in the United States), and combined border-state GDPs in 2006 were approximately US$3.3 trillion. It is expected that border state GDPs in both countries will double every 17 years, whereas Mexican GDP will require 23 years and US GDP 20 years. In part, border-state GDP has grown more rapidly because population has grown, leading to more workers and more output. The total actual value of merchandise trade (both exports and imports to and from the US and Mexico) in 2008 was $367 billion—a 266% increase since 1994. A combination of favorable tax policies and access to export markets will likely serve to maintain this trend in the future. Additionally, deep production chains by industrial sectors and "just-in-time" production dynamics, call for border state growth in economic activity and demand for all critical inputs. This fact in combination with higher rates of immigration and population growth, have resulted in forecasts of electricity growth that maintain stable, continued growth in electricity demand well above the national average.

According to the CFE's publication on the Works and Investment Program of the Electrical Sector (POISE) for 2008-2017, Mexico continues to search for alternatives to its growing reliance on natural gas for electricity generation, which has grown by 17% between 1998 and 2008 (CFE 2008). One alternative that promises considerable benefit to Mexican industrial consumers is the import of US-based supply during peak hours. For example, under the high voltage tariffs (HT-L), large industrial customers experience electricity prices at or above US$0.15 per kWh in addition to billing demand charges between US$8-17 (Puga 2006). These prices are highest in Baja California and Sonora, and create a strong incentive for trade. Moreover, peak demand and load factor (average demand divided by peak demand) vary seasonally at different times between different regions of Mexico and the United States. For example, in Texas (ERCOT) annual demand and electricity sales typically peak in August, whereas in Mexico (CFE) the highest levels are experienced in May (Figure 4.4). As a result, significant gains in efficiency would be available through greater interconnections to allow for higher use of existing capacity to meet seasonal demand needs in cross-border areas.

Figure 4.4
Comparison Between ERCOT and CFE Electricity Demand Profiles



Source: Gulf Coast Power Association, 2006.

The following analysis covers each of the border states and their characteristics.

California

With a total population of 37.7 million, California is the most populous state and largest economy of the United States (Table 4.2). It accounts for 13% of national GDP, largely due to the growth of its technology sector. Over the past 15 years, it has been the fastest growing state, and from 1995 to 2025 it is expected to add 17.7 million people (roughly the current population of New York State), primarily through international migration (Census 2011). This growth has driven electricity demand, which has gradually grown at an average rate of 2% to a cumulative increase of about 65% (CEC 2010). Since 1980, both annual consumption and peak load have grown by about 50%, with commercial buildings accounting for the largest growth and current largest share at 42%—a trend indicating the gradual transition of California's economy away from energy-intensive manufacturing to less energy-intensive services (Brown et al. 2003, CEC 2010). Today, California's workforce is well diversified over many sectors with manufacturing accounting for only 10% of in-state jobs (LAO 2010).

Table 4.2
California Summary Statistics

Item	Value	US Rank
NERC Region(s)		WECC
Primary Energy Source		Gas
Total Energy Consumption (trillion Btu)	8,005.50	2
Gross Domestic Product (billion 2005 dollars)	1,736.90	1
Energy Intensity per Real Dollar of GDP (thousand Btu per 2005 dollar)	4.60	45
Net Summer Capacity (megawatts)	65,948	2
Electric Utilities	28,021	2
Independent Power Producers and Combined Heat and Power	37,927	4
Net Generation (megawatt hours)	204,776,132	4
Electric Utilities	85,123,706	13
Independent Power Producers and Combined Heat and Power	119,652,427	4
Carbon Dioxide Emissions (thousand metric tons)	55,406	16
Total Retail Sales (megawatt hours)	259,583,623	2
Distribution of Retail Sales	Year 2000	Year 2010
Share Residential	32.5	33.8
Share Commercial	38.0	46.9
Share Industrial	26.4	19.1
Average Retail Price (cents/kWh)	13.01	11

Sources: US Energy Information Administration (2010), Form EIA-860, "Annual Electric Generator Report." US Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report." US Energy Information Administration, Form EIA-923, "Power Plant Operations Report" and predecessor forms.

While California has remained the fastest growing state over the past 30 years, this growth has been relatively stable and predictable. As early as 1988, the California Electricity Commission overpredicted 2000 demand as the subsequent recession of the early 1990s slowed growth to a greater degree than was anticipated. Long-term planning challenges for the California ISO have instead stemmed from political opposition to the construction of new internal generating capacity—namely coal, natural gas, or nuclear—on environmental grounds. Over 80% of California's internal generating capacity is from plants that are more than 35 years old, and relatively few capacity additions have been made in the last 20 years, despite continued demand growth (CEC 2010). As a result, California imports an average of about 23% of its annual electricity consumption, largely from conventional hydro in the Pacific northwest and conventional fossil fuel production from the southwest.

California's daily demand trend varies greatly over the time of day and year. Typically, demand increases by over 60% from the overnight low to the mid-afternoon high (CEC 2010). Air conditioning loads are the primary driver of peak demand in the summer; incidentally, generation capacity that sits idle for the majority of the year is needed to meet peak demand for a few hours each summer. On a hot summer day, it is possible to see a demand increase of over 90% from the early morning through late afternoon (CEC 2010).

Natural gas is California's primary fuel source for electricity generation, accounting for over 53% of in-state generation. The state's domestic hydro and nuclear each account for roughly 14.6% of generation. Additionally, a relatively sizeable renewables portfolio (excluding hydro) accounts for over 14.6% of domestic generation. The state's 35 geothermal power plants, while only accounting for 6.2% of in state generation, are responsible for more than 80% of total US geothermal electricity (EIA 2011). As a whole, the state produces approximately 70% of its electricity consumption domestically. Nearly 30% is imported from the Pacific northwest and American southwest, with a breakdown of approximately 30% and 70%, respectively. Synchronous connections between Baja California and California, operated over two 230 kv lines, hold a combined capacity of 800MW. However, due to transmission capacity constraints between La Rosita and Tijuana I the import potential is limited to 408MW (Puga 2006).

California is perhaps best known (in energy) for its aggressive policies on environmental protection and de-carbonization. Its policies have often positioned it as a first mover in emissions standards, investment in renewable generation capacity, and carbon reduction efforts. The state has imposed generous subsidy programs for building retrofits and energy efficiency programs that, in addition to other factors, are responsible for a flattening of its demand growth forecast over time despite continued projections of steady population growth; in 2011, California's per capita energy use ranked 47th out of 50 states (EIA 2011). Importantly, California benefits from a relatively moderate climate that necessitates comparatively lower heating and cooling needs in the summer and winter than other states in the border region. This makes California's energy demands less sensitive to growth in population or economic output. In general, growth in electricity consumption has been steady and anticipated.

While California maintains a robust target for reducing greenhouse gas emissions by 33% by 2020, the percent of retail sales provided by renewable generation remains below 15% for most regions (Wolak 2009). A major constraint limiting investment by utilities is the lack of adequate transmission capacity. The Tehachapi region holds an estimated 4,500 MW of wind potential, while significant geothermal and solar resources are sited in Imperial Valley (Wolak ibid. 2009). In an effort to facilitate construction of transmission capacity to connect these resource zones, the California state government established a process known as the Renewable Energy Transmission Initiative to identify high priority transmission projects. Neither resource zone named above has been developed, however, due to other difficulties in obtaining permits and cost recovery for transmission expansion.

Regulatory requirements by the California Independent System Operator (CAISO) required new generating facilities and proposed grid expansions to submit several studies related to the impact of expansion on grid reliability as well as the environment. This creates a significant barrier to the development of new resources both in-state as well as potential wind resources in Baja California that are available for export. Specific to the development of out-of-country renewable generation facilities, California requires extensive documentation of the environmental impact of the facility as if it was located within the state pursuant to California Environmental Quality Laws, Ordinances, Regulations, and Standards (LORS). This includes not only an assessment of potential impact, but also a plan of how the developer or operator will secure and put in place mitigation measures to ensure the LORS are complied with. Despite regulatory barriers, interest in bi-directional electricity trade between California and Baja California is likely to remain high. The wind resource potential in Baja California ranges between estimates of 2,000 MW to upwards of 10,000 MW throughout the Juarez Mountains (Puga 2006). Other resources, such as pumped storage hydro capacity and small scale geothermal are also currently being studied by CFE.

Texas

The state of Texas is the largest producer and consumer of energy in the United States—a fact that underscores the vitality of energy supply to the state's economic prosperity, as is shown in Chapter 1 of the report (Table 4.3). Over the past decade, growth in Texas has outpaced the national average, and in 2009, over half of the nation's net new private sector jobs were generated in Texas (Hayward et al. 2010). Growth in both population and GDP are expected to continue to outpace the national average, forecasted at 3.2% and 1.7% annually through 2030, respectively.

Annually, Texas accounts for about one-tenth of total US energy consumption, in large part due to its position as home to the largest industrial sector in the nation. A high concentration of energy-intensive industries in Texas—aluminum, chemicals, forest products, glass, and petroleum refining—use more energy than the next three top consumers (California, Louisiana, and Ohio) combined. In total, nearly half of Texas' total energy use is consumed by the industrial sector and is 33% higher than the national average (EIA 2011). Since 1990, electricity consumption has growth by 45.43%.

Population growth and new housing builds have driven residential consumption at a higher growth rate of 57.24%, which since 1997 has accounted for the largest share of total consumption.

Table 4.3
Texas Summary Statistics

Item	Value	US Rank
NERC Region(s)		TRE
Primary Energy Source		Gas
Total Energy Consumption (trillion Btu)	11,297.40	1
Gross Domestic Product (billion 2005 dollars)	1,066.40	2
Energy Intensity per Real Dollar of GDP (thousand Btu per 2005 dollar)	10.60	14
Net Summer Capacity (megawatts)	108,258	1
Electric Utilities	26,533	4
Independent Power Producers and Combined Heat and Power	81,724	1
Net Generation (megawatt hours)	411,695,046	1
Electric Utilities	95,099,161	9
Independent Power Producers and Combined Heat and Power	316,595,885	1
Carbon Dioxide Emissions (thousand metric tons)	251,409	1
Total Retail Sales (megawatt hours)	358,457,550	1
Distribution of Retail Sales	Year 2000	Year 2010
Share Residential	36.7	38.3
Share Commercial	26.7	33.9
Share Industrial	31.9	27.8
Average Retail Price (cents/kWh)	9.34	21

Sources: US Energy Information Administration (2010), Form EIA-860, “Annual Electric Generator Report.” US Energy Information Administration, Form EIA-861, “Annual Electric Power Industry Report.’ US Energy Information Administration, Form EIA-923, “Power Plant Operations Report” and predecessor forms

The majority of Texans receive electricity as part of a bulk power system regulated by the Texas Reliability Entity (TRE), which is the regional entity responsible for enforcing NERC compliance within the ERCOT service area. ERCOT serves 85% of the load in Texas, but does not include portions of northeast Texas, southeast Texas, the Panhandle and El Paso. In total, the ERCOT market serves 22 million people with an annual total generation of 308 billion kWh (ERCOT 2010). In 2011, Texas recorded its highest ever peak load demand of 68,379 MW during high-temperature days in August. During this time capacity reserves dropped below 8% and supplemental supply was purchased from Mexico and neighboring states. ERCOT planners have voiced significant concern about the need to maintain future reserve margins above the 13.75% target used in the ERCOT region to avoid outages during higher-than-normal temperatures or other generator outages. Current projections hold ERCOT reserve margins at 12.1% for summer 2012, while they are expected to drop to 7.6% by 2014 and to fall below 0 by 2020 (ERCOT 2010). Even with planned capacity additions, reserve margins are projected to remain below the target level for the foreseeable future. Since Texas does not have a capacity market that can easily induce construction of new power plants, one potential solution would be additional electricity imports from Mexico where the existence of complementary load characteristics could allow existing generating facilities to supplement in state generation during peak days in August (when demand in Mexico is comparatively lower).

Electricity in Texas is mainly generated from coal and natural gas-fired power plants, with nuclear and renewables—predominantly wind—accounting for the rest. While over two-thirds of Texas' generating capacity is based on natural-gas fired power plants, a significantly smaller percentage of actual generation (47.7%) is attributed to natural gas. The higher percentage of coal-based generation reflects the fact that coal is the cheapest fuel source and as a result the primary source of base load capacity, while gas-fired plants are used largely for peak load generation. Current installed capacity in the ERCOT region is about 80,000 MW, which includes 3,000 MW of generation not currently in active use.

Over the past two decades, new capacity additions have largely been met through the construction of new natural-gas fired power plants. Given the recent growth in shale gas reserve estimates and that many utilities have entered into long-term power purchase agreements with natural gas suppliers, there is a strong likelihood that this trend will continue in the near term. Since 1995, about 75% of added capacity has been natural gas facilities, despite coal being cheaper on a total cost basis. According to the Department of Energy, the cost of coal-fired electricity in Texas in 2010 was $1.81 per million BTU, compared to $4.48 per million BTU for natural gas. In part due to EPA regulations that govern mandate emissions reductions in key pollutants of older coal-fired power plants, such as mercury, the viability of coal as a generation resource has become uncertain—a fact that is reflected in the low rate of new coal plants under construction nationwide.

Congestion in the ERCOT region reached a record high in 2008 when system inefficiency reached a total cost of $375 million (ERCOT 2010). These costs have since receeded, due to reductions in fuel cost, revised market rules, and transmission system improvement, to reach the lowest level recorded in over a decade in 2008. Transmission improvements since 2009 have included over $2 billion of investment in new autotransformer capacity and over 1,933 miles of transmission. Additionally, major investments over the next five years include $9 billion to add another 7,866 circuit miles of transmission lines. A major component of these improvements involve the addition of planned expansions to the Competitive Renewable Energy Zone (CREZ) in the western portion of the state where significant wind resources exist. Connecting these resources to the most heavily constrained (and highest growth) counties—namely, Bexar, Harris, Dallas, and Tarrant—remains a significant challenge. While wind energy serves as 11.4% of generating capacity, intermittency and transmission constraints reduce that amount to 1.1% of available capacity (ERCOT 2010). No major plans exist to build signficant new cross-border transmission capacity for the purpose of wholesale power exchanges, despite the ackowledged benefits of connecting new wind resources from neighboring Mexican states. It is well understood that integrating wind resources across larger geographic regions helps to reduce problems with intermittency by smoothing drops in available capacity. The last major study of potential benefits of additional cross-border ties between ERCOT and CFE was conducted through a joint CFE-ERCOT Interconnection Study in 2003. It concluded that opportunity exists for mutual benefit in block load transfers at Ciudad Acuña in the state of Coahuila, and asynchronous ties at Laredo and McAllen. A question remains, however, as to what financing mechanisms, public or private, are most appropriate to pay for the establishment of new cross-border ties. While benefits associated with grid reliability and security are easy to ascertain, gains from increases in trade from a yet-to-be-utilitized connection are harder to determine.

In one assessment of the potential gains from additional ties between CFE and ERCOT, Navigant Consulting compared historical ERCOT and CFE marginal production costs and simulated electricity prices for both sides of the border. Using an hour-by-hour comparison of ERCOT's market clearing prices for energy and CFE's marginal production costs in 2003, a forward estimate for years 2007 to 2015 was established. The result of the study concluded that the direction of trade between CFE and ERCOT would vary seasonally in accordance with price differentials, leading power exchanges to flow northbound in January, February, June, July and August; and southbound in all other months. Price differnetials between ERCOT and CFE also varied by time of day, as the market clearing price for ERCOT rises and falls along with demand (compared to CFE marginal production costs that remain relatively flat with respect to time of day). The result of the analysis concluded that the potential trade benefits of DC Tie connections would yield between US$11-16 million for northbound trade of CFE exports to ERCOT, and between US$4-8 million in potential trade benefits as a result of southbound exports from ERCOT to CFE (GCPA 2006).

Arizona

Arizona's electricity consumption has also been growing markedly faster than the national average growth rate over the past few decades. In the 1980s, electricity use in Arizona grew by 4.7% a year compared to a national growth rate of 3% during the same period. In the 1990s, electricity use in Arizona grew by 3.5% a year as compared to a national growth rate of 2.3% during the same period. This pattern of growth rate in electricity use continued in the 2000s, with a growth rate of 3.4% for the period between 2000 and 2007 as compared to a national growth rate of 1.3%.

Most of the recent growth in Arizona's electricity use has occurred in the residential and commercial sectors, as suggested by the growing share of retail sales for each sector (Table 4.4). In 2010, residential and commercial electricity consumption accounted for over 84% of total electricity consumption, with residential use the largest consuming sector requiring over 32 million MWh. Commercial and industrial use followed with consumption figures of 28 million MWh and 12 million MWh, respectively. This growth has been primarily caused by population growth. From 1980 to 2006 the population grew from 2.7 million to 6.2 million. From 1990 and on, electricity growth rates have surpassed population growth rates; this is partially the consequence of decreasing real rates of electric power (Considine et al. 2008). However, in the mid-2000s rates began to level off and rates now appear to be increasing. Much of the time changes in end-use electricity rates are reflections of changes in the average costs of generation.

Table 4.4
Arizona Summary Statistics

Item	Value	US Rank
NERC Region(s)		WECC
Primary Energy Source		Coal
Total Energy Consumption (trillion Btu)	1,454.30	24
Gross Domestic Product (billion 2005 dollars)	230.90	19
Energy Intensity per Real Dollar of GDP (thousand Btu per 2005 dollar)	6.30	37
Net Summer Capacity (megawatts)	26,392	15
Electric Utilities	20,115	14
Independent Power Producers and Combined Heat and Power	6,277	16
Net Generation (megawatt hours)	111,750,957	12
Electric Utilities	91,232,664	11
Independent Power Producers and Combined Heat and Power	20,518,293	17
Carbon Dioxide Emissions (thousand metric tons)	55,683	15
Total Retail Sales (megawatt hours)	72,831,737	21
Distribution of Retail Sales	Year 2000	Year 2010
Share Residential	40.6	44.6
Share Commercial	35.0	39.7
Share Industrial	19.6	15.7
Average Retail Price (cents/kWh)	9.69	20

Sources: US Energy Information Administration (2010), Form EIA-860, “Annual Electric Generator Report.” US Energy Information Administration, Form EIA-861, “Annual Electric Power Industry Report.” US Energy Information Administration, Form EIA-923, “Power Plant Operations Report” and predecessor forms.

For Arizona, coal-fired generation is currently the largest producer of electricity, producing more than 40 million MWh. Arizona possesses significant coal reserves in the Black Mesa region and produces over 8 million tons of coal a year. Natural gas generation, Arizona’s second-largest source of electricity production, supplied the state with over 36 million MWh of electricity in 2006. Since the 1990s, natural gas-fired electricity generation has grown rapidly and is reflected in the national trend. This is a result of the nature of natural gas plant price structure; natural gas plants are relatively capitally inexpensive and require less pollution control measures than coal-fired plants. The remainder of Arizona's fuel mix comes predominantly from nuclear power, which has declined in percent contribution since the 1990s, and hydroelectric power, which is generated primarily by large dams along the Colorado River, Glen Canyon, and the Hoover Dam. Combined, these four traditional sources of electricity generation provide more than 100 million MWh, of which a quarter is excess production greater than Arizona's end use. As a result, Arizona is an exporter of electric power and regularly supplies its neighboring states of Nevada and southern California through long-term power purchasing agreements (Considine et al. 2008). This would suggest that Arizona does not possess the immediate incentives, apparent in Texas and California, which would create a justification for greater regional integration. However, in order to meet its state renewable energy goal of 15% by 2025, Arizona will need to find replacements for coal as its primary source of electricity. While the state ranks 24th in total energy consumption, it ranks 15th nationally in terms of carbon emissions. Opportunities for replacing coal-based electricity with in-state solar or the importation of electricity from renewable sources in Baja California, Sonora, or Chihuahua are potential solutions for meeting this goal.

New Mexico

New Mexico has low energy demand, ranking 38th nationally, primarily due to a comparatively small population of just over 2 million. During the 2008 recession the state lost an estimated 53,000 jobs, more than 20,000 of which were in construction (Department of Labor 2010). Forecasts for growth in 2012 suggest a modest recover with GDP growing by about 1%, primarily due to a recovery in private industries like mining and oil and gas. Budget deficits, however, are expected to continue to depress growth as state and local governments continue to shed jobs.

Like Arizona, New Mexico's power generation is dominated by coal, which provides almost four-fifths of the state's electricity. In terms of electricity end-use, the state's retail sales by sector are 30.1% residential, 40.2% commercial, and 29.7% industrial, for a total 2010 net generation figure of 36.2 million MWh (EIA 2011). These consumption figures are with respect to an average annual increase in electricity consumption between 1980 and 2005 of 3.3%, ranking the state fifth in percent demand growth among all other states (EIA 2011).

In 2010, the primary sources for electric power generation in New Mexico were coal and natural gas, at 85% and 13%, respectively (EIA 2011). This trend of electricity generation is in large part the direct result of New Mexico's large fossil fuel resource endowment. The state possesses the largest proven natural gas field in the country, as well as several of the country's largest oil fields.

Table 4.5
New Mexico Summary Statistics

Item	Value	US Rank
NERC Region(s)		WECC
Primary Energy Source		Coal
Total Energy Consumption (Trillion Btu)	670.10	38
Gross Domestic Product (Billion 2005 Dollars)	69.10	38
Energy Intensity per Real Dollar of GDP (Thousand Btu per 2005 Dollar)	9.70	19
Net Summer Capacity (megawatts)	8,130	36
Electric Utilities	6,345	33
Independent Power Producers & Combined Heat and Power	1,785	36
Net Generation (megawatthours)	36,251,542	37
Electric Utilities	30,848,406	33
Independent Power Producers & Combined Heat and Power	5,403,136	37
Carbon Dioxide Emissions (thousand metric tons)	29,379	31
Total Retail Sales (megawatthours)	22,428,344	39
Distribution of Retail Sales	Year 2000	Year 2010
Share Residential	26.3	30.1
Share Commercial	35.5	40.2
Share Industrial	29.2	29.7
Average Retail Price (cents/kWh)	8.40	33

Sources: US Energy Information Administration (2010), Form EIA-860, "Annual Electric Generator Report." US Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report." US Energy Information Administration, Form EIA-923, "Power Plant Operations Report" and predecessor forms

In 2010, the primary sources for electric power generation in New Mexico were coal and natural gas, at 85% and 13%, respectively (EIA 2011). This trend of electricity generation is in large part the direct result of New Mexico's large fossil fuel resource endowment. The state possesses the largest proven natural gas field in the country, as well as several of the country's largest oil fields.

New Mexico possesses an extraordinary potential for solar development; in fact, the state ranks second in solar potential following only Arizona. The state's southern deserts offer the most concentrated solar potential. Additionally, New Mexico's Rocky Mountain region holds significant geothermal power potential due to its geological activity along with regional pockets suitable for wind power development. However, despite these abundant and attractive renewable energy reserves, at present the state produces less than 1% of its electricity from these resources (excluding hydroelectric) with a total installed capacity of less than 4 MW. Given the right price incentives, development of these resources could be available to export to neighboring states and Mexico.

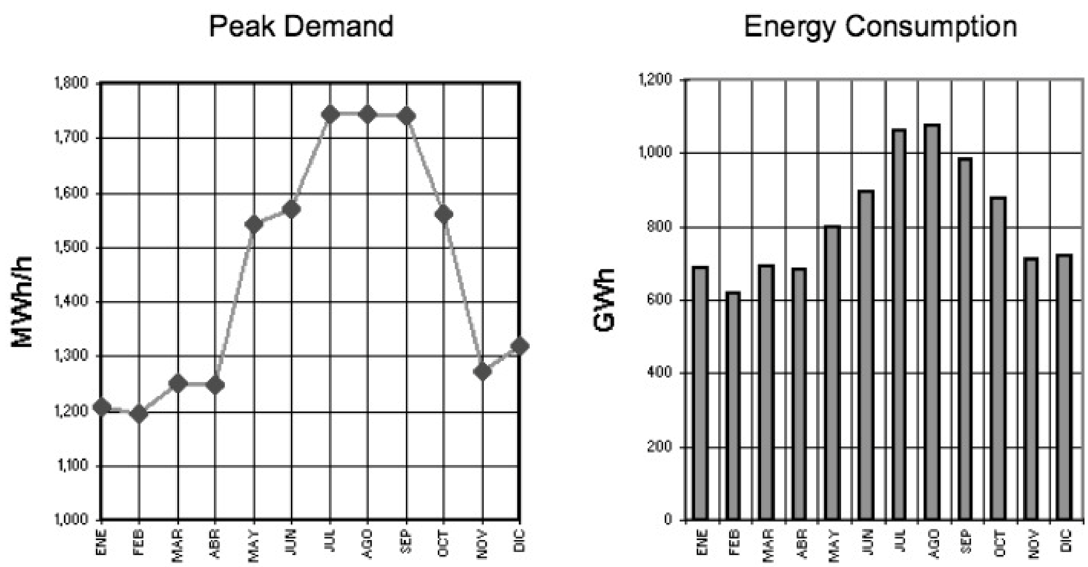
Baja California

Baja California, located in the northwest portion of Mexico, is composed of variable topology that includes hills, deserts, and large mountain ranges. With elevations that vary from sea level to mountaintops in the Juarez and San Pedro Martir ranges sitting above 3,000 meters, the climate of Baja California is characterized by hot and dry summers and wet, cold winters. The state is both geographically isolated and electrically independent from the rest of Mexico. Instead, due to its geographic disposition, Baja California has developed a unique energy interdependence with California and the southwest United States that involves regular cross-border trade of electricity and natural gas. Its electrical grid connects synchronously with the US at two locations: the Mesa de Otay power plant in Tijuana, across the border from San Diego, and the La Rosita plant in Mexicali, across from Imperial Valley. Studies are ongoing regarding anticipated interconnection with the SIN grid in 2013, accompanied by disconnection from the US grid. The Secretary of Energy believes that the move will help reduce generation and infrastructure spending in Mexico, in part through postponement or cancellation of generation projects with high investment costs. The Secretary also suggests that interconnection will present "new opportunities for power and energy transactions" with the US while allowing Mexico to capitalize on demand diversity between the SIN and Baja California systems (SENER 2008).

In 2007, the primary types of energy produced in Baja California were geothermal and natural gas, with each representing 47% of the state's electricity; fuel oil and diesel accounted for the remaining 6%. The state has two major CFE-owned power plants in operation, including Cerro Prieto, the world's largest geothermal power station. Located in Mexicali, it has a capacity of 720 MW (SENER 2011). As of 2007, it provided 46% of the state's electricity. The other CFE-owned plant, the Presidente Juárez Oil Thermal Power Station in Rosarito, has three generators (one conventional thermoelectric, one combined cycle, and one gas turbine) for a combined capacity of 1,093 MW (BECC 2010). Also in operation is a combined cycle IPP in Mexicali with a capacity of 489 MW. Together with the Presidente Juarez combined cycle unit, it provides another 46% of the state's electricity. The remaining 8% is provided by Presidente Juarez's other two units (6%) and imports from the US (2%) (BECC 2010). Between now and 2025, the country is expected to increase its dependence on natural gas significantly, along with geothermal. Meanwhile, it will reduce dependence on diesel and phase out use of fuel oil altogether (BECC 2010).

Over the last decade, consumption of energy in Baja California grew more slowly than in the other border states, though it outpaced them in population growth. Consumption grew at an annual average of 1.94% from 2000-2010, representing an overall increase of 20.78% (CFE 2010). According to the Secretary of Energy, while "industrial and population growth in cities like Tijuana and Mexicali" are important drivers of electricity consumption, climate also plays an important role because the "region's principal characteristic is extreme climate with high summer temperatures and intense winter colds, affecting electric power consumption patterns in the region's urban zones" (SENER 2008). As a result, the load profile for Baja California peaks in the summer (July-September) with overall demand on average about 40% higher than peak demand in the winter (Figure 4.5). Over half of this demand is the result of sales to commercial and small to medium-sized industrial businesses, while the majority of demand growth is the result of commercial and residential growth in the Tijuana and Mexicali urban and suburban areas.

Figure 4.5
Energy Load Pattern in Baja California Norte, 2004



Source: California Energy Commission (2005), Energy Supply and Demand Assessment For the Border Region.

The state development plan identifies climate change as a concern, citing the Intergovernmental Panel on Climate Change's estimates that Mexico's northwest region may experience significant decreases in rainfall (Gobierno del Estado de Baja California 2010). It has launched several new initiatives in the last three years, including creation of the State Energy Commission and the development of a State Program for the Sustainable Use of Energy. Baja California has also joined the other border states in collecting data on greenhouse gas emissions. Based on consumption figures, Baja California had the lowest emissions of all the border states in 2005. Emissions forecasts show that natural gas will be the primary driver of greenhouse gas increases through 2025 (BECC 2010).

Baja California is the fastest growing of the border states, with population expanding by nearly 40% over the last 10 years, at an average annual rate of 3.14%. Nuevo Leon and

Tamaulipas followed, each of which grew nearly 1.5% a year in that time (CONAPO 2011). Baja California is expected to double its 2010 population by 2041 (Gobierno del Estado de Baja California 2010).

Baja California is highly urbanized, with only 14% of its population living in rural areas. Nearly 50% of the states' inhabitants live in Tijuana, the state's largest city, while almost 30% live in Mexicali, the state capital (Gobierno del Estado de Baja California 2010). While these two cities accounted for the bulk of the state's population growth over the last five years, population in the smaller coastal cities of Rosarito Beach (4.57%) and Ensenada (2.61%) experienced accelerated growth during that time and are expected to double by 2025 and 2037, respectively. Meanwhile, annual growth rates in Tijuana and Mexicali are expected to slow slightly, with forecasted averages of 2.6% and 2.3% between 2005-2030 (San Diego Association of Governments 2008).

The main drivers of Baja California's economy are manufacturing, agriculture, and tourism. The state's maquiladora industry is centered in Tijuana—which accounts for more than half of the state's GDP and will likely continue to do so through 2030—as well as Tecate and Mexicali (San Diego Association of Governments 2008). The most economically important agricultural areas are Mexicali Valley and Ensenada, home of the state's sole deep-water port, where fishing and other maritime activities contribute significantly to the economy. The coastal cities are important to the tourism industry as well; an estimated 85% of tourists come from the US (Standish 2009).

Both the tourism and maquiladora industries suffered during the recent economic downturn (Gobierno del Estado de Baja California 2010), with Tijuana alone losing 37,148 manufacturing jobs between July 2007 and December 2009 (Villarreal 2011). Nonetheless, the state government reports indicators of recovery, including steadily decreasing unemployment numbers beginning in late 2009 and continuing through 2011 (Gobierno del Estado de Baja California 2010). Employment is expected to double by 2030, at an average annual growth rate of 3.2% statewide. Tijuana, Tecate, Mexicali, Ensenada, and Rosarito Beach will experience the bulk of that growth, with the fastest growth expected in Tecate and Rosarito Beach (4.3% and 5% annually) (San Diego Association of Governments 2008). The state government also cites changes in the population structure over the last two decades as a sign of continued economic prosperity. The older population (age 15 and older) has increased relative to the number of children, creating a low ratio of dependents relative to the working-age population. Known as a "demographic bonus," the ratio suggests a particularly favorable economic climate going forward (Gobierno del Estado de Baja California 2010).

In recent years, Baja California has been a net exporter of electricity to the United States. Operating synchronously with the WECC region of the United States, in 2007 it sent over 1,000 GWh in net exports to California. As stated previously, increased power sharing between Baja California and the United States allows for the deferment of new power plant constructions, in addition to more efficient use of existing generation facilities. The main barrier to increases in cross-border trade is the extent of transmission infrastructure that is currently limited, due to congestion, to an effective capacity of 400 MW. Given the high concentration of populations residing in the San Diego-Tijuana urban area, the addition of increased transmission capacity would improve reliability and create gains from trade for both economies. The existence of large undeveloped potential in geothermal, wind, and solar resources suggest future opportunities for investment in developing these resources with the purpose of serving both communities.

Sonora

Sonora is the second-largest Mexican state in area, accounting for more than 9% of the country's total, much of which is used for agriculture, the state's economic backbone (Standish 2009). As the nation's "breadbasket," Sonora is known for its cattle, fisheries, and production of wheat, safflower, soybeans, and other products, two-thirds of which are exported (Gobierno del Estado de Sonora 2009). Packaging and processing of these agricultural products play a major role in the state's industrial sector (Standish 2009). Sonora's maquiladoras employ more than 85,000 people, with two-thirds of industrial GDP associated with production of food and metal products. While the industry is spread throughout 43 industrial parks in 15 cities, it is primarily concentrated in Hermosillo, the state's capital as well as its most populous city, where 30% of the state's inhabitants live.

Hermosillo is known for its automotive manufacturing in particular (Gobierno del Estado de Sonora 2009). Ford's Hermosillo Stamping and Assembly Plant is often cited as a testament to the automotive sector's success, both in symbol and fact. Despite setbacks across the region due to the economic slowdown, production at the Ford plant doubled between 2000 and 2010 (Ford Motor Company 2011). Mining of gold, silver, and copper also plays an important role in the state economy, with Sonora being the country's largest copper producer. The mining sector showed the strongest growth from 1996-2006, at 13.97%. Meanwhile, manufacturing grew by 4.99% while agriculture shrank by 2.83% (Gobierno del Estado de Sonora 2009).

Although all of the border states have traditionally grown faster than the national average in terms of both population and GDP, Sonora has for many years contributed least in both areas. In terms of contribution to the national GDP, Sonora consistently ranked last from 2003 to 2007 (Gobierno del Estado de Sonora 2009). Nonetheless, it has shown the strongest GDP growth of all the border states, with an annual average growth rate of 9.7% from 2003-2010 and overall growth of 89.3% (INEGI 2010). In addition, consumption of energy in the northwest statistical region (which includes both Sonora and Sinaloa) grew at an annual average rate of 2.51% over the last decade, resulting in overall growth of 28.03% (CFE). These numbers held despite an annual average population growth rate of just 1.14% from 2000 to 2010, the lowest among the border states (although still higher than the national average, 0.98%) (CONAPO 2011). Reflecting similar trends predicted nationwide, CONAPO forecasts a less robust population growth rate over the next 15 years, with an expected annual average of 0.62%, slightly higher than the estimated national rate of 0.59%.

Sonora is home to two CFE-owned thermoelectric plants in operation as of 2010. The Puerto Libertad Thermal Power Plant in Pitiquito has a capacity of 632 MW, while the Carlos Rodriguez Rivero Thermal Power Plant in Guaymas has 484 MW of capacity.

Sonora also has two operating IPPs: a 250 MW plant in Hermosillo, and the 258 MW Naco Nogales gas plant in Agua Prieta. A second, combined-cycle unit with a solar array is under construction in Agua Prieta and expected to come online in 2013 with 394.1 MW of capacity (SENER 2008).

The country's primary sources of energy, in terms of both generation and consumption, are natural gas and fuel oil, which accounted for 35.9% and 61.9% of generation in 2004, respectively, while accounting for 33.4% and 66.5% of consumption. Generation and consumption of fuel oil—which is responsible for 73.3% of Sonora's electricity-related greenhouse gas—are expected to double by 2020. Meanwhile, generation and consumption of natural gas—responsible for 26.7% of emissions—is forecasted to decrease slightly (BECC 2010).

Hydroelectric energy accounts for a small fraction of the country's generation, at 2.1%, and will increase somewhat over the next decade, from 221 MW to 330 MW (BECC 2010). Sonora also has several renewable energy projects in the planning stages, including three solar projects in Hermosillo, each with a planned capacity of 50 MW. Another four 50 MW solar projects are in the process of land acquisition in Caborca, with a fifth planned for San Luis Rio Colorado (BECC 2011).

Because 70% of Sonora's land is characterized by desert vegetation, Sonora's aquifer system is particularly vulnerable to over-pumping and is severely depleted in some areas, including Hermosillo, posing a threat to both agriculture and industry (Standish 2009). Moreover, the IPCC predicts significant decreases in rainfall throughout northwest Mexico, including both Sonora and Baja California (Gobierno del Estado de Baja California 2010). As such, the Sonoran government is active in sustainability efforts. It recently created an Energy Commission charged with promoting renewables and efficiency. Current energy-related projects include Fondo Nuevo Sonora, a fund for supporting efficiency efforts, and a rural electrification project that aims to generate 1,016 MWh of clean energy (BECC 2011). Industry players have also joined the effort. Ford reduced its water use at the Hermosillo plant by 40% over the last decade and recently announced global plans to implement an additional 30% cut by 2015 (Ford Motor Company 2011).

Chihuahua

Chihuahua is the largest state in Mexico and accommodates about 17% of the "fronterizos" (border-state inhabitants). As an important manufacturing hub, Chihuahua is home to 25% of Mexico's maquiladora workers, and 85% of the population lives in metropolitan areas (Standish 2009). It ranks first among the border states, as well as fourth in the nation, as a draw for foreign direct investment. The capital city of Chihuahua boasts seven industrial parks, while Ciudad Juarez—the state's manufacturing epicenter—is home to 25. Altogether, there are more than 400 maquiladoras in the state (Standish 2009).

Juarez is Chihuahua's most populous city and most transient, with 75% of its inhabitants having been born elsewhere. Other population centers include Chihuahua city; Delicias, the state's agricultural center; and Hidalgo del Parral, known for its mining (Standish 2009). Due to the development of several large mining installations, this sector has proven a particularly important source of economic growth in recent years, providing employment opportunities in rural areas and helping offset setbacks in the industrial sector due to the economic downturn, in which Juarez alone lost 46,261 jobs (Villarreal 2011). Forestry also plays an important role in the economy, producing a variety of pine trees useful in manufacturing (Standish, 2009). GDP in Chihuahua grew by an annual average of 6.7% between 2003 and 2010, expanding overall by nearly 56% in seven years (INEGI 2010).

Population growth statewide was robust compared to the national average over the last decade, yet it was slow relative to other border states. At an annual average rate of 1.17%, it surpassed only Sonora (1.14%) in that time, bringing overall growth to 13.15%. According to CONAPO's forecasts, the two neighboring states will keep pace with each other through 2025, with population growing at an average annual rate of 0.62% (CONAPO 2011). Chihuahua is likely to become a net importer of electricity around 2020, as natural gas consumption surpasses generation capacity. While Chihuahua has an interconnection with the neighboring state of Durango as well as with the US (at Juarez-El Paso), a report from the Border Environment Cooperation Commission (BECC) suggests that those imports will most likely come from Coahuila, based on projections of production and transmission capacity (BECC 2010).

Natural gas accounts for 86% of gross electricity generation in Chihuahua; fuel oil, diesel, and hydroelectric account for the remaining generation, at 11%, 2%, and 1% respectively. CFE owns several power plants in Chihuahua, three of which run on natural gas. Juarez is home to one pair, Samalayuca I and II, which have 522 and 316 MW of capacity respectively. The former is a six-unit, conventional thermoelectric power station, while the latter is a two-unit combined cycle plant. A third thermoelectric plant, located in Delicias, also belongs to CFE; known as the Francisco Villa power station, it has five units and a capacity of 300 MW. CFE also owns a five-unit hydroelectric plant known as El Encino; located in Chihuahua, it has 619 MW of capacity (BECC 2010, CFE 2010). A combined-cycle IPP-owned plant, Chihuahua III, is located in Juarez and has 259 MW of capacity. A second IPP plant, Norte II, is anticipated to come online in 2013 in the city of Chihuahua, with a capacity of 376.65 MW (CFE 2010).

Natural gas is the primary source of the state's electricity-related greenhouse gas emissions, responsible for 70,804 terajoules in 2010; fuel oil, by contrast, accounted for 20,279 TJ, while diesel oil accounted for 50. According to BECC's forecasts, electricity-related emissions from fuel and diesel oil will virtually disappear by 2025, while emissions from natural-gas production will grow. Overall, in the next 15 years, annual GHG emissions from production-based electricity supply are expected to peak at 8.22 MMtCO2e in 2015 before dropping to 7.55 in 2025 (BECC 2010). Along with participation in the border states' efforts to collect emissions data, Chihuahua's other carbon mitigation initiatives include a mandate to optimize use of solar energy under the aegis of the National Housing Program, as outlined in the state's 2005 environmental protection law.

Coahuila

Coahuila de Zaragoza is Mexico's third-largest state; its population, however, is relatively small, at a density of 16 people per square kilometer, well below the national average of 50. The state is highly urbanized nonetheless, with up to 90% of Coahuila's inhabitants living in urban areas, compared to 76% nationally (Standish 2009). Coahuila grew at a relatively modest rate of 1.27% over the last decade (expanding by 14.39% overall), greater than the annual averages of Sonora and Chihuahua, but less than the remaining border states. Forecasts suggest Coahuila will maintain that relative standing through 2025, though at a slower annual average growth rate of 0.74% (CONAPO 2011).

The state's most significant centers of economic and population growth are found in the border municipalities of Acuña and Piedras Negras, along with Monclova, San Pedro, Saltillo, and Torreón (Gobierno del Estado de Coahuila 2011). Three-fourths of the state's inhabitants live in these seven centers of industry. Automotive manufacturing is particularly influential there, with one in four of Mexico's vehicles produced in Coahuila. The state also produces a third of Mexico's steel, to supply Chrysler and General Motors, among other US companies. Coahuila's mining region boasts significant coal deposits, sufficient to meet 100% of industrial energy demand, while the Gulf of Sabinas has important natural gas reserves (Standish 2009).

The Coahuilan government boasts a long list of "primer lugar nacional" data (statistics in which the state ranks first in the country), including highest manufacturing GDP per capita and greatest number of registered exporting companies.

Coal is the dominant source of electricity in Coahuila, making up 91% of the fuel mix as of 2007; hydroelectric meanwhile accounted for 8%, while natural gas accounted for only 1%. CFE currently owns two coal-fired power plants in Coahuila, both located south of Piedras Negras. The José López Portillo plant (also known as Carbón I) has a capacity of 1,200 MW, while Carbón II has 1,400 MW; each has four units (CFE 2010). CFE also owns La Amistad hydroelectric plant, which has a gross capacity of 66 MW (BECC 2010). The combined cycle Saltillo Power Station, located in Ramos Arizpe, is IPP-owned, with a capacity of 247.5 MW for main industrial centers in both the Ramos Arizpe and Saltillo metro areas (CFE 2010). Planning for a second natural gas plant is under way, with an expected capacity of 668 MW; it will begin operating in 2017. Generation forecasts project dependence on coal, diesel, and hydro to remain at current levels through 2025 (at 17,907 GW, 819 GW, and 147 GW, respectively); meanwhile, natural gas generation will increase from 1,834 GW to an estimated 6,233 (BECC 2010).

Coahuila accounts for an estimated 6% of Mexico's carbon dioxide emissions, based on 2005 data. In terms of gross consumption, electricity, industrial processes, and the fossil fuel industry account for the majority of the state's greenhouse gas emissions (72.7%). Natural gas, coal, and diesel oil are responsible for Coahuila's GHG emissions related to the production of electricity. While annual coal- and diesel-based emissions should remain steady through 2025 (at 18 and 0.09 MMtCO2e, respectively), emissions from natural gas are expected to increase, from 0.85 MMtCO2e in 2010 to 2.62 in 2025 (BECC 2010).

Coahuila has in place a state climate action plan under which the Coahuila Climate Change Advisory Group (CCAG) is currently developing a GHG-reduction strategy. The group, which met for the first time in February 2011, is divided into five technical working groups that focus individually on mitigation and adaptation strategies. In addition, the state sponsors a program for distributing compact fluorescent lightbulbs to families. In three years, it has given away four-bulb packages to 186,000 households, at an estimated energy savings of 80% (BECC 2010).

Nuevo Leon

Nuevo Leon is by far the most economically vibrant of the Mexican border states, accounting for 34% of the corridor's GDP in 2010. Over the last decade, it produced 7.5% (annual average) of Mexico's total GDP (INEGI 2010). It is also the most populous border state, accounting for 23% of the region's inhabitants, with 80% living in and around the capital city of Monterrey (CONAPO 2011). Between 2000 and 2011, Nuevo Leon's population grew at a robust annual average of 1.47%, with overall growth of 16.9%; such that the only faster growing border state was Baja California (CONAPO 2011). Population expansion through 2025 is expected to slow to 0.95% annually, but it will still remain higher than the national average and, among the border states, come second only to Baja California. The state's largest population centers after Monterrey are the cities of Guadalupe, Apodaca, and San Nicolas de los Garza, all in the capital metropolitan area.

The same time period oversaw the state's success in becoming a global economic player, making it the leader among Mexico's 32 states in terms of global competitiveness (Gobierno del Estado de Sonora 2009). The state has a reputation as the "industrial center of Mexico," with much of its manufacturing centered in Monterrey (Standish 2009). Current trends in the industrial sector reflect a greater focus on research and technology, with the state government making efforts to encourage investment in aeronautics, biotechnology, and the like. Meanwhile, the state is moving toward a service-based economy. The service sector accounts for half of the state's GDP, while manufacturing accounts for about 25% (Gobierno del Estado de Nuevo León 2010). The state has a rich agricultural area known as the "orange belt" (Standish 2009). While agriculture accounts for only 1% of GDP, it is considered important environmentally, as it preserves space in an otherwise densely populated country (Gobierno del Estado de Nuevo Leon 2010).

In 2005, Nuevo Leon's greenhouse gas emissions were the highest among the border states, with the primary contributors being electricity use and industrial processing (BECC 2011). Nuevo Leon has joined the other border states in a large-scale effort to collect and catalog emissions data. As of 2010, its total emissions related to electricity consumption stood at 8.49 MMtCO2e; that number is expected to reach 18.3 MMtCO2e by 2025 (BECC 2010).

The state's primary source of electricity is natural gas, which stands currently at 5,443 GWh of installed capacity. Expansions are expected to bring that total to 16,747 GWh by 2025 (BECC 2010). Currently, records show that the state has one currently operating CFE-owned power plant, Huinalá, a 978 MW-capacity thermoelectric plant with one gas turbine unit and two combined cycle. An IPP-owned combined cycle natural gas plant, Monterrey III, operates in San Nicolás de los Garza with a capacity of 449 MW. Two combined cycle plants are currently in the planning stages, each with a capacity of 517 MW. They are expected to begin operation in 2015 and 2016 (SENER 2008).

Tamaulipas

Tamaulipas, Mexico's easternmost border state, is relatively modest in size yet has more border cities than any other, thanks to a strip of land jutting west along its northern edge, between Nuevo Leon and the Texas. Known as Faja Fronteriza, the highly populated and industrialized region's nine cities are home to more than 350 maquiladoras. Some of the most populous cities in the region are Nuevo Laredo, Reynosa, and Matamoros. The southeast region is industrialized as well, with activities related to the fishing industry along Tamaulipas' Gulf Coast. The state's size belies its many distinct regions, with tourism along its beaches, cattle-raising in the mountainous Alta del Poniente region, manufacturing (accounting for 20% of the state's economy) in its urban centers, and oil refining in both the north (where oil and natural gas deposits are abundant) and the south. Agriculture also plays a large role in the economy, with sorghum being a particularly important crop (Standish 2009).

The state saw overall GDP growth of 58.6% from 2003-2010, at an annual average growth rate of 7.1%. That number actually hides an erratic pattern in annual growth, which hit a high of 16.48% in 2003-2004 (second only, among the border states, to Nuevo Leon, at 16.65%). Half a decade later, in 2008-2009, GDP growth not only slowed but reversed in five of the six border states (Sonora being the exception); Tamaulipas was among the hardest hit, with an average annual growth rate of -9.68%, faring better only than Coahuila at -10.04%. Unlike Coahuila, however, which sprang back in 2010 with a growth rate of 16.28%, Tamaulipas recovered to a more modest 5.44% (INEGI 2010).

Nonetheless, 2011 saw signs of continued recovery, with companies such as Black & Decker, DuPont, and Matamoros Spellman investing heavily in new operations. The state's development plan for 2011-2016 includes extensive modernization of border and port infrastructure to support security and promote private investment (Torre Cantu 2011). Tamaulipas was among the fastest growing border states in recent years, with population expanding at an average annual rate of 1.42%; overall, it grew by 16.28% in the last decade. According to CONAPO forecasts, population will continue to expand relatively quickly, at an average annual growth rate of 0.89% through 2025 (CONAPO 2011).

Tamaulipas is Mexico's second most prolific generator of electricity, with a total capacity of 5,458 MW (BECC 2010). According to a report from the Border Environment Cooperation Commission, Tamaulipas is a net exporter of electricity and will remain so at least through 2025 (Chacon Anaya, Tamaulipas, 2010; see Chapter 8 of this report). CFE data show that there are currently six IPP and two CFE-owned power stations in operation (CFE 2010). CFE's two plants have four units each; Altamira is a conventional thermoelectric plant, with 800 MW of capacity, while Rio Bravo (also known as Emilio Portes Gil) is a combined-cycle plant, with 511 MW of capacity. All six IPP plants are combined cycle. Three are in Altamira (named Altamira II, III-IV, and V), with capacities of 1,121, 1,036, and 495 MW, respectively. Of the remaining three, all located in Valle Hermoso, two (Rio Bravo II and III) have 495 MW of capacity each, and the other (Rio Bravo IV) has 500 MW (CFE 2010). The BECC report's account of Tamaulipas' energy mix also includes one hydroelectric plant with 54 MW of capacity (BECC 2010). According to a Tamaulipas state government report, as of June 2011, the federal government had awarded 27 federal permits for electricity generation and import, 19 of which were industrial, six commercial, and two agribusiness (Torres Cantu 2011).

As of 2010, natural gas accounted for 96% of the state's capacity, while fuel and diesel oil rounded out the remaining 4%. Dependence on fuel oil will likely decrease over the next 15 years, dropping from 389 GWh in 2010 to 68 in 2025; meanwhile, natural gas generation will increase, from 29,440 GWh to 34,203 (use of diesel oil for electricity, already negligible, will remain so). Greenhouse gas emissions will follow these trends: emissions from natural gas will increase from 12.8 MMtCO2e in 2010 to an estimated 14.9 in 2025. Fuel oil will decrease from 0.61 MMtCO2e to 0.11 (BECC 2010).

The Tamaulipas state development plan outlines broad goals for the promotion of clean energy, including research and technological development initiatives, outreach to both industrial and residential consumers, and a focus on wind and solar in particular (Gobierno del Estado Tamaulipas 2011). As of 2011, 17 of 40 wind projects registered with CRE were in Tamaulipas (Torres Cantu 2011).

4.5 Conclusion

Literature on the effects of power market integration provide ample documentation, through theoretical and empirical study, of the mutual benefit available to neighboring countries. Electricity interconnections between the United States and Mexico can provide benefits to consumers in the form of reliability and emergency support (such as in the case of outages in Texas), reserve reduction and power sharing (leading to more efficient use of existing generating facilities, and by allowing for bilateral energy sales (allowing prices to converge towards a lower final price). The US-Mexico border region is a particularly suitable candidate for integration because of the near universal high demand growth scenario facing the region as a whole. In the coming decades, all state governments will face the requirement of meeting new capacity requirements through the construction of new generating assets, through gains in efficiency, or from the importation of electricity from other areas. Imports hold addition benefits to states such as California and Texas that face structural (market design) or regulatory (environmental laws) impediments to the construction of new domestic capacity.

As a result, the existence of ample renewable resource potential—wind, solar, and geothermal—in Mexico's northern states could provide consumers in the United States with a low carbon energy supply while producers in Mexico would realize gains from trade. Similarly, as has been studied in the ERCOT market, seasonal and hourly price differentials between ERCOT wholesale prices and CFE's marginal cost of production suggest additional gains from trade may be available to producers on both sides of the border.

Texas is clearly the state with the most to gain from integration due to the size of its capacity requirements and the short-term forecast of inadequate reserve margins. However, it may also be the state most unwilling to explore synchronous connections with other regions due to its historical preference for autonomy and independence from FERC oversight. If integration is to be considered in future planning, it will be important for several steps to be taken by regulators. Namely, UN-DESA (2005) describes several preconditions for successful integration initiatives to materialize. These include the exchange of information about demand forecasts and needs between regulating entities, coordination of resource and infrastructure planning to identify congestion zones and opportunities for the siting of new generation assets, engagement of government agencies from both countries in the decision-making process at the ISO level, and the establishment of feasibility studies to determine how cross-border electric transmission facilities would be financed. The forecast for electricity demand growth in the region shows clear economic benefits of integration, and as a result, barriers to increased integration are primarily legal and political.

References

American Public Power Association (APPA). 2010. Retail Electric Rates in Deregulated and Regulated States: 2010 Update. Retrieved January 10, 2012, at http://www.publicpower.org/files/PDFs/RKWFinal2010.pdf.

Bird, L., D. Hurlbut, P. Donohoo, K. Cory, and C. Kreycik. 2009. An Examination of the Regional Supply and Demand Balance for Renewable Electricity in the United States through 2015: Projecting from 2009 through 2015. Retrieved October 15, 2011, at http://www.nrel.gov/docs/fy10osti/45041.pdf.

Border Environmental Cooperation Commission (BECC). 2011. Energia Renovable Y Eficiencia Energetica en Regiones Fronterizas: Iniciativas de la COCEF en Materia de Cambio Climático. PowerPoint Presentation presented at Mexicali, Baja California. Retrieved December 5, 2011, at http://www.energiabc.gob.mx/files/public/downloads/foro_soluciones/10%20Iniciativas%20de%20la%20COCEF%20en%20Materia%20de%20Cambio%20Clima%CC%81tico%20-%20COCEF.pdf.

Border Environment Cooperation Commission (BECC). 2010. Greenhouse Gas Emissions in Baja California and Reference Case Projections 1990-2025. Retrieved December 5, 2011, at http://www.becc.org/english/VLibrary/Publications/Greenhouse_Gas_Emissions/Summary%20Greenhouse%20Gas%20Emissions%20in%20the%20Six%20Border%20States%20and%20Reference%20Case%20Projections.pdf.

Border Governors Conference (BGC), Woodrow Wilson International Center for Scholars. 2009. Strategic Guidelines for the Competitive and Sustainable Development of the U.S.-Mexico Transborder Region. Retrieved December 12, 2011, at http://www.gobernadoresfronterizos2010.org.

Brown, R., and J. Koomey. 2003. “Electricity Use in California: Past Trends and Present Usage Patterns.” *Energy Policy* (also LBNL-47992) 31(9): 849-864.

Bureau of Economic Geology (BEG). 2006. Guide to Electric Power in Mexico. Center for Energy Economics. Retrieved January 1, 2012, at http://www.beg.utexas.edu/energyecon/documents/Guide_To_Electric_Power_in_Mexico.pdf.

CEC. 2010. California Energy Demand Staff Forecast 2010-2020. California Energy Commission. Retrieved December 5, 2011, at http://www.energy.ca.gov/2009publications/CEC-200-2009-012/CEC-200-2009-012-SD.PDF.

CENSUS. 2011. Population Distribution and Change. Issued March 11. Retrieved October 5, 2011, at http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf.

CFE. 2010. Comisión Federal de Electricidad Annual Report 2010, Mexico DF. Retrieved November 20, 2011, at http://www.cfe.gob.mx.

Consejo Nacional de Poblacion (CONAPO). 2011. Population data statistics. Retrieved October 31, 2011, at http://www.conapo.gob.mx.

Considine, T., and D. McLaren. 2008. Powering Arizona: Choices & Trade-Offs for Electricity Policy: A Study Assessing Arizona's Energy Future. Retrieved December 5, 2011, at http://wms.communicationsinstitute.org/uploads/File/Powering-Arizona-Study-Draft-Final.pdf.

Department of Labor. 2010. Bureau of Labor Online Statistics. Retrieved February 2, 2012, at http://www.bls.gov/eag/eag.nm.htm.

Dukert, J. 2003. The Quiet Reality of North American Energy Independence. Institute for Research on Public Policy Working Paper no. 2003-09h, retrieved January 16, 2012, at http://www.irpp.org/miscpubs/archive/NA_integ/wp2004-09h.pdf.

Ford Motor Company. 2011. Ford Targets 30 Percent Water Reduction Per Vehicle. PR NewsWire. Retrieved January 5, 2012, at http://www.prnewswire.com.

Economic Consulting Associates. 2010. The Potential of Regional Power Sector Integration. ESMAP. Retrieved January 15, 2012, at http://www.esmap.org/esmap/sites/esmap.org/files/BN004-10_REISP-CD_The%20Potential%20of%20Regional%20Power%20Sector%20Integration-Literature%20Review.pdf.

EIA. 2011. Energy Information Administration Official Energy Statistics. Retrieved November 11, 2011, at http://www.eia.doe.gov.

Electric Reliability Council of Texas (ERCOT). 2010. Report on Existing and Potential Electric System Constraints and Needs. December 2010. Retrieved September 5, 2011, at http://ercot.com/content/news/presentations/2011/2010%20Constraints%20and%20Needs%20Report.pdf.

EPA. 2012. U.S.-Mexico Border XXI Program. United States-Mexico Border Environmental Indicators, EPA /909/R-98/001. Retrieved January 12, 2012 at http://www.epa.gov/usmexicoborder/indica97.

Gandara, A. 1995. United States-Mexico Electricity Transfers: Of Alien Electrons and the Migration of Undocumented Environmental Burdens. *Energy Law Journal, 16*(1), 1-63.

Garrison, J. 2010. Clean Energy & Climate Change Opportunities Assessment for USAID/Mexico. Retrieved September 5, 2011, at http://pdf.usaid.gov/pdf_docs/PNADS950.pdf.

Gobierno del Estado de Baja California. 2010. Actualizacion Plan Estatal de Desarrollo 2008-2013. Retrieved December 5, 2011, at http://www.bajacalifornia.gob.mx/portal/gobierno/ped/ped.htm.

Gobierno del Estado de Coahuila. 2011. State Government of Coahuila Statistics. Retrieved December 5, 2011, at http://www.coahuila.gob.mx.

Gobierno del Estado de Nuevo León. 2010. Plan Estatal de Desarrollo 2010-2015. Retrieved December 5, 2011, at http://www.nl.gob.mx.

Gobierno del Estado de Sonora. 2009. Marco Juridico Del Plan Estatal De Desarrollo 2009-2015. Retrieved December 5, 2011, at http://www.esonora.gob.mx.

Gobierno Del Estado de Tamaulipas. 2011. Plan Estatal de Desarrollo Tamaulipas 2011-2016. Retrieved December 5, 2011, at http://www.tamaulipas.gob.mx.

Gulf Coast Power Association (GCPA). 2006. The Evolution of US-Mexico Trade – From the Gulf to the Pacific. Gulf Coast Power Association Monthly Luncheon Presentation. Houston, Tex., February 16, 2006.

Hayward, S., and K. Green. Texas Energy and the Energy of Texas. Texas Public Policy Foundation. Retrieved January 5, 2012, at http://www.texaspolicy.com/pdf/2011-01-RR02-TexasEnergyandtheEnergyofTexas-CEE-Hayward-Green.pdf.

Hobbs, B., F. Rijkers, and M. Boots. 2005. The more cooperation, the more competition? A Cournot analysis of the benefits of electric market coupling. *The Energy Journal*. 26 (4): 69–97.

Horlick, G. 2002. NAFTA Provisions and the Electricity Sector. International Institute for Sustainable Development. Retrieved January 15, 2012, at http://www.cec.org/Storage/46/3844_nfta5-final-e2.pdf.

Hughes, T. 1983. *Networks of Power: Electrification in Western Society, 1880-1930*. Johns Hopkins University Press.

Independent Evaluation Group, World Bank (IEG). 2007. The Development Potential of Regional Programs—An Evaluation of World Bank Support of Multicountry Operations. Washington, DC. Retrieved January 5, 2012, at http://siteresources.worldbank.org/EXTREGPROPART/Resources/reg_pgms_full.pdf.

Instituto Nacional de Estadistica y Geografia (INEGI). 2010. Producto Interno Bruto [Data file]. Retrieved November 13, 2011, at http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVR150070#ARBOL.

Karin, C., K. David, and P. Nicolas. 2008. Challenges and Opportunities to Deliver Renewable Energy From Baja California Norte to California. From California Energy Commission website. Retrieved January 15, 2011, at http://www.energy.ca.gov.

Legislative Analyst's Office (LAO). 2010. State of California 2011 Economy and Budget in Perspective. Retrieved January 5, 2012, at http://www.lao.ca.gov/reports/2011/calfacts/calfacts_010511.aspx.

Neuhoff, K., and D. Newbery. 2005. Evolution of electricity markets: does sequencing matter? *Utilities Policy* 13: 163–173.

Pacific Council for International Policy (PCIP). 2009. Managing the United States-Mexico Border: Cooperative Solutions to Common Challenges. Retrieved October 15, 2011, at http://www.pacificcouncil.org/admin/document.doc?id=31.

Pineau, P., and K. Froschauer. 2004. Measuring International Electricity Integration: A Comparative Study of the Power Systems Under the Nordic Council, MERCOSUR, and NAFTA. Retrieved February 15, 2012, at http://www.provedor.nuca.ie.ufrj.br/eletrobras/estudos/pineau1.pdf.

Puga, N. 2006. Recent Developments in US-Mexico Electricity Trade: A Tale of Two Borders. Border Energy Forum XIV. San Diego, California. Retrieved January 1, 2012, at http://www.bateswhite.com/media/pnc/4/media.274.pdf.

Renewable Energy and Energy Efficiency Partnership (REEEP). 2011. Mexico Power Sector Statistics. Retrieved February 2, 2012, at http://www.reeep.org/index.php?id=9353&text=policy&special=viewitem&cid=26.

Rosas-Flores, J., D. Rosas-Flores, and D. Gálvez. 2011. Saturation, energy consumption, CO2 emission and energy efficiency from urban and rural households appliances in Mexico. *Energy and Buildings 43:* 10-18.

San Diego Association of Governments. 2008. California-Baja California Border Master Plan. Retrieved January 15, 2012, at http://www.sandag.org/servicebureau.

Sarmiento, H. 2010. Issues associated with international power grid interconnections in Mexico. Transmission and Distribution Conference and Exposition, 2010 IEEE PES, pp.1-6, April 19-22, 2010. Retrieved February 12, 2012, at http://ieeexplore.ieee.org.ezproxy.lib.utexas.edu/stamp/stamp.jsp?tp=&arnumber=5484529&isnumber=5484192.

SENER. 2008. Secretaría de Energía *Prospectiva del Sector Eléctrico 2008-2017*. Mexico, D.F. Retrieved November 15, 2011, at http://www.sener.gob.mx.

SENER. 2011. Electricity Statistics: Basic Information, 1999-2011 [Data file]. Retrieved January 5, 2011, at http://www.sener.gob.mx/portal/Default.aspx?id=1606.

Standish, P. (2009). *The States of Mexico: A Reference Guide to History and Culture*. Greenwood Press.

Sweedler, A. 2003. Energy Issues in the U.S.-Mexican Border Environment: Trade, Energy and the Environment: Challenges and Opportunities for the Border Region. San Diego State University Press. Retrieved December 5, 2011, at http://scerp.org/pubs/m11/chapter%201-5.pdf.

Torre Cantú, E. 2011. Primer Informe De Gobierno. State Government of Tamaulipas. Retrieved December 5, 2011, at http://transparencia.tamaulipas.gob.mx/wp-content/uploads/2011/11/primerinfotamps2011.pdf.

Torres Roldán, F., and E. Gómez Morales. 2006. Energías Renovables para el Desarrollo Sustentable en México [Renewable Energies for Sustainable Development in Mexico]. Retrieved November 15, 2011, at http://www.sener.gob.mx/res/PE_y_DT/pe/FolletoERenMex-SENER-GTZ_ISBN.pdf.

United Nations, Department of Economic and Social Affairs (UN-DESA). 2005. MultiDimensional Issues in International Electric Power Grid Interconnections. New York: United Nations. Retrieved January 15, 2012, at http://www.un.org/esa/sustdev/publications/energy/interconnections.pdf.

US Department of State. 2011. US-Mexico Bilateral Framework on Clean Energy and Climate Change, H.R. Doc. No. tk-tk99834. Retrieved January 2, 2011, at http://mexico.usembassy.gov/press-releases/ep110523-climate.html.

Valeri, L. 2008. Welfare and competition effects of electricity interconnection between Ireland and Great Britain. *Energy Policy* 37: 4679-4688.

Villarreal, M. 2011. U.S.-Mexico Economic Relations: Trends, Issues, and Implications. Congressional Research Service. Retrieved December 14, 2011, at http://www.crs.gov.

Wolak, F. 2009. Making More from Less: Environmental Constraints and California's Future Electricity Investments. Stanford University Press. Retrieved January 5, 2012, at http://www.stanford.edu/group/fwolak/cgi-bin/sites/default/files/files/Making%20More%20from%20Less_Environmental%20Constraints%20and%20California%E2%80%99s%20Future%20Electricity%20Investments_Wolak.pdf.

Wood, D. 2010. Environment, Development, and Growth: U.S.-Mexico Cooperation in Renewable Energies. Woodrow Wilson International Center for Scholars. Retrieved October 8, 2011, at http://www.wilsoncenter.org/sites/default/files/Renewable%20Energy%20report.pdf.

Chapter 5. The Grid, International Pools, and Exchanges

by Dyan Knapp and Claire McEnery

Abstract

After the North American Free Trade Agreement, The United States, Canada, and Mexico began discussions of an integrative electricity market. However, the events of September 11, 2001, and subsequent security concerns delayed this endeavor. Electricity demand on both sides of the United States-Mexico border is resuming its rapid growth after 2008-2009. With this growing demand for energy and increased pressure to bring green energy alternatives to the market, consumers in North America can benefit from an integrated energy market in the form of lower prices and cleaner energy resources. The development of this market, without disrupting current supply and keeping costs low, is a major concern in the drive for market integration in North America. This chapter addresses the benefits and challenges of establishing an integrative North American electricity grid. It will look carefully at other international electricity pools in Britain, Chile, Argentina, Scandinavia, and Spain. These systems will provide lessons for North America concerning regulatory structure, efficient pricing, and the sharing of maintenance and upgrade costs.

5.1 Introduction

After the launch of the North American Free Trade Agreement (NAFTA), the post-NAFTA economic and political environment in North America led to discussions of further integration of the electricity markets of the United States, Canada, and Mexico. The United States and Canada began the creation of a rather integrative bilateral grid, and Canada is part of the National Energy Reliability Council (NERC) application of standards. The two economies benefit from seasonal energy consumption differences and the ultimate goal of is a well-regulated transmission network with a competitive market for generating capacity that also includes Mexico. A more integrated grid and increased trade throughout North American would allow customers to enjoy a host of benefits, including lower prices and cleaner energy resources. The ideal network includes a total social welfare-maximizing plan to expand the transmission network, curb the monopolistic tendencies of generation participants in the market, and maximize the use of clean energy.

Reliability, congestion, price, and the environment are four major concerns for grid expansion. A United States-Canada report on the causes and effects of the 2003 blackout states that the disaster affected approximately 50 million people and that the cost of the blackout was about $6 billion (Minkel 2008). This is one example of the high costs of unreliable transmission, especially in today’s global economy. According to the report, the principal causes of the blackout were inadequate regulation, ignorance of or lack of adherence to industry policies, and insufficient management on the ground. Tree growth was the perpetrator of three of the transmission line outages. This particular example points to the necessity of meticulous oversight and maintenance in order to ensure reliable supply. The design and function of the system operator and regulator are paramount to ensuring reliability of generation and transmission (Minkel 2008).

Increased demand for electricity and the high potential for congestion along the United States-Mexico border is one major motivation for an enhanced North American grid that includes the Southern NAFTA partner. A challenge of grid expansion will be ensuring that supply does not underestimate demand and that transmission congestion does not drive up prices or cause power shortages and blackouts. This is especially challenging for an international grid, because it requires regulators to communicate increases and changes in demand to one another.

Recent literature points to the positive relationship among electric grids, economic development, and clean energy innovation (Kaudinya and Balachandra 2009). Lower prices to consumers and industry have many potential benefits. Electrification is commonly associated with increased living standards and growth of national economies. The benefits to industry are most obvious. More lighting and power are often associated with more innovation and faster rates of economic growth (Hogan 1992; Leautier and Thelen 2009). No country seeks to decrease the amount of light and energy it can provide to its citizens, and regulators must ensure reliability for domestic consumers before exporting electricity services out of a country. Keeping electricity affordable is paramount to increased rates of economic growth and increasing standards of living. The creation of this competitive market is a major challenge for integrated electricity grids

We can greatly enhance the use of clean energy in place of non-renewable sources through the creation of a well-functioning integrated market. This is already happening on some parts of the continent. For example, British Columbia exports energy to the American Northwest in the summertime and imports energy during the winter. This allows both the western United States and Canada to take advantage of lower prices and increase reliability. As a bonus, British Columbia's energy exports include hydroelectric power, which allows Americans to consume more energy without causing additional harm to the environment. The Nordic market has had a similar experience, as clean hydropower from Norway is available for purchase and use by Sweden and Finland via a common energy pool (Dugstad and Roland 2003).

Concerns over global warming have persuaded policymakers to utilize supplies of clean energy in a national electricity grid. However, introducing clean energy sources is not as easy as simply installing solar panels in the desert or erecting wind turbines in West Texas. The experience of the Electric Reliability Council of Texas (ERCOT) in pricing electricity produced by wind as well as connecting turbines to the electric grid provides an example of the challenges of integrating clean energy sources into the existing market (Sioshansi 2009). Nevertheless, the availability of clean energy sources via an integrated market is a step in the right direction.

This chapter is organized as follows. Section 5.2 provides the underlying reasons for grid expansion in North America and the inevitable challenges we foresee. In 5.3, we analyze global experiences of grid expansion and extrapolate lessons for North America. Section

5.4 reviews the dominant literature on the optimal structure of electricity markets. In 5.5 we apply findings from that literature to the North American grid to assess the countries' readiness of further integration. Section 5.6 describes the relationship between increasing the use of renewables and expanding the grid. And Section 5.7 concludes by summarizing the benefits and challenges associated with increased trade of electricity through the creation of a more integrated transmission network.

5.2 Grid Expansion and Underlying Reasons

Decisions concerning grid expansion include how to organize and monitor transmission, how to attract investment in transmission, how to deal with congested lines in the short versus the long run, and best methods of pricing electricity that incentivize expansion (Kristiansen and Rosellon 2007; Leautier and Thelen 2009; Hogan, Rosellon, and Vogelsang 2010; Vogelsang 2001). Without coming to a consensus on these methods, the North American market faces social welfare losses that may include higher prices, lower reliability, and increased congestion on the grid.

The transmission system is the most important element of the grid. Connecting generators to distributors, a strong transmission system is crucial for maintaining power reliability and facilitating competition among generators. The transmission system is vital to the future of renewable power generation as it connects these often remotely located power sources to cities (Gilbert et al. 2002). Investment in US transmission expansion declined steadily between 1975 and 2000 at an average rate of $115 million per year (Hirst 2000). Building generation closer to loads and new technologies that allow system operators to operate the grid closer to its physical limits have substituted for grid upgrades; however, this cannot last forever (Hirst 2000). Expanding the grid is a critical challenge.

Experiences in deregulation of the power market show that competition among generators provides low-cost reliable power to consumers; however, transmission and distribution are still considered natural monopolies (Rosellon 2003). Under these circumstances, the expansion of transmission capacity is far more difficult than the expansion of privately owned generation. Additionally, from an engineering standpoint, the nature of electricity flow makes grid expansion difficult. Suppliers cannot determine the path of electricity transmission, since electricity takes the path of least resistance. Expansions in the grid therefore affect other parts of the network (Gilbert et al. 2002). Building transmission in increments of voltage further complicates investment decisions, since the added capacity cannot perfectly meet demand for increased voltage (Hirst and Kirby 2001).

The natural monopoly aspect of the grid makes investment decisions particularly difficult. The question of who should pay for upgrades and expansion has no simple, widely accepted answer. One school of thought, known as "beneficiary pays," says that the beneficiaries of expansion should pay for the upgrades. Another asserts that transmission is a regional social good and therefore everyone in the region should bear some of the cost. This is known as postage-stamp pricing (Hirst 2000). However, before deciding who should bear the cost of an expansion project, the project itself must be approved. This is no easy task. Opposition to new projects is often fierce, as is shown in the corresponding chapter on US regulations. Hirst (2000) points out that "The key obstacles to building new transmission lines are local opposition and the associated local and state regulatory-approval processes." Opposition to new lines is typically of the not-in-my-backyard variety with environmental and aesthetic concerns being the leading reasons for opposing transmission expansion projects. To overcome this, Hirst recommends that rather than utility companies presenting a completed plan to the local community for approval, the planning process should involve local community leaders as much as possible to increase the likelihood that the project will be approved (Hirst 2000).

Different methods of approaching the investor problem for transmission expansion exist in the academic literature. One is the "merchant approach" where an independent systems operator (ISO) facilitates auctions for long-term financial transmission rights (FTRs). To be economically viable, long-term FTRs require a fixed-price charge to enable investors of the expansion project to recover upfront costs. A "cost-of-service" regulation allows for the recovery of these fixed costs in the United States, in specific cases such as the PJM interconnection, originally between Pennsylvania, New Jersey, and Maryland (Rosellon 2003). Another approach is that of the regulated transmission company (TRANSCO). The method builds on the natural monopoly characteristics of the transmission system and combines a regulator in the form of an ISO with private investment. The ISO offers the Transco a range of expansion project possibilities, all allowing the Transco to recover its costs while efficiently building and upgrading the grid. This mechanism is thought to be preferable to the auction of long-term FTRs since it places the responsibility for all externality considerations with one firm (Rosellon 2003; Schill, Rosellon, and Egerer 2011). This is expected to make expansion projects more efficient both in terms of gaining approval and implementation. The third method, "strategic behavior of generators," involves the ISO leading the facilitation of transmission investment. Under vertical integration, the integrated company makes all decisions concerning whether to invest in expanding transmission capacity, added generation or both.

The proposed methods for attracting investment and the problems that arise for each method lead to two general conclusions. First, investors in transmission capacity must be able to recover the costs of their investments. If they cannot they will become reluctant to invest in future expansion (Hirst 2000). Second, regulatory uncertainty hinders grid expansion. In order to expand capacity, utilities must acquire a variety of permits and approvals from various state agencies, often from more than one state. To alleviate some of this regulatory burden FERC recommends utilities form Regional Transmission Organizations to better coordinate planning efforts and eliminate many of these overlapping regulatory requirements (Hirst 2000; Kirby 2001).

The Electricity Reliability Council of Texas has successfully implemented new transmission projects. ERCOT has been able to move forward with these investments because it is a smaller system than PJM, for example, so loop flows are less of an issue, and it faces far fewer regulatory hurdles since it lies outside FERC's jurisdiction and works with an ISO in the planning process (Hirst 2000). ERCOT is a functioning ISO for most of the state of Texas.

Further complicating the future of transmission capacity is the anticipated smart grid revolution. Allowing customers to change their demand patterns through the use of smart meters, smart devices, dynamic pricing, and distributed generation will reduce congestion on the grid to make expanding transmission capacity less necessary. Avoiding capital costs is the name of the game (Fox-Penner 2010). However, the smart grid can only be implemented in steps as utilities install smart meters and shift to dynamic pricing. Consumers must purchase smart devices and develop new habits of demand management, mostly from industrial and commercial activities. It will take time to introduce smart grid technologies to residential markets. In the meantime, demand for electricity continues to rise, placing ever more strain on the current grid structure.

The future of the grid is difficult to predict. The structure of utilities is heading towards deregulation and competition for generators with public or privately-owned, yet regulated, transmission and distribution systems. Added generation capabilities, the smart grid and new technologies that allow for operation of the transmission system closer to its physical capabilities all suggest the need for less expansion than more. However, these advances are still somewhere off in the future while demand placed on the grid continues to increase. The economies of scale inherent in transmission favor overbuilding rather than underbuilding (Hirst 2000; Kirby 2001).

As a natural monopoly, it makes economic sense for one transmission grid to serve all of North America. Currently however, Canada, the United States, and Mexico do not regulate their grids in a uniform manner. Convergence must be reached concerning the ownership and regulation of the grid. The grid as such is a collective action problem and questions concerning ownership, investment, and expansion inevitably arise. While the transmission system is best left in the hands of large, integrated operators, vibrant market competition can exist within generation. Ideally, this competition will lead to greater efficiency in the system and lower cost for consumers.

The electricity industry is concerned with minimizing costs of investment in expanded transmission networks and increases in generating capacity while maintaining reliability of the system to meet forecasted demand for electricity. Transmission infrastructure facilitates the availability of electricity to light cities and homes and provide power for industry. As such, electricity tends to increase overall social welfare. Economic theory asserts that total social welfare is composed of consumer as well as producer surplus. As producers attempt to keep the cost of generation and transmission investment low, consumers want the price of electricity to remain low. At first glance, it might seem that the two are compatible. However, private generators and owners of transmission networks, operating within a competitive market, must accrue a profit in order to invest in the future of the grid at the same time that competitive forces are present.

Ideally, owners and generators operate in the context of a perfectly competitive market where price is equal to marginal cost and no market participant can exercise any sort of monopolistic control over the market. However, the reality of maintaining fair prices for consumers is the pervasive problem of the regulator. In many countries, generators exercise their market power, and in some instances cozy relations with regulators and politicians have exacerbated these power dynamics.

The challenging endeavor of creating a North American grid includes an increase in the supply and transmission of electricity, including increased use of renewable energy and the introduction of smart grid technology. Regulators must assess the costs and benefits associated with each stage of this transformation. While proponents of smart grids emphasize the enormous environmental and economic benefits of introducing this new technology, regulators are often reticent when it comes to taking risks on cutting edge technology without the support of any historical precedent. While there are precedents for establishing international pools and exchanges results have been mixed. In order to ensure that this particular international grid is successful, we must draw on all of the examples of other international pools as we seek to maximize benefits and overcome challenges. What follows are country specific analyses of restructured electricity markets. These cases shed light on the most effective way to create a North American grid while ensuring reliability, minimizing congestion, reducing price, and incorporating clean energy resources.

5.3 Country Profiles

According to Bye and Hope (2005), five basic requirements must be met for a market-based power system to operate: a market for trade, instruments for hedging risks, short-term markets to balance supply and demand, markets for investment in new capacity and markets for trade in environmental energy products.

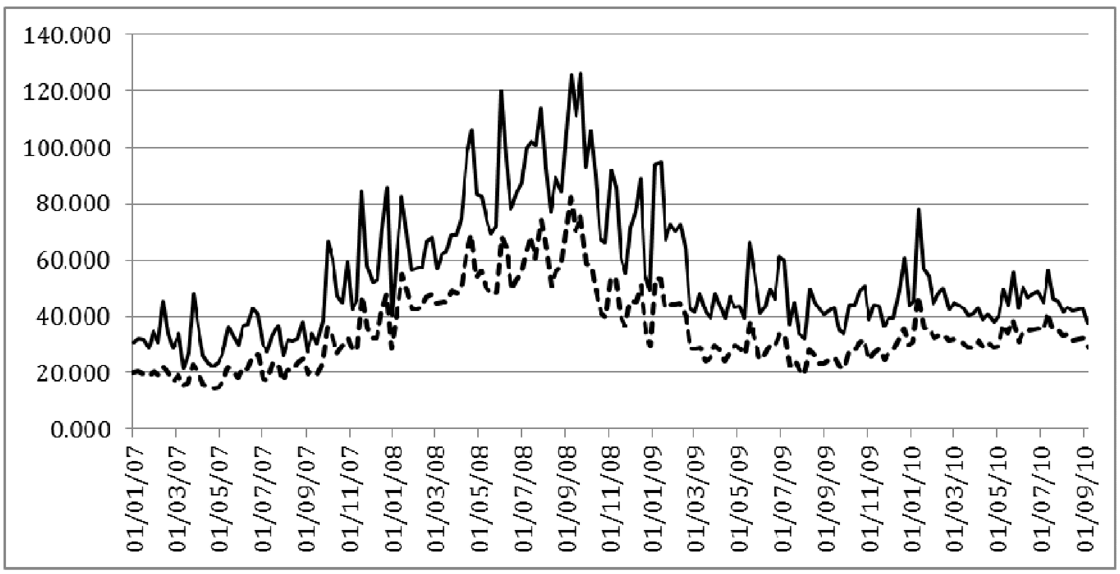
5.3.1 The British Experience and Hurdles

In 1980, Britain launched a privatization program for its energy markets. Three objectives motivated the privatization of Britain's energy markets: "Generation of government revenues, widening share of ownership and breaking trade union power" (Thomas 2005). Privatization included flotation of shares in the telecoms, gas and water industries. Shares were also made available for the public to purchase. Not knowing the market value of the public utilities, the government underestimated the true value of them to encourage sale of the shares and to minimize risk to investors. However, Britain did not break up the large generating companies prior to privatization. Furthermore, the government remained committed to the use of nuclear as an energy source, and attempted to privatize them via "shelter" companies owning most of the capacity. This led to a duopoly between the two largest companies, National Power and Nuclear Electric (Thomas 2005).

In terms of the transmission structure for Britain's energy market, the priority was that transmission not be owned by a generator. All generators were meant to have equal access to the United Kingdom's transmission network. Coupled with a competitive market for generation, the expectation was for lower prices for electricity. However, in 1990 in Britain the cost of generation made up only 60% of the price of electricity. The "Power Pool" was created to facilitate competition among generators for access to the electricity grid. In the Pool, supply and demand would balance every half hour, generators would have to place successful bids, the Pool price would be the highest bid and be paid to all bidders and retails would be forced to buy their supplies from the Pool (Thomas 2005). The intention of the Power Pool was to lower barriers to entry for Britain's generators and retailers.

The following graph shows the bid and ask wholesale price in Great Britain, to demonstrate that prices are more complex than only assuming the market to be liberalized. Bid and ask prices show a downward trend, where bid prices are always higher, with some spikes such as the beginning of year 2010.

Figure 5.1
Bid and Ask Prices in the UK



Source: OFGEN, online overall and average prices (2012).

Note: Bid is continuous line, Ask is dotted line.

By 2004, Britain's electricity market appeared to be competitive. No company owned more than 15% of market share. However, financially distressed companies owned 40% of capacity. The experience of privatization and deregulation in Britain has been judged a failure (Thomas 2005). The Power Pool mechanism was undermined by the allowance of bilateral contracts in the market. Under these arrangements, a generator and supplier contracted for a fixed price regardless of the Pool price. British generators were required by the government to buy British coal for three years following privatization, for which the pass-through of prices of inputs were compulsorily being granted to final prices by generators. The contracts were renewed for five years in 1993. The price for British coal was well above world market price at the time. The government was also forced to subsidize the nuclear plants. All these arrangements undermined the establishment of a competitive market for energy in Great Britain. Failure to break up the large generating companies, bilateral contracts between generators and suppliers, and the subsidies to the nuclear plants all worked against the establishment of a competitive generating capacity competing for access to a well-regulated transmission network (Thomas 2005).

Interestingly, the experience of privatization in Britain resulted in lower prices. However, this had little to do with privatization and more to do with outside influences. In 1996, the government eliminated the subsidy to nuclear plants. Between 1990 and 2001, the price of fossil fuels fell between 30% and 50%. Privatization did allow for the elimination of monopoly pricing. Three foreign companies, Electricite de France, E.ON, and RWE have fared well in the British market, and they have added outside competition in the former monopoly market in Great Britain. Few, if any of these price decreases have been passed on to British consumers. Thomas (2005) passes harsh judgment on the British electricity market, stating "The criterion on which the reforms must be judged is whether efficient markets have been created. On this criterion, they have failed."

During the structural adjustment era in Latin America, many countries restructured their electricity markets following the British example. Chile, Argentina, Bolivia, Brazil, and Colombia had all begun to reform their power markets by the mid-1990s and by 2005 Mexico and Venezuela were the only two Latin American countries that had engaged in very little reform (Millan 2005). However, the motivations for reform in these developing countries were different than they were for Britain. Developed countries liberalized their electricity sectors to reap the benefits of greater efficiency while Chile (the "pioneer" of electricity liberalization) and other Latin American countries had suffered economic crises during the 1970s and 1980s, and pursued liberalization and privatization as a means of relieving state governments from investing capital in public utilities (Weigt 2009).

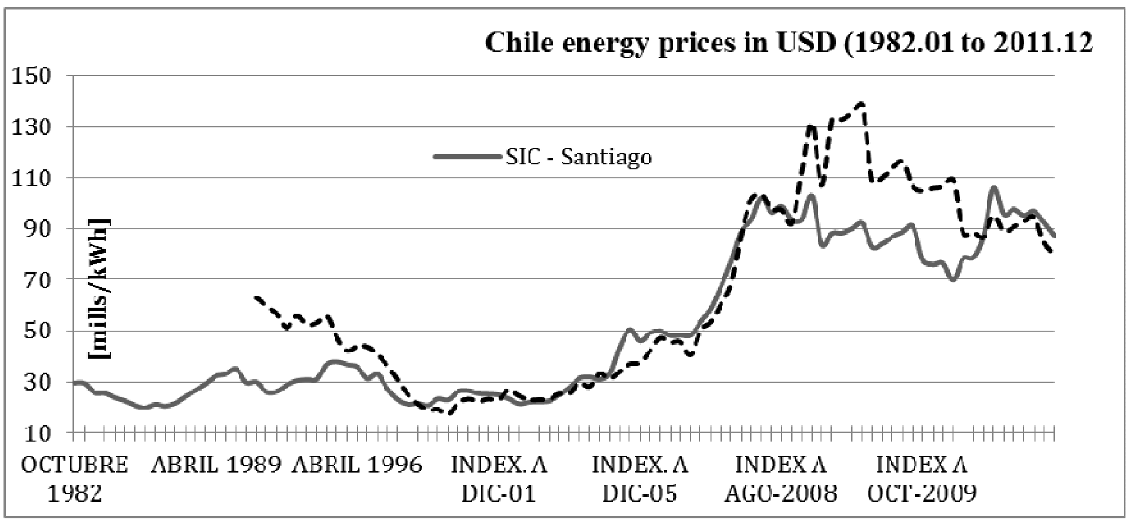
5.3.2 Chile as Latin American Leading Restructured Market, and Partnership with Argentina

Chile was the first Latin American country to restructure its electricity sector. State officials drew on what little global experience there was in 1982 when they privatized the sector, unbundled generation from distribution, and implemented spot pricing and marginal cost pricing. Chile was among the first countries to use the "merchant transmission" mechanism, which meant generators paid for transmission access to existing lines as well as for new lines, either by building their own or by negotiating with transmission companies. This became problematic because it did not allow transmission companies to charge consumers for expansion, and it was difficult to attract investment in new lines (Pollitt 2004a; Pollitt 2004b).

Chile established the National Energy Commission (CNE) to set distribution charges and report to the Minister of Energy. The Superintendent of Prices of Electricity and Fuels ensured quality of service and that all firms abide by laws and regulations. Despite the privatization and horizontal unbundling of generation, the sector remained highly concentrated in the hands of three firms: Endesa, AES Gener, and Tractevel. In 2004, Chile enacted the *ley corta* or "short law" in an attempt to overcome many of the shortcomings of restructuring, including this highly concentrated generation sector and the difficulty of attracting investment in transmission expansion (Pollitt 2004a).

Chile's restructuring and privatization program as a whole did succeed in attracting investment and expanding transmission lines. The number of households with electricity more than doubled between 1982 and 2002, prices fell substantially for industrial consumers (the effect on residential prices is less clear), and labor productivity improved dramatically. Chile, the pioneer of electricity reform in Latin America, set the wheels in motion for the rest of the continent (Pollitt 2004a). The following graph shows the main Interconnected System (SIN) node prices in this economy. Prices have recently experienced an upward trend, mainly due to drought conditions in 2008 in the sub-continent, since Chile shares water resources for generation with Argentina:

Figure 5.2
Chile Energy Prices 1982-2011



Source: Chile Comisión Nacional de Energía. Retrieved February 22, 2012, at http://www.cne.cl/cnewww/opencms/06_Estadisticas/energia/Electricidad.html.

In 1992 and 1993 Argentina passed Law 24,605, which privatized 80% of its generation sector, 60% of its distribution, and all of its transmission. It vertically and horizontally unbundled the industry and its two largest state-owned companies, Servicios Electricos del Gran Buenos Aires and Agua y Energia Electrica, were broken up into a number of generation and distribution firms. Like Britain, Argentina realized the natural monopoly character of transmission and distribution and established an independent national electricity regulator to prevent firms from exploiting market power. The state recognized that generation would be a competitive market, however it did mandate that all generators receive a uniform rate. By 2001 there were more than 40 generation firms and more than 30 distribution utilities in Argentina (Pollitt 2004b).

Argentina mimicked Britain and Chile's privatization and wholesale market designs. It used a cost based bidding system and an independent systems operator. It followed Britain's lead when it unbundled generation, transmission, and distribution, and created MEM, a Wholesale Electricity Market, which in 2004 covered approximately 93% of Argentines' demand. Its generation sector proved less concentrated and more competitive than most European and North American countries, according to Pollitt (2004b).

Again, one of the major challenges of transmission expansion is deciding who pays for the new lines. Argentina used the "Public Contest" mechanism, whereby consumers retroactively pay for expansion**.** This mechanism proved problematic because users who were not the ones receiving large economic gains from the expansion, became reluctant to pay for new transmission lines. Estache and Trujillo (2008) stress the fact that infrastructure restructuring via privatization is more successful when it incorporates stricter regulations alongside market driven forces (see also Pollitt 2004b).

The restructuring and privatization of Argentina's electricity sector succeeded in attracting a high degree of foreign investment (although many argue that it is difficult to measure the direct results of electricity market restructuring, due to the structural adjustment period and subsequent increased foreign investment into the economy at large). In 2004 electricity prices were lower than anywhere else in Latin America and in most of the world. Plant availability and labor productivity also improved drastically (Dubash and Singh 2005).

5.3.3 The Scandinavian Regional Market

With a competitive international market, Scandinavia is often touted as the quintessential example of successful privatization, deregulation, and energy market integration. The slow pace of privatization and the role of public ownership mark the Scandinavian experience as unique from most other attempts at liberalization and market integration. The focus for Nordic reforms on the establishment of a competitive market and less on privatization also makes the Scandinavian experience different from others (Dugstad and Roland 2003).

Norwegian reforms began with an act passed in Parliament in 1990. The institutional structure was completed in 1993. Norway's power companies were required to separate grid and production activities. The responsibility for the grid was hived off from Statkraft, the major public utility company, and placed in the care of newly created Stattnett. Norway removed any remaining impediment to competition in 1997. Reforms in Sweden were similar in nature to Norway's with the addition of the requirement for complete separation of distribution and supply activities (Dugstad and Roland 2003).

In 1996, Norway and Sweden integrated their power markets. Svenska Kraftnet, Sweden's grid operator acquired 50% of Statkraft. The new entity was dubbed Nord Pool. Power companies in Finland were granted access to Nord Pool later that year. Finland was fully integrated into Nord Pool in 1998. Denmark joined in two stages. First Jutland entered in 1999, followed by Zealand the next year. Today, all power trade among the four countries is conducted through Nord Pool as a coordinated power exchange in the regional market NORDEL that accounted for 9% of the total European installed capacity since 2000, according to Bielecki (2004). The major factor influencing the success of Nordic energy liberalization is the elimination of the national policies of self-sufficiency, a characteristic unique to the Scandinavian market and not present in North America. This could be a main impediment to full integration in North America along the lines of the Nordic example. In the current Nord Pool market, Denmark is typically a capacity exporter, while Norway and Sweden are importers, while the compact NORDEL exports both to the European Russia and also to the South (the so-called UCTE market, led by Germany and France), with high capacity connectors, and insured installed capacity, to face energy balances with high variations in the pool (Dugstad and Roland 2003; Montravel 2004).

The experience of the Nordic countries seems to suggest that the transmission network works best as a public good. National champions Stattnett in Norway and Svenska Stattkraft in Sweden are firmly in control of a large part of the Scandinavian transmission grid. Working under a common, independent regulator these two companies are able to ensure reliable, low-cost electricity to the Nordic energy market (Dugstad and Roland 2003).

5.3.4 Spain and its Dismembered Regions

Attempted deregulation in the Spanish electricity market provides an excellent example of how firms attempt to utilize market power. The two largest electricity providers, Endesa and Iderbola, act as a duopoly in the market, with several smaller firms participating. While Spain was able to establish an independent regulator in 1997, the two largest firms have been able to outmaneuver it. Political ties to the Ministry of Industry and contracts with the largest producer of fuel for generation have enabled Spain's twin electrical powerhouses to get around much of Spanish regulation (Arocena, Kuhn, and Regibeau 1999). Arguments for this situation include the need to have large companies in order to compete on the global electricity market. However, Spain is barely connected to even its closest neighbors, France and Portugal. Not breaking up the two utility giants prior to privatization has allowed them to become practically monopolies (Arocena, Kuhn, and Regibeau 1999).

5.4 Literature Review on Approaches to Grid Evaluation

There is much debate concerning the optimal structure of an integrated energy market. The type of transmission system, the role of generators and regulators, and benefits of vertical integration versus unbundled systems are questions plaguing the energy industry. Existing literature provides suggestions as to how to identify the current systems that work best and how to design the most efficient grids.

Design of the optimal network structure must take into account many elements of generation, distribution, transmission, and regulation. According to Tangeras (2005), the optimal network structure depends on four challenges. The first challenge is finding a common regulator that can successfully balance the interests of all member states, as well as deciding whether one or more regulators should manage the transnational network.

The second dilemma is the fact that market integration will vary from one country to another. The third is substitutability versus complementarily of network characteristics. And the fourth is the social cost of operator rent. A thorough analysis of how domestic and international pools have confronted these challenges in the past provides lessons concerning what the optimal structure is for North America.

Schweppe (1988) identifies the transmission grid as essential to the functioning of power markets. The role of the transmission grid in a post-restructuring setting is to increase competition among generators, in addition to its role of improving reliability and meeting demand. While market-based competition among generators may be ideal, the transmission grid is the ultimate natural monopoly. In the context of an international grid, debate now turns to who should own, operate, and invest in grid expansion and maintenance. Leautier and Thelen (2009) provide an overview on grid expansion and then compare experiences from 16 jurisdictions that have restructured power systems over the last 20 years. They assert that "while vertical separation may be necessary, it is not sufficient to induce grid expansion: a well designed incentive scheme is also required." These incentives include financial rewards and penalties for controlling congestion. When both vertical separation and specific incentives are present, significant congestion reduction is observed.

Tangeras (2005) discusses whether an integrated or separated transmission grid is the best option. In this example, he cites the Scandinavian energy market as a textbook case of optimal network structure. Each member of Nord Pool has its own national regulatory agency, while the entire network is overseen by a common regulatory agency. Most current literature favors unbundling over vertical integration of the network structure. However, Leautier and Thelen question whether full vertical unbundling is necessary, or whether "legal unbundling" is sufficient enough to induce grid expansion (Leautier and Thelen 2009). Again, Tangeras presents the Scandinavian network structure as the ultimate compromise between a separated and integrated network structure.

A properly operating transmission grid in an efficient market will significantly reduce the risk of congestion. Persistent congestion problems logically seem to necessitate grid expansion. However, Leautier and Thelen emphasize that reduction in the cost of congestion is not the only way to measure the necessity of grid expansion. Factors such as load growth, fuel prices, availability of alternative energy sources and lack of adequate generating capacity also contribute to congestion and may not necessarily be related to an inadequate transmission infrastructure. Numerous articles suggest that regulatory contracts can be structured to induce an independent transmission company to expand the grid optimally, under various alternative scenarios ranging from command and control by a regulator, passing through allocating part of expansion incentives to market forces and part to Financial Transmission Rights (LTFTRs) plus reserve funds to full market social allocation of any grid improvement (Leautier 2000, Vogelsang 2001, Hogan et al. 2007).

While much focus has been given to the role of the transmission system, the transmission grid represents only about 6% to 10% of costs of producing electricity for many power systems, but given the nature of sunk costs and network externalities, making the long-run investment is a complex project with less than clear profitability outcomes. As a natural monopoly, it is likely that the transmission grid will be publicly owned. How then can competition be created in the electricity markets? The answer lies with the role of the generators. Competition among generators is the key to creating an efficient market-based energy system. Bye and Hope (2005) provide a description of the proper design and operation of a market-based power market. They list five basic requirements:

1. A market for trade;
2. Instruments for risk hedging;
3. Short-term markets to balance supply and demand;
4. Markets for investment in new capacity; and
5. Markets for trade in environmental energy products.

Thomas (2005) judges the results of Britain's liberalization of its electricity system by the criteria of whether or not efficient retail and wholesale markets have been created. The government's priority was to ensure the separation of transmission from generation. Competition among privately owned generation companies was expected to significantly reduce prices. High entry barriers to new generation capacity resulted in the failure of the British wholesale market to promote competition and reduce prices. While prices have been lowered in the British market, it has been due to exogenous factors, such as decreases in the price of fossil fuels and the undervalued sale of power stations by the British government.

The literature on existing integrated energy markets identifies many cases of success and failures. The experience of the Scandinavian countries is generally judged the penultimate success story of an integrated energy pool with an efficient market-based system of generator competition. Nord Pool meets four out of five of Bye and Hope's five basic criteria for a market-based power system. The authors maintain that Nord Pool does not meet the requirement for investment in new capacity due to concerns over environmental degradation by expanding capacity. This has resulted in price increases, but not yet to the level triggering further expansion.

Dugstad and Roland (2003) analyze the formation of the Scandinavian electricity market. While judged the most successful international pool in existence, Nord Pool still faces challenges, particularly in the area of new capacity building. Electricity prices in Scandinavia have significantly decreased since Nord Pool's creation; however, that has been due to the utilization of surplus capacity in the national systems. Conflicting political agendas concerning the environment have stalled the building of new generating capacity to serve the Nordic market. The most significant point of this literature is the assertion that a "market-based system will not work without the support of a well-designed regulation" (p. 143). Competition was assumed to decrease the role of regulation. In practice, the tendency is however for an increased role of the regulator in competitive markets.

As we strive to design a successful transnational North American grid, we must integrate the theoretical work of authors like Joskow, Tangeras, Bye, and Hope with the more specific case studies of the Scandinavian, British, and Spanish experiences. Furthermore one must carefully consider elements of the political and economic climate of North America that will determine what the optimal structure is for North America.

5.5 Application of Bye Requirements to the North American Grid

Bye and Hope's (2005) five requirements for a market-based power system are largely present in North America. The market for trade is evident in the volume of binational trade that already occurs between Canada and the United States and the growing demand for power along the United States-Mexico border. Since load is the most important factor determining the price of electricity, drastic climate differences among and within the three North American countries ensure that there will be high demand among consumers and wholesale buyers for increased trade. Recent blackouts and congestion in the Pacific Northwest are also evidence that that there is a market for increased trade even between the United States and Canada.

Instruments for risk hedging are also present in North America. While many markets in the United States no longer trade electricity futures, they do use forward contracts in over the counter markets to protect themselves against price volatility. Other North American markets take advantage of weather derivatives. The Chicago Mercantile Exchange, for example, started a market for Heating Degree Days and Cooling Degree Days derivatives in 1999, and by 2005 it had reached a trading volume of 30,000. Weather derivatives are a major component of trade between Canada and the United States and will continue to play a key role in the expansion of trade in that part of North America (Oum, Oren, and Deng 2006). As far as Bye and Hope's third requirement, short-term markets to balance supply and demand, a number of ISO's throughout the United States provide real time market prices. ERCOT, for example provides day-ahead market prices as well real-time market prices on an interval basis.

Bye and Hope's fourth requirement, markets for investment in new capacity, has been a challenge in North America as it has been in energy markets around the world. In the United States and Canada, investment in transmission lags behind investment in generation, which means that areas that could benefit from more trade, such as the Pacific Northwest and western Canada, suffer from congestion and lack of infrastructure. As demand increases in both countries, so will investment in generation, which will call for steep investments in transmission capacity to avoid congestion (Egan 2007). Investment in connections along the US-Mexico border will also have to increase in order to meet growing demand and generation investment there. There is clearly demand for investment in new capacity, but the challenge will be determining who takes on the risk of investment, a particular challenge for an international pool.

The final requirement, markets for trade in environmental energy products, is another challenge. The degree to which North American governments mandate reductions in emissions from fossil-fuel generation varies from country to country. Canada has been the most committed to the Kyoto protocol where we have seen a surge in hydro renewable projects throughout the provinces. Cost effective, long-term investment in environmental energy products has been difficult in the United States as the US Congress constantly debates bills that require increased emissions reductions. While there have been binational agreements such as the Canada-US Clean Air Agreement, more must be done in order to foster a larger North American market for trade in environmental energy products (Egan 2007).

As for Mexico, it does not completely pass the test for a market-based power system as established by Bye and Hope. Criteria 1, 3, and 5 are at least partially present between the two neighboring economies of the United States and Mexico. Mexico does not utilize risk-hedging instruments, but rather has a shadow market for wheeling electricity sold from private generators (auto-generating and co-generating permit holders) to the integrated CENACE grid. These prices are bilateral and over-the-counter, rather than transparent and traded in a true market. Most importantly, there are no markets for long-term capacity expansion in Mexico (Ibarra-Yunez 2011; Martimort 2008).

5.6 The Inclusion of Renewables to the Stressed Grid

Currently, there are competing views on transmission expansion. Some argue expansion should be avoided at all costs to be replaced by energy savings via smart grid technologies and more distributed generation, while others favor a vision of a "transmission superhighway" connecting the entire North American market and allowing more renewable energy sources to plug into the grid (Fox-Penner 2010).

Our hypothesis is that increased trade of electricity among the United States, Canada, and Mexico will lead to lower prices and to an increase in the utilization of clean energy as a provider of electricity. We also expect to find another relationship between the utilization of clean energy resources and price. One particular sample (Denmark) has suggested that legal structures, which require a substantial investment in clean energy resources, can lead to a smaller decline, or even an increase, in price, at least in the short run.

The integration of renewable energy sources to the transmission system poses a unique challenge to grid expansion. (Chapter 9 spells out all intricacies of renewable energy markets in North America.) In short, renewable energy sources, particularly solar and wind power, are typically located in rural areas, far from the most energy-hungry locations such as cities. The transmission grid was built to transport power from large power plants to dispersed load centers. Transporting power from small, remote locations generating intermittent power was not originally thought of as part of the transmission system. Expanding the transmission grid into a complex mesh by way of a "transmission backbone" into areas where renewable such as solar and wind have a high potential for development could greatly enhance the possibility of bringing these sources to consumers.

With the establishment of this backbone producers would only be responsible for their smaller connection to the larger grid, thus providing incentives to develop these renewable sources (Booz Allen Hamilton 2007). In addition, the intermittent nature of these types of energy sources exacerbates the difficulty of transmission expansion, since it is unclear at what capacity lines should be built to bring these sources to the grid. In general, experts have argued for overbuilding rather than underbuilding the grid. No matter how it is accomplished, grid expansion always increases total social welfare when compared to not expanding (Schill et al. 2011). However, the same problem of financing and cost recovery exists in the case of renewable energy. Building a renewable energy plant requires less time than it takes to expanding the transmission grid. But, without a guarantee of access to the grid, producers are reluctant to build. (Booz Allen Hamilton 2007).

5.7 Conclusions: The Future of North America's Grid

In this chapter we proposed that the four major reasons for grid expansion and increased trade of electricity in North America are reliability, congestion, price, and environment. As congestion increases throughout the continent due to growing populations and industry, reliability will diminish, prices will rise, and the continued dependence on fossil fuels will be devastating to the environment. While the introduction of smart grid technologies may be a fix in the long run, expanding transmission capacity and increasing trade throughout the region is the most effective way to address these concerns.

Challenges to grid expansion include the organization and monitoring of the transmission grid, attracting investment in transmission capacity, dealing with congested lines in the short versus as well as the long run, and finding methods for pricing electricity that incentivize expansion. This chapter has proposed many methods of addressing each of these challenges and the next step must be deciding which of these options will work for North America.

Country-specific cases have provided examples of how best to create competition among generators to keep prices low for consumers. They also provide lessons on how to encourage investment in transmission expansion, ensure reliability, avoid congestion, and promote increased integration of renewable energy. By applying Bye and Hope's requirements to markets in North America, we analyzed North America's readiness to increase trade and expand its transmission capacity.

The anticipated "smart grid" revolution complicates the question of the need for transmission capacity expansion, as smart devices and new technologies allow operation of the grid closer to its physical limits. In the long run these technologies are expected to lower demand for added capacity. However, regulators should be wary of counting on these new technologies to solve their transmission troubles. Overexpansion is better for social welfare than dangers of underexpansion.

Finally, we addressed the inclusion of renewables into the grid. Renewable energy sources provide a unique challenge to the existing transmission structure since they are typically located far from areas that demand the most electricity, such as urban centers. Expansion of the transmission grid to reach these areas is necessary to incentivize further construction of renewable power sources.

References

Arocena, P., K. Kuhn and P. Regibeau. 1999. Regulatory Reform in the Spanish Electricity Industry: A Missed Opportunity for Competition. *Energy Policy* 27: 387-399.

Booz Allen Hamilton Inc. 2007. Linking Distributed Electricity Production from Alternative Energy Sources to the Traditional Generation and Transmission System. Prepared for the United States Department of Agriculture. Contract Number GS-23F-0025K, Order Number 0408DO63003.

Bye, T. and E. Hope. 2005. Deregulation of Electricity Markets: The Norwegian Experience. *Economic and Political Weekly* 40(50).

Comisión Nacional de Energía: Data for Chilean Energy Prices. Retrieved March 14, 2012, at http://www.cne.cl.

Dubash, N. and D. Singh. 2005. Of Rocks and Hard Places: A Critical Overview of Recent Global Experience with Electricity Restructuring. *Economic and Political Weekly.*

Dugstad, E. and K. Roland. 2003. So Far So Good: Experiences and Challenges in the Scandinavian Power Market. *International Journal of Regulation and Governance* 3(2).

Egan, T. 2007. The Integrated North American Electricity Market: Energy Security: A North American Concern. *Canadian Electricity Association.*

Estache, A., and L. Trujillo. 2008. *Privatization in Latin America: The Good, the Ugly, and the Unfair*. New York: Columbia University Press.

Fox-Penner, E. 2010. *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*. Washington DC: Island Press.

Gilbert, R., K. Neuhoff and D. Newbery. 2002. Allocating Transmission to Mitigate Market Power in Electricity Networks. *University of California Energy Institute Energy Policy and Economics* 001.

Hirst, E. 2000. Expanding US Transmission Capacity. Prepared for Edison Electric Institute.

Hirst, E. and B. Kirby. 2001. Key Transmission Planning Issues. *The Electricity Journal* 14(8): 59-70.

Hogan, W. 1992. Contract Networks and Electric Power Transmission. *Journal of Regulatory Economics* 4(3): 211-242.

Hogan, W., J. Rosellon, and I. Vogelsang. 2010. Toward a combined merchant-regulatory mechanism for electricity transmission expansion. *Journal of Regulatory Economics* 38(2): 113-143.

Kaundinya, D., P. Balachandra, and N.H. Ravindrananth. 2009. Grid-connected verses stand- alone energy systems for decentralized Power – A review of literature. *Renewable and Sustainable Energy Reviews* 13(8): 2041-2050.

Kristiansen, T. and J. Rosellon. 2010. Merchant mechanism electricity transmission expansion: a European case study. *Energy* 35(10): 4107-4115.

Leautier, T. and V. Thelen. 2009. Optimal Expansion of the Power Transmission Grid: Why Not? *Journal of Regulatory Economics* 36(2): 127-153.

Millan, J. 2006. *Power Sector Reform in Latin America: Accomplishments, Failures, and Challenges*. Inter-American Development Bank: Washington DC.

Minkel, J.R. 2008. The 2003 Northeast Blackout – Five Years Later. *Scientific American.* Retrieved November 26, 2011, at http://www.scientificamerican.com/ article.cfm?id=2003-blackout-five-years-later.

Montravel, G. 2004. European Interconnection: State of the Art 2003 in *Electricity Trade in Europe: Review of Economic and Regulatory Challenges*, J. Bielecki and M. Goboye Desta, eds. The Hague, Kluwer Law International.

Ofgem data for 2012 United Kingdom bid and ask prices. Retrieved March 14, 2012, at http://www.ofgem.gov.uk.

Oum, Y., S. Oren and S. Deng. 2006. Hedging Quantity Risks with Standard Power Options in a Competitive Wholesale Electricity Market. *Wiley InterScience.* Retrieved February 24, 2012, at http://www.interscience.wiley.com.

Pollitt, M.G. 2004a. Electricity Reform in Argentina – Lessons for Developing Countries. *CMI Electricity Project*.

Pollitt, M.G. 2004b. Electricity Reform in Chile – Lessons for Developing Countries. *CMI Electricity Project.*

Rosellon, J. 2003. Different Approaches Towards Electricity Transmission Expansion. *Review of Network Economics* 2(36): 48-79.

Schill, W.P., J. Rosellon and J. Egerer. 2011. Regulated Expansion of Electricity Transmission Networks: The Effects of Fluctuating Demand and Wind Generation. *Deutsches Institut fur Wirtschaftsforschung.* Discussion Paper 1109.

Schweppe, F., M. Caramanis, R. Tabors, and R. Bohn. 1988. *Spot Pricing of Electricity*. Boston, Massachusetts: Kluwer Academic Publishers.

Sioshansi, R. 2009. Evaluating the Impact of Real-Time Pricing on the Cost and Value of Wind Generationg. The Ohio State University, 2nd Power Systems Modeling Conference.

Thomas, S. 2005. British Experience of Liberalisation: A Model for India? *Economic and Political Weekly* 40(50).

Tangeras, T.P. 2010. Optimal Transmission in an Integrated Energy Market. *Research Institute of Industrial Economics.*

Weigt, H. 2009. A Review of Liberalization and Modeling of Electricity Markets. *Electric Markets Working Papers* WP-EM-34.

Vogelsang, I. 2001. Price regulation for independent transmission companies. *Journal of Regulatory Economics* 20(2): 41-165.

Chapter 6. Cross-Border Cooperation: Assessing Regulatory and Political Challenges to the US-Mexico Electricity Market

by Alejandro Márquez and Michael Simpson

Abstract

This chapter identifies the current state of Mexico's market and regulatory system within the framework of structural and market-based liberalization efforts. It reviews international trends in the context of challenges to the Mexican situation, examining structural, regulatory, and market lessons of the international experience as a lens for current Mexican challenges. In particular, it highlights the problems of high costs; significant entry barriers to non-utility investors; inefficiencies within the market in the form of high prices, strict reliance on contractual obligations, and market rigidity; the relationship between lax regulatory structures and the CFE's uncompetitive monopoly on transmission; and, finally, the relationship between US border-state integration and continued strength of Mexican electricity exports and imports. In addition to the comparative international analysis, it characterizes potential reforms by highlighting the relative gap between the interests, objectives, and visions of stakeholders and government entities, and provides a blueprint for bridging that gap.

6.1 Introduction: An Overview of the Market and Regulations in Mexico

Mexico's electricity sector is at a crossroads. Technical efficiency and factors of production are expanding as older generators are retired and new and innovative methods of generation are incorporated into the production process. New generation permits granted to private producers increased annually until 2009. Mexico has likewise increased its overall electricity export margins to the United States nearly ten-fold over the past decade (EIA 2011). Moreover, regulatory oversight continues to expand incrementally to address the Mexican electricity sector's increasingly unsustainable market structure. Nevertheless, political obstinacy and unfavorable public opinion have impeded any attempts at privatization and regulatory reform (Mier-y-Terán 2005). The absence of well-defined financial transmission rights and the risks associated with long-term contracts further hinder investment and infrastructural expansion (Mier-y-Terán 2005).

The contemporary electricity market in Mexico can trace its unique challenges to five primary events:

1. The creation of the *Comisíon Federal de Electricidad* (CFE) in 1934;

2. The 1960 amendment to Article 27 of the Mexican Constitution that placed CFE in state hands;

3. Passage of the *Ley del Servicio Público de Energía Eléctrica* (LSPEE) in 1975 and its subsequent revision in 1992 to sanction private generation;

4. Implementation of the North American Free Trade Agreement (NAFTA) by Canada, the US, and Mexico, beginning in 1994; and

5. The evolution of the *Comisión Reguladora de Energía* (CRE) from 1993-1995 and its incremental regulatory powers in following years.

While these five events certainly do not fully capture the history of the Mexican electricity sector and all its idiosyncrasies, they do underscore the key structural realities and sectoral players that currently shape the market. Any potential reforms must therefore account for each.

The *Comisión Federal de Electricidad* (CFE) was originally developed as utilities that would function as both a regulatory body and a supplier to the electricity market. As urbanization increased demand for electricity in the cities and a faltering post-war economy discouraged private investment in generation, Mexican authorities attempted to reconcile the notion of electricity as a public good with the gap between supply and demand. To this end, the Mexican Congress first amended Article 27 of the Mexican Constitution in 1960 and subsequently passed the *Ley del Servicio Público de Energía Eléctrica* (LSPEE) in 1975. The former asserted political control over the electricity sector, while the latter formally established CFE and the *Compañía de Luz y Fuerza del Centro* (LFC) as the sole public suppliers of electricity.

The ramifications of nationalizing Mexico's electricity sector have manifested themselves in three significant interrelated ways: (1) providing CFE with a substantial, federally-guaranteed budget; (2) consequently ensuring CFE's overwhelming market power by enabling it to invest in infrastructure and capital; and (3) gradually accumulating unsustainable levels of public debt in response to growing consumer demand (Carreón et al 2003; Ibarra-Yunez 2002). The first two conditions have created considerable physical entry barriers to private generators, who must rely on favorable power purchase agreements (PPAs) to survive but continue to lack adequate incentives. The third has concurrently decreased CFE's ability to expand efficiently (Mier-y-Terán 2005; Ibarra-Yunez 2010).

In response to the mounting burdens associated with its relatively monopolistic market power, CFE has attempted to diversify its generation capital. In addition to retiring older, oil-based technologies in favor of gas, combined cycle- and coal-based solutions (Peltier 2011), CFE decision-makers have pledged to transition 25% of their generating capacity to renewable energy sources (Bonetto 2010). This reflects a general trend away from fuel oil, which saw its supply to generators decline by almost 500 trillion BTUs from 2000 to 2010 (EIA 2011) and its proportion among generable energy sources decline relative to hydroelectric and natural gas during the same period (SENER 2010).

Following its presidentially-decreed takeover of LFC in 2009, however, CFE is now in complete control of all Mexican transmission and distribution functionality and is responsible for more than 70% of all produced electricity in Mexico (Bonetto 2010). This development reinforces the conclusion that energy source diversification and infrastructural expansion alone do not provide a solution to the challenges of regulatory reform, not to mention privatization and unbundling.

The revisions to LSPEE and passage of the North American Free Trade Agreement (NAFTA) occurred only two years apart (1992-1994), reflecting a growing recognition of the importance of market liberalization. In response to CFE's increasing fiscal and structural challenges, the Mexican Congress amended LSPEE to allow Independent Power Producers (IPPs), co-generators, and self-suppliers to participate in the generation market. Private generators were permitted to sell their power through the state-owned distributors, reflecting CFE's and LFC's duopoly over transmission and distribution until 2009 when LFC was liquidated. The terms of sale for IPPs further allow for 30-year PPAs and minimal pricing flexibility (Ibarra-Yunez 2002). NAFTA and LSPEE, as amended, are nonetheless symbolic of the overarching push for electricity market liberalization.

Private producers in Mexico have concurrently encountered a number of limiting factors. First, CFE's continued hegemony in transmission and distribution precludes any sort of truly unbundled, competitive market from emerging and has stalled proposals for qualified users. Next, the inception of guaranteed credits called PIDIREGAS in 1995, redesigned CFE's infrastructure financing to shift short-term liabilities to long-term capacity payments. However, this creates the potential for asset devaluation and debt agglomeration (Ibarra-Yunez 2002; Carreón 2003; OECD 2004). This adds a disincentive for CFE's generation subsidiaries to expand their infrastructure over the long run.

Given the dearth of incentives and CFE's prevailing market power, private companies likewise currently could face little impetus to expand significantly. Finally, while permits for private producers have grown steadily during the last decade, the barriers to market entry continue to prevent IPP growth from matching market demand. Some have argued that self-supply and co-generation firms must expand in order to offset the cost limitations on generators who have entered into PPAs with CFE (Demófilo 2005). In contrast to many international cases in which additional generating capacity supports the need for transmission expansion under various financing options, the Mexican generators seeking to invest in expansion projects face legal uncertainties. There are no simple answers to the problem of increasing private participation in the generation market, and policymakers will have to enact creative solutions in order to encourage investment and limit long-term costs. For the time being, PIDIREGAS have been suspended and new, more transparent financial instruments are now implemented to IPPs and co-generators (Zenon and Rosellon 2010).

The final—and most weakly pursued—development in the Mexican electricity market was the creation of the *Comisión Reguladora de Energía* (CRE) in 1993. Originally envisioned to be an advisory body rather than a regulator, CRE was redefined in 1995 as a semi-autonomous regulatory body tasked with issuing generation permits and overseeing the generation process between non-utilities and utilities (Jacobzone et al.

2007). CRE's relative impotence reflects the fact that regulatory authority over Mexico's utilities lies with the Secretary of Energy (SENER) and the Secretary of the Treasury (SHCP). The outsize market power exercised by CFE and other state-owned enterprises thus precludes CRE from implementing any comprehensive regulatory reforms.

Incentive programs, subsidies, tariffs, and pricing structures are likewise determined and carried out by SENER and SHCP, while CRE has relatively little impact on the inner-workings of the market. Without the moderating influence of an independent regulatory body, SHCP has tended to keep tariffs artificially low for residential and agricultural consumers and high for industrial users (Carreón 2003; OECD 2004; Halpern et al. 2009). This result diverges from other neighboring markets, where incentives are applied primarily to industrial activities. Nevertheless, the resulting subsidies have not as yet succeeded in offsetting high costs and have, on the contrary, hampered international cooperation and competitive trade.

Despite CRE's lack of impact on pricing and incentive structures for utilities, it has seen its role, concentrated in non-utilities and their private role in the transition market, gradually increase over the past decade. In 2002, the Mexican government charged CRE with authorizing permits to exporters of generated electricity (Breceda 2002). Mexico's post-NAFTA trade deficit to the US in electricity generation, coupled with its more slowly-expanding investment in infrastructure, thus created the opportunity for the government to expand market access to private producers without compromising CFE's domestic market power. CRE's scope correspondingly expanded beyond its intended charge of managing domestic permits. Moreover, the 2008 CRE Law empowered the agency to issue directives regarding renewable energy generation. The CRE Law represents a marginal increase in CRE's authority, especially given the relatively high cost of generating non-renewable energy sources.

Physical restructuring and energy source diversification are certainly crucial to the long-term viability of Mexico's electricity sector. Without liberalizing (but not necessarily privatizing) the market structure, however, electricity generation will fail to meet the persisting demand of a portion of its citizenry. Government subsidies to rural areas have, by and large, closed the gap between rural and urban electricity needs (Halpern 2009). Indeed, roughly 95% of rural residents and 98% of all Mexican citizens now have access to electricity (World Bank 2004). Overall generating capacity increased by 48% between 1999 and 2010, from 35,666 MW to 52,945 MW, while consumer demand increased by only 2.8% during the same period (SENER 2010). Still, roughly 6 million Mexicans continue to lack access to electricity (Dukert 2007). These numbers suggest that incremental reforms do not provide a short-term answer to the problem.

Most of the literature concerning Mexican electricity sector liberalization emphasizes the potential benefits of various internal reforms, such as instituting private financial transmission rights, expanding CRE's regulatory authority, restructuring CFE's transmission and distribution subsidiaries, and extending incentives to industrial consumers and capital investors. Given the intractable political response to wholesale restructuring of the Mexican electricity sector (Mier-y-Terán 2005), the goal of full market liberalization seems more amenable to medium and long-term solutions. In the short term, however, the discrepancy between capacity and demand requires unconventional solutions. In particular, this chapter argues that heightened collaboration between the US and Mexico would not only provide a stop-gap measure to address demand concerns in the short-term, but more importantly facilitate sustainable infrastructural investment and long-term market solutions in Mexico. However, converging or cooperative policy stances face challenges in the political, economic, strategic-visionary, institutional, and practical areas,[1] which we critically analyze by applying the methodological lens of New Historical and Sociological Institutionalism, but also analyzing self-interested motivations of regulatory change. Specifically, the chapter aims to develop and contextualize the main challenges and opportunities for regulatory decisions and their effects in a concentrated (but arguably more open) market.

The chapter first reviews relevant theories and methodological frameworks in the following section. Section 6.3 grounds the Mexican experience in a comparative international analysis by examining analogues in the liberalization of international markets and assessing possible bases for Mexican reform. Following a summary of the methodological approach in Section 6.4, Section 6.5 characterizes the current makeup of institutions, market structures, and regulatory agents in Mexico, including recent developments, trends, and implications. Section 6.6 applies an institutional analysis to the market and political situations. Finally, Section 6.7 adds a bilateral dimension, discussing the current state of US-Mexico electricity border trade and its implications for Mexico's regulatory and market arrangement.

In this vein, we conclude by addressing the individual and collective concerns of stakeholder and governments—both US and Mexican—focusing in particular on the gap between short-term interests and long-term viability. Fostering international cooperation certainly entails its own list of challenges. The chapter will draw on international analogues to provide a general overview of interconnection and international cooperation. We thus attempt to reconcile the regulatory and legal challenges associated with expanding the interconnection between the US and Mexico, in the broader context of integration in the international experience.

6.2 General Review of International Institutional-Political Analogues

The privatization of the British electrical power industry in 1989 brought a wave of similar reforms around the world, along with many theoretical and technical academic works on liberalization of the sector. The interest in Britain's privatization stems from the potential for liberalization to improve efficiency in electricity generation, transmission, distribution, and retail supply, lower prices and thus improve social welfare. Additionally, regulation helped reduce the costs to governments. Within a larger context, deregulation of the electrical power industry is one of the central components to a liberal model of economic development that gained political influence in the 1980s and remains to this day. The benefits of regulation of the electrical power industry are exemplified in

[1] These areas encapsulate the modified stakeholder analysis, which arises from the so-called PESTEL framework as a risk-based assessment tool for strategic decisions.

the British case, but liberalization still requires further study—especially in the implementation of regulation—in order to develop the mechanisms that will help societies reap the benefits that the model promises. Woo et al. (2003) show that even the textbook examples of deregulation may result in sector failures. Hence, this section will analyze the different frameworks of deregulation available and elucidate their potential to improve social welfare in different political contexts, particularly in the case of Mexico.

One of the central components of marketization in the electricity industry involves the regulatory regime that will ensure benefits to society. Regulation takes shape in the form of rules and a network of institutions that facilitate efficient access to the transmission network and allocate scarce transmission capacity. Regulatory institutions must have good information, expert staff, and the authority to regulate distribution and transmission prices. Moreover, the regulatory bodies could incorporate performance-based regulatory mechanisms that set standards for the quality of service (Joskow 2008); cost-of-service regulation that is more centered on day-to-day operations; or benchmark regulation, which uses econometric models to set generation standards. Stern and Cubbin (2005) emphasize the importance of establishing sound and powerful regulatory agencies in Latin America by noting that they are the foundation for promoting investment in the sector. CFE is the principal player in the market, while the only regulatory agency (CRE) simply oversees non-utilities. If, as Stigler (1971) indicates, “regulation is acquired by the industry and is designed and operated primarily for its benefit” then the need for a strong and autonomous regulatory agency in Mexico is clear. Moreover, an in-depth analysis must consider formal and informal aspects of regulation. Often, the regulatory framework looks good on paper, but informal regulatory governance may be more helpful in explaining failures and promoting policies attuned to political realities on the ground (Stern and Cubbin 2005).

But what do we mean by strong regulatory institutions? Lofstedt and Vogel (2001) show that trust in these institutions is key to their authority and power. They contend that the US model of incorporating risk assessment with risk management tasks in regulatory operations (in contrast to the current European model, which separates tasks) will increase trust in institutions and eliminate unproductive adversarial dynamics. New currents of regulatory policies are considering opening forums to civil society and interested parties in electricity power regulation. Participatory regulation, then, will increase the legitimacy of regulators and improve its services to clients.

Neither strong regulatory institutions nor privatization will be enough, though. Competition is by far the single most significant variable in fostering performance improvements in developing countries. However, weak competition can bring some performance improvements when a sound regulatory framework has been established (Zhang et al. 2007). It is also important to keep in mind that social welfare is higher when the regulatory agencies are established before liberalization, as opposed to erecting the regime as the market is restructured (Ibarra-Yunez 2002). Ultimately, improved market conditions for electricity consumers will hinge on the legitimate, participatory, and strong regulatory institutions that will attract investment. From this point, investment and competition will follow, which will set off gains in efficiency, better service, and lower wholesale and retail prices.

6.3 Theoretical Framework on Institutional Economics and Decision Making

6.3.1 Economic Theory on Regulation

One of the most recognized theories of regulation is the normative analysis as a positive theory (NPT), which posits that regulation is necessary in free markets when allocation of goods and services is not efficient, i.e., market failure. Market failure will normally arise from externalities (external effects of economic activity that are not reflected in prices), asymmetric information, imperfect competition (insufficient alternatives in supply or demand), or a combination of these (Ogus 2004). Consequently, economic analyses will identify the failure of the market and determine which method of intervention will fix it at the least possible cost. Ideally, the point where marginal costs of regulation meet the marginal benefit would provide the optimal economic solution. Additionally, the institutional makeup of regulatory regimes is another factor that merits consideration. It is within government and quasi-independent institutions that incentives are shaped to wield the most efficient outcomes in the market. Finally, the enforcement of regulation is equally important to correct market failures (Ogus 2004*)*.

The economic theory of regulation proposed by members of the Chicago School of Economics indicates that regulation in democratic contexts is not a free good, but can be framed as a market for regulation. Regulation is a good demanded by constituents (consumers and industries) and supplied by regulators (or politicians) via political processes. In other words, both regulators and politicians seek to maximize their individual utility. This market dynamic to regulation facilitates a better understanding of the forces that drive regulation. In other words, regulators will react to whoever provides the most effective demand. Stigler (1971) showed that industries seek to influence the coercive ability of the state by "acquiring" regulation to meet their own demands. Another way to consider the acquisition of regulatory mechanisms is simply as a transfer of wealth. Industries "pay" for regulation by providing votes and resources to politicians. Additionally, one could find cases of *ex ante* influence of "affected" participants before a regulatory regime is implemented, whereas in other cases industry lobbyists act after or *ex post* regulation implementation (Beato and Laffont 2002).

The source of regulation, then, may be dependent on the structure of the industry in question. Industries with economies of scale at the local level and with no externalities on other communities will see oversight bodies develop endogenously (Beato 2002). Alternatively, those industries operating at a larger scale (e.g. regional, national) cannot adopt regulatory regimes from various endogenous sources. Rather, these will require a high degree of technical expertise and coordination that, for practical purposes, will be implemented exogenously. As a result, the cooptation of regulation is feasible and economical at this scale.

The most sought-after form of regulation is that which limits the numbers of new entrants to the market (such as quotas over tariffs and occupational licenses), even if economic efficiency is trumped as a result. The degree of influence (and outcomes) is dependent on the size of the industry (Stigler 1971). Peltzman (1976) later enhanced the theory by showing that industries must spend resources on gathering information and interacting with politicians—costs that must be offset by the prospective benefits of "acquiring" regulation. This marginal condition would theoretically allow smaller groups to effectively demand transfers from regulators.

Additionally, the larger the group that seeks influence, the larger the costs required are to "pay" politicians, i.e. diseconomies of scale (in the form of votes, resources, campaign contributions, placating the opposition, etc.). Becker (1983) proposes that groups competing for transfers would support changes in regulation that reduce economic deadweight losses arising from regulation. Peltzman (1989) further determined that deregulation itself is a result of a coalition's interest in reducing costs associated with regulation that are higher than without regulation. Another alternative is that regulation itself causes economic inefficiencies, thereby costing more than an unregulated regime. Stigler's theory ultimately holds in showing that, as long as groups/coalitions see a benefit in (de)regulating an industry, they will exert pressure on politicians to regulate in the manner that maximizes their utility.

Another school of thought, the Virginia School of public choice, is critical of the private interest school (Chicago) for focusing on prescriptive rather than normative analyses. The overriding point is that the costs incurred in extracting rents from regulators are a waste to social welfare. Similarly, the concentration of power to influence, or "acquire," regulation by small groups over the interests of the majority results in gross inefficiencies (Ogus 2004). Public choice scholars, then, have focused on who wins and who loses from regulations and public management, with a conviction to test their benefits to society (Mashaw 1989).

Finally, the progressive law-and-economics school of regulation has strived at getting economic incentives right. This involves the use of regulatory impact analysis, a type of cost-benefit analysis, to provide better information to policymakers in the design and implementation of regulatory policy (Ogus 2004). This school of regulation gained influence as governments began relying on economic expertise in the 1980s and 1990s, during which the OECD encouraged the so-called technocratization of legislative and regulatory processes. The standards for these analyses are based on aggregate social welfare, so their input, which does not provide a determinative answer as to what is socially desirable, is necessarily limited (Adler and Posner 1999). As a result, regulatory impact analyses works as a complement, rather than a substitute, to regulatory decision-making (Ogus 2004).

Up to this point, the discussion on literature has focused on conceptions of regulation developed in the United States that generally entail specific sets of rules to be enforced by some regulatory agency. Regulation outside the United States before the 1990s had a more broad meaning that encompassed all efforts by the state to steer the economy, including taxation, redistribution, subsidies, among other measures. The rise of global-wide regulatory reforms and independent regulatory agencies led to a convergence of these meanings, which is now used by economists. Additionally, a third definition of regulation has gained notoriety with global problems, such as climate change and weapons of mass destruction, which involves all mechanisms of social control—even those that are unintentional or outside state purview.

It seems, then, that regulation is increasing in its technical and institutional character, as well as its scope. The dominant interpretation of this type of regulation points to the increasing use of state authority to set standards and rules in spheres previously dominated by public ownership, public subsidies, and directly provided services. In other words, regulation is the extension of the modern state (Hood et al. 1999).

Jordana and Levi-Faur (2004) caution that the new regulatory state advances more in some sectors of the economy than in others. The regulatory state does not emerge from a vacuum, but rather inserts itself in different layers of governance created for different purposes and at different times. As a result, the types of regulatory states vary. Opinions on the underlying forces that create the regulatory state likewise diverge. Some consider the regulatory state a result of imitation across regions and countries, based on conventions of best practices for economic governance. Others consider the regulatory state an outcome of regional integration within the context of liberalization and technocratic legitimacy. For others, the rise of the regulatory state is merely a political and administrative process at the national level. The variety of stances suggests the multiple levels of regulation that Levi-Faur posits (2004) around the political-institutional dimensions of the regulator, its conditioned strategies by the state of the industry and the regulators' original "endowments," and legal settings.

The discussion of the regulatory state has also explored other political foundations. It seems that the liberalization of the last 20 years would lead to less regulation, one marked with conservative, classically liberal underpinnings. However, the rise of the regulatory state provides a messier picture of the political forces behind regulation. Braithwaite (2000) perhaps provides the clearest interpretation of the regulatory state. He contends that the steering (thinking, guiding, directing) and rowing (service-provision) forces of regulatory regimes have come from either civil society or the state. During the 19th century, both activities were conducted by civil society; both by the state during the post-war era; and steering by the state and rowing by civil society in the neoliberal (post-1980s) era (Jordana and Levi-Faur 2004).

6.3.2 Liberalization and Regulation Across Countries: Some Relevant Examples

In addition to being the first privatization of a national electrical power industry, Britain's case is considered among the most successful (Joskow 2008). The process involved the division or unbundling of generating, transmission, and distribution operations of the Central Electricity Generating Board (CEGB). The process of liberalization began with the entry of independent generators to the market, who sold electricity to CEGB, followed by the creation of National Power and Power Gen (the former CEGB) and their sale to institutional (28%), national (49%), and international (23%) investors.

Transmission and distribution were also privatized following the institutional structure already in place. These changes resulted in lower prices relative to other European markets, lower carbon emissions, fewer employees in the industry, and greater economic efficiency and productivity.

The regulation of National Power and Power Gen (now RWE Npower and E. ON UK respectively) is carried out by the Office of Energy Regulation (OFFER). It guards against duopolistic behavior and also established price caps after privatization. Subsequently, the UK adopted a performance-based ratemaking mechanism to regulate the sector. Among its benefits are increased penetration to areas that did not previously have service and reductions in losses due to poor maintenance and antiquated equipment (Joskow 2008). However, the positive outcomes of liberalization were not felt among the consumer base because most of the savings accrued among stockholders.

Norway's government, on the other hand, sought to liberalize its electricity power industry through structural competition while keeping ownership of generation operations. Liberalization involved the privatization of electricity transmission, introduction of a common carrier system, grid access to third parties, and the establishment of voluntary wholesale markets (Weigt 2009). It is important to consider that the Norwegian government liberalized its electricity sector due to environmental concerns and not necessarily to reduce prices. As a result, Norway's regulatory framework employed cost-of-service regulation, which ultimately led to reduced capacity investment and congestion translating to market power (Woo et al. 2003).

The experience of large, centralized countries such as China is one of slower liberalization, mostly due to its regime structure. China's breakup of the vertically-integrated and centrally-managed industry has been slow, and today only generation is partly restructured to increase competition (Weigt 2009). China's regulatory agency, the State Electricity Regulatory Commission of China (SERC) lacks authority and independence in pricing and investment decisions due to the centralized nature of the law instituting the agency. Therefore, China's incentives to regulate might not arise from a will to decentralize authority to increase investment, but to achieve other goals consistent with its regime structure. Rather, Austin (2005) suggests that China's ascending role in the world economy will incentivize the establishment of a regulatory framework that makes the energy sector efficient, more than anything else.

The experiences of these countries indicate that the decision to liberalize the electricity power industry involves a political context and a will to steer the sector in a particular direction, be it price reduction, environmental protection, or increased energy efficiency. Having a clear objective in this respect will deepen our analysis of liberalization and make policy-making for market integration more effective.

6.3.3 Transnational Cooperation on Trade and Regulation: Looking Forward Across the World

The prime example of a transnational regulatory cooperation is the European Union. Jabko (2004) indicates that the intriguing aspect of regulatory reform in the European

Union coincided with the expansion of market forces during the 1980s and 1990s. Equally surprising is the wide scope of these reforms that would not have taken place under regular economic pressures. The most dramatic regulatory reforms in Europe took place in sectors where technological innovation was slow and market forces were weak; in other words, where the forces of globalization were not as strong, justifying the focus on the technological aspects as drivers of regulation. This adds a contextual dimension to regulatory supply and shows that there are different frameworks for regulation.

As markets were liberalized in the 1980s and 1990s, new regulatory frameworks also emerged and support for this package grew as public intervention in the economy came under scrutiny. Many of the non-market interventions implemented during this period, however, carried over from old monopoly regulations due to the market imperfections and engineering limitations, such as those found in the wholesale and retail electricity markets (Joskow and Tirole 2005). This policy momentum created a strong support base for market liberalization, and the framework to both increase economic efficiency and create a complementary regulatory regime offered by the EU convinced countries to participate in this project (Jabko 2004).

With the political will to cooperate on regional liberalization and regulatory reforms, countries must engage in a conversation about the financing of transnational trade if it requires infrastructure. In the case of Mexico, this will require large sums of sunk costs that must be allocated among all participants. As a result, mechanisms to deal with the free-rider problem must be established in order to provide enough confidence on the projects. According to Laffont and Martimont (2004), international agencies should play a central role in coordinating financing obligations. In the case of Europe, the EU provided a strong institution with political capital and an attractive reciprocity scheme that provided incentives for cooperation. In other settings, cooperation is more difficult. The mechanism described by Laffont and Martimont often impose restrictions on domestic redistributive policies, reduce consumption by the poor, and condition prices. The limitations imposed on individual countries will reduce the likelihood of cooperation, the effect of which will be heightened if levels of industrialization are disparate among participants.

6.3.4 Regulation in Latin America

Regulation in Latin America has increased dramatically since the 1980s, when the debt crisis signaled the end of import-substitution industrialization and the start of a series of structural adjustments. Latin America's regulatory capitalism thus rose to unprecedented levels, going further and faster than any other region of the world. Of course, the pace varied for each country and, as Jordana and Levi-Faur (2005) point out, the start of this trend began early in the 20th century—suggesting that regulatory reforms are not structural in nature, but rather sectoral and a result of diffusion. Their study on the growing number of regulatory agencies in the region shows that probabilities of regulatory reform in a country are higher if other countries adopted similar changes, rather than if reforms occurred in other sectors of the same country. The authors suggest that socialization and information sharing within the international community of technocrats (policy-designers) is responsible for the uniformity in regulation change in Latin America. Another potential explanation, which they allude to but do not develop, is that privatization is largely correlated with the emergence of new agencies. Privatization in the region has grown since structural adjustments were likely prescribed by the International Monetary Fund and Washington. Perhaps regulatory reforms were also part of the model forced onto Latin America in the 1980s.

A good place to start an analysis of electricity trade between the United States and Mexico is the manner in which electricity is treated in various multilateral trade agreements. The General Agreement on Tariffs and Trade (GATT) does not apply its framework to electricity trade because it is not considered a good, but often a (public) service. The non-storable nature of electricity and the complicated nature of the sector, involving vast intermediate products, prevent it from being treated as a commodity. The General Agreement on Trade in Services (GATS) also fails to provide trade regulations due to electricity's ambiguous nature. Furthermore, the WTO's Services Sectoral Classification List (W/120) only considers "services incidental to energy distribution" as services, excluding most of the electricity sector – from generation to distribution. Table 6.1 provides a list of the electricity-related products as they are treated by different trade agreements and international standards.

Finally, the North American Free Trade Agreement (NAFTA) does not provide a uniform application of electricity trade in the region. The United States and Canada had a previous arrangement in electricity trade that remained unmodified after NAFTA, while Mexico's electricity sector was excluded from any provisions as a public utility, although trade in electricity is addressed in Chapter 6 of the Agreement. This gives the Mexican state sole regulatory control over the industry. In the case of NAFTA, electricity is treated as a good with regard to the inputs (listed above). As a result, NAFTA works as a trade and investment tool for the sub-sectors related to steps between generation and distribution, and does not force the Mexican industry to liberalize further (Pineau 2004). Areas in which electricity generation occurs outside the confines of the *Comisión Federal de Electricidad* (CFE) include generation for own use and co-generation in industrial settings and Independent Power Production (IPP) enterprises. In the first two cases, excess electricity is to be sold to CFE, while in the latter CFE should be sold all electricity generated (DeGrandis and Owen 1995). On its part, CFE as a company can directly export or import once connections are physically set and owned by the parastatal.

With regard to electricity trading via non-utilities, NAFTA Chapter 6 allows (non-binding) export and import licenses in the energy sector. Under this scheme, CFE can sell and buy electricity from the United States but also other private permit-holders. However, Mexico's electricity trade with the United States has been rather limited (given that the United States is also under the restrictions of the Federal Energy Regulatory Commission). In fact, NAFTA has changed little of the electricity industry in the region, with most of the integration taking place between the United States and Canada under the provisions of their previous free trade agreement.

Table 6.1
Product Classification Systems

Systems	Position of Electricity in System's Hierarchy	Explanation
Harmonized Commodity Description and Coding System (HS 2002)	Chapter 27 Mineral fuels, mineral oils, and products of their distillations; bituminous substances; mineral waxes 2716.00 Electrical energy (Optional heading)	The system only classifies goods. Electrical energy is included only as optional, its nature as a good or service being ambiguous.
WTO Services Sectoral Classification List (1991) W/120	1. Business Services F. Other Business Services j. Services incidental to energy distribution	This section contains 12 sectors of services and reflects the fact that energy services were not discussed in the Uruguay round.
Central Product Classification (CPC Version 1.1 2002)	Section 1- Ores and mineral; electricity, gas, and water Division 17- Electricity, town gas, steam and hot water Group 171 – Electrical energy Class 1710 – Electrical energy Subclass: 17100 – Electrical energy Section 5 – Construction services Division 54 – Construction services Group: 546 – Installation services Subclass: 54611 – Electrical wiring and fitting services Section: 6 – Distributive trade services; lodging; food and beverage servicing services; transport services; and utilities distribution services Division: 69 – Electricity distribution services; gas and water distribution services through mains Class 6911– Electricity transmission and distribution services Subclass: 69111 – Transmission of electricity Subclass: 69112 – Distribution of electricity Section: 8 – Business and production services Division: 85 – Support services Group: 859 – Other support services Class: 8599 –Other support services n.e.c. Subclass: 85990 – Other support services n.e.c. (including reading of electric, gas, and water meters) Division: 86 – Services incidental to agriculture, hunting, forestry, fishing, mining, and utilities Group: 863 – Services incidental to electricity, gas, and water distribution Class: 86311 – Services incidental to electricity Subclass: 86311 – Electricity transmission services (on a fee or contract basis) Subclass: 86312 – Electricity distribution services (on fee or contract basis)	The products related to the electricity industry are in many different sections of goods and services.

Source: Pineau 2004.

6.4 Methodological Approach

The study of regulatory agencies has gained increased attention, given their prevalence in both developed and developing countries. Most studies focus on specific cases with an increasing interest in comparing regulatory regimes across countries and sectors. Gilardi (2004) indicates that new institutionalism provides a valuable analytical framework to improve understanding of regulatory institutions as they change. New institutionalism has three main analytical schools of thought, each with its own strengths and weaknesses. First, historical institutionalism provides a path-dependent approach to the study of institutions in which their development is contingent upon "critical juncture" decisions—usually when they are established—that lead institutions along a path reinforced by the initial and subsequent decisions. This approach takes time and history into account, but its application is mainly limited to specific case studies and broad comparisons are difficult to make. Rational choice institutionalism argues that politicians establish regulatory institutions because they seek to improve their credibility and reduce political uncertainty—even if costly in the short-term—in order to solve problems of choice over time. Rational choice institutionalism provides an endogenous explanation to institutional change in which functional pressures are systematically identified. However, this approach does not provide much insight for long-term dynamics. Finally, sociological institutionalism illustrates how the symbolic nature of institutions perpetuates them, but says nothing of their beginnings (Gilardi 2004).

These three variations of new institutionalism provide valuable insights for the state of regulation in Mexico's electricity sector. Historical institutionalism is an excellent method for explaining the state's control of energy sectors in Mexico. Sociological institutionalism suggests the importance of keeping the energy sector under the purview of the state, from the perspective of Mexican society or government decision makers. Rational action provides answers as to why CFE and politicians push for (or against) certain reforms. Given that we are mainly interested in exploring the state of regulation in Mexico and the possibilities for (welfare-enhancing) electricity trade between Mexico and the United States, we will employ historical and rational choice institutionalism to understand how Mexico's regulatory regime arrived at its current state and to elucidate the political dynamics that encourage change towards a liberal electricity market.

To ground our institutionalism-oriented analysis in actual institutional developments, we will analyze the interaction between political agents, regulatory bodies, and the electricity market in Mexico in the context of existing regulations. In particular, we present three overarching analytic layers: (1) general regulatory framework; (2) relevant regulatory bodies and the state of regulation in the electricity market; and (3) political involvement in the regulatory apparatus. Therein, we depict recent political and regulatory trends which may potentially affect the trajectory of the Mexican electricity sector. The instruments of historical and rational agent institutionalism, finally, allow us to evaluate Mexico's relative conduciveness to exogenous change, namely further integration with the US electricity market. Given this approach, the present study contributes, as an applied interface with binational implications, to the stakeholder PESTE literature, Porter’s risk analysis for decisions, and the political “government endowments” literatures.

Having established the regulatory barriers or non-barriers to integration, we will provide an assessment of the current state of cooperation between the US and Mexico. Specifically, we highlight the dialogue among political, regulatory, bureaucratic, and market-based agents from the two countries. The ultimate objective is to ground this dialogue within the framework of historical and rational agent institutionalism we apply to the Mexican regulatory regime. We thus conclude with recommendations for improving transnational cooperation under the regulatory constraints that shape our analysis.

6.5 The State of Mexican Regulations

6.5.1 General Regulatory Framework

Partly in response to a 1999 OECD study that detailed the sprawling disjointedness of Mexican regulations, Mexico has, over the past decade, embarked in a program of reforms aimed at simplifying and integrating the regulatory apparatus. In collaboration with the federal, state, and local governments, independent monitoring agencies have striven to ease international trade restrictiveness, forge public-private partnerships, increase governmental transparency and accountability, and synchronize regulations with domestic and foreign standards (OECD 2004). Such efforts have consequently yielded lower levels of regulatory fluctuation and increased regulatory stringency (Wijen and Tulder 2011). Andres et al. (2008) likewise rank the Mexican electricity regulatory regime as the fourth-most transparent among 19 developing Latin American nations. In contrast, the same authors’ Electricity Regulatory Governance Index (ERGI) places Mexico behind all but five of the included nations. Mexico’s low ERGI rating underscores the fundamental impediment to regulatory reform in its electricity sector: namely, CFE’s lack of accountability to independent regulators, stemming from its constitutionally-guaranteed autonomy.

The principal catalyst behind Mexico’s incipient reform efforts was a presidential initiative to revise the *Ley Federal de Procedimiento Adminitrativo* in 2000, which led to the creation of the *Comisión Federal de Mejora Regulatoria* (COFEMER). As a “technically and functionally” autonomous subsidiary of the Ministry of the Economy, COFEMER’s stated mission is to ensure regulatory transparency and demonstrate the benefits of regulatory reform. To this end, COFEMER concentrates primarily on eliminating and simplifying formalities, reviewing the language and impact of all draft regulations, gauging the need for legal and regulatory reform in specific economic sectors, and helping state and local governments implement reform programs (OECD 2004). All federal agencies are required to regularly submit two-year regulatory blueprints to COFEMER. The review process then consists of an assessment of potential alternatives; recurring consultations; drafting requirements; and systematic appraisals of existing regulations (Jacobzone 2007).

COFEMER utilizes several bureaucratic instruments to facilitate the review process. Regulatory Impact Analysis (RIA), a metric commonly used in OECD countries, provides a standardized cost-benefit analysis of draft regulations. The Federal Registry of Procedures and Services, *Registro Federal de Trámites y Servicios* (RFTS) is a compilation of all federal procedures, which COFEMER administers to increase transparency and efficiency. Consultation procedures include reports from specific ministries on regulatory progress, as well as an accumulation of private stakeholder perspectives and a four-week window for public comments (Jacobzone 2007). The *amparo* process, a form of judicial appeal, likewise provides a juridical complement to COFEMER's assessments. However, the *amparo* could be over-used by firms to blockade COFEMER's determinations.

Finally, COFEMER has minimized inconsistencies and redundancies among federal, state, and municipal governments by signing coordination agreements with the states. The integrative effects of such agreements, coupled with COFEMER's sweeping implementation of the System that Promotes Fast Opening of Firms, *Sistema de Apertura Rápida de Empresas* (SARE), have yielded renewed federal-local and public-private relationships and reduced entry barriers to small businesses (OECD 2004).

Monitoring the regulatory processes of so many different economic sectors prevents COFEMER from becoming too intimately involved with any one area. That the agency's principal interaction with the electricity sector has been with the Secretary of Energy (SENER) reflects the limited extent to which it is willing—or able—to influence comprehensive, market-wide regulatory reform. COFEMER has thus typically restricted the scope of its analysis to day-to-day issues, such as pricing methodologies, tariffs, and renewable energy. In 2009, for example, COFEMER reviewed a methodology for determining maximum wholesale prices for natural gas. The agency recommended that SENER incorporate a valuation of externalities into the methodology, which it claimed would both clarify the regulations, themselves, and contribute public health benefits (COFEMER 2009). COFEMER also addressed a SENER proposal—a *de facto* extension of Article 27 of the Constitution to cover audits of generation plants—by simplifying the process and eliminating onerous costs. In 2010, COFEMER helped SENER implement changes to an impending rule that would differentiate tariffs according to generation method (COFEMER 2010). Specifically, COFEMER suggested that SENER arrange the tariffs around the maximum and minimum sales per plant type. These tariffs are, incidentally, short of prices that reflect marginal costs either at zonal or nodal levels, as was evident in interviews with Mexican officials in Mexico City during the first week of January 2012.

While it is important to note that SENER adopted all of the preceding proposals, COFEMER's influence in the electricity sector has nonetheless been relatively constrained. Not only has it not achieved any sort of meaningful dialogue with other relevant organizations, such as CRE, SHCP,[2] or CFE, but its 2010 characterization of CFE as a perpetrator of high levels of pollution conveys the complex separation of

---

[2] That is, in an electricity-market capacity; COFEMER interacts with SHCP frequently in other contexts.

powers in the electricity sector (COFEMER 2010). The diffuse regulatory accountability that this separation implies ultimately allows for only piecemeal reforms. Because COFEMER is limited to reviewing submitted regulations, it is not typically proactive in suggesting regulatory reform, which is legally dictated and delegated to CRE, on one hand, and SENER-CFE and SHCP, on the other. Its role as an independent monitoring agency therefore extends only as far as the sector's governing bodies are willing to lead it. The power dynamic between the electricity sector's main players will be further explored in the following two sections.

The *Comisión Federal de Competencia* (CFC, or COFECO), or Federal Competition Commission, represents another cog in the wheel of regulatory reform. While Article 28 of the Mexican Constitution expressly prohibits monopolistic practices in the economy, competition policy was not formally codified until the Federal Competition Law *Ley Federal de Competencia Económica* (LFCE), which excludes parastatals from CFC oversight and juridical breadth, was passed in 1993. CFC is broadly charged with ensuring open access to markets and upholding market efficiency. It further contributes to the approval process for government bidding and private non-utilities participation, as well as setting competition standards for specific economic sectors. Pursuant to Article 28 of the Constitution and Article 4 of the LFCE, however, CFC's authority does not extend to "strategic areas" under state control. Given electricity's status as a strategic economic sector, CFE's monopoly over publicly-distributed electricity is thus not considered anticompetitive (OECD 2004). This distinction effectively limits CFC's authority to mere observer and arbitrator (mainly regarding anti-competitive conduct), rather than true *ex post* regulator, in the electricity market.

In contrast, Article 4 of the LFCE grants CFC full jurisdiction in activities not explicitly covered under the umbrella of public service. CFC's purview could therefore theoretically encompass relevant electricity market issues, such as interconnection and renewable energy. Thus far, however, CFC has only applied its authority to reviewing bid applications for IPPs seeking contracts with CFE (OECD 2004). In April 2011, the Mexican Senate passed a series of changes to the LFCE that similarly enhance CFC's regulatory authority (Harrup 2011). In particular, the amendments clarify CFC's power to impose sanctions on firms engaging in anticompetitive behavior, while concurrently increasing the severity of the sanctions themselves.

Whereas COFEMER has tended to confine its interaction with the electricity sector to discussing matters of efficiency and public welfare with SENER, CFC has typically engaged a broader range of public organizations. Indeed, under the *Convenio de Colaboración Administrativa*, CFC maintains regular meetings with CFE to discuss pertinent competition-related matters (OECD 2004). It further conducted three separate bidding investigations in 2008 regarding CFE,[3] and delivered multiple opinions on SENER proposals concerning natural gas tariffs and pricing (CFC 2008). The review process of a number of such proposals, including PMXREF-00-002 and DIR-GAS-001-1996, notably included COFEMER as an interlocutor. Nevertheless, CFC's interaction

[3] Each of which, it should be noted, was ruled in CFE's favor.

with the electricity market remains, relative to that of other economic sectors, rather constrained. It conducted only seven total electricity-related proceedings in 2008, including three mergers and four biddings, concessions, and permits (CFC 2008). It likewise oversaw 18 combined proceedings for the electricity, water, and gas supply sectors in 2009, including one merger and 17 biddings, concessions, and permits (CFC 2009). In contrast, CFC conducted 46 proceedings in manufacturing industries, 57 in transportation, and 113 in mass media in 2009. These figures suggest that CFC's overarching impact on competition issues in the electricity sector has been minimal.

CFC's reformative influence on the electricity sector is equally debatable. The commission determined in 2009, for instance, that the most relevant market power challenge facing the Mexican electricity sector was CFE's lack of unreserved acceptance of the 28 current Independent Power Producers (IPPs), which supply electricity exclusively to CFE (CFC 2009). It further concluded that the present constitution of market shares negates any need for CFE to pursue extraordinary bidding procedures (as established in Article 33 of the LFCE) outside of "exceptional cases." Since IPPs nonetheless continue to be subject to long-term PPAs with CFE, CFC's treatment of CFE appears to rely heavily on the latter's designation as an incumbent public-service organization. This hands-off approach is endemic among regulators' treatment of CFE, and it suggests that CFC's influence on public-entity competition in the electricity sector is modest, at best. Ibarra-Yunez (2008) similarly notes that CFC has gained little traction in the interaction between public and private firms. Unlike COFEMER, CFC's predicament is thus rooted not in a limited dialogue with the industry, but rather in a general bureaucratic resistance to reform the constitutionally-protected CFE.

The jurisdiction of independent monitoring agencies such as COFEMER (through oversight) and CFC (through full adjudication capacities) has importantly been extended to international trade. Mexico has, for instance, signed several competition-related bilateral agreements. Moreover, most free trade agreements generally contain clauses which explicitly address competition; Chapter 15 of NAFTA covers competition policy, monopolies, and state enterprises. Article 603 of NAFTA likewise prohibits restrictions on the importation and exportation of energy by member countries, while Article 604 forbids taxation on energy exports. Specific regulatory reforms within Mexico, such as RIA and the RFTS' revision process, have expanded on the NAFTA provisions to simplify trade restrictiveness (OECD 2004). The Mexican government has also attempted to align its trade policy with international regulatory standards.

The primary impediment to further regulatory harmonization between Mexico and the other NAFTA signatories continues to be the principle of National Treatment, outlined in Article 301 of NAFTA. This clause requires that the member countries treat the investment interests of other partners "no less favorably" than those of resident investors. Article 601, which governs energy policy, further stipulates that any trade arrangements between the member countries uphold the basic principles outlined in the parties' individual constitutions (Lock 1993). Taken in tandem, these two provisions ostensibly clash with CFE's public monopoly on transmission. Given Mexico's constitutional designation of energy as a publicly-guaranteed asset, the challenge of disentangling the transnational energy trade from the Mexican electricity sector's complex power balance is intimately connected to the more narrow regulatory obstacles outlined above. With this overarching framework in mind, we now consider recent trends in the Mexican electricity sector's regulatory structure.

6.5.2 Regulatory Trends in the Electricity Market

The potential for regulatory synchronization implied by the emergence of such institutions as CFC, COFEMER, and NAFTA has reached an impasse in the Mexican electricity market. Given the nature of Mexico's mixed market, one must consider both the role of the *Comisión Reguladora de Energía* (CRE) as a regulator of non-utilities and IPP permits, on the one hand, and the role of SENER and SHCP in overseeing the state-owned enterprises CFE and oil-gas PEMEX, on the other—not not to mention the overall role of COFEMER. Ultimately, collaboration between regulators and independent monitoring agencies has been too shallow and market-wide reform efforts too diffident to yield a stronger regulatory presence, despite a 2003 collaboration agreement between CRE and CFC (OECD 2004). Despite the modest dialogue that has evolved between outside organizations and relevant sectoral players over the past decade, progress has thus far been limited to technicalities. This understated role is primarily attributable to the distribution of regulatory authority across the Mexican electricity sector. In the absence of robust political will, this market structure is unlikely to change in the short-term. Two possible areas of conflict between regulators and the industry in the coming years, however, are renewable energy and interconnection.

At the center of Mexico's electricity market activity is CFE, the vertically-integrated parastatal organization charged with providing electricity as a public service. Under CFE auspices, certain subsidiaries have historically overseen the various network functions, including generation, transmission, and distribution. The National Center for Energy Control, *Centro Nacional de Control de Energía* (CENACE), which maintains CFE's transmission grid, occupies a particularly influential position in the market. Indeed, CENACE analyzes spot market trends to apply electricity prices and facilitate transfer payments along the supply chain. In the resulting shadow market, which flows from CENACE to other CFE subsidiaries and non-utilities' wheeling activities, as well as companies with excess self-supply generation and foreign trade partners, CENACE's role is analogous to that of an Independent System Operator (ISO) in more liberalized markets (Mier-y-Terán 2005).

In addition to managing the internal financing dynamics of the public electricity market via CENACE, CFE further assesses transmission investment projects (Mier-y-Terán 2005). Currently, CFE disperses investment costs across the market, both as tariffs (coordinated by SHCP) and through negotiated power purchase agreements (PPAs). Although more progressive financing models have been explored, including auctioned transmission rights and direct regulation, CFE continues to operate a *de facto* monopoly on public infrastructure financing (Ibarra-Yunez 2010). Once CFE has determined its annual investment budget, it must then receive government approval—both from the relevant departments (SENER, SHCP, and Secretary of the Environment) and from the

Mexican Congress (Carreón 2003; Ibarra-Yunez 2010). A significant portion of CFE's operating budget is derived from a cyclical process through which it receives federal funds to invest in new infrastructure projects and, in exchange, contributes rate-of-return payments to the government (OECD 2004; Halpern 2009). The resulting zero-sum game represents perhaps the most detrimental consequence of publicly-financed infrastructural expansion. Indeed, the consumer subsidies disseminated by SENER and SHCP, which account for more than one-third of the electricity sector's gross revenues, should theoretically be counterbalanced by interest payments from CFE (Halpern 2009). However, the government's patronage of CFE's investment projects, compounded by said subsidies, adds more debt than can be offset by revenues alone.

CFE's constitutional designation as a public service organization has been interpreted as an explicit stake in all energy destined for retail sale. Article 36, Frac. III, of the *Ley del Servicio Público de Energía Eléctrica* (LSPEE) entitles CFE to all electricity generated by independent combined-cycle and natural gas producers (SENER 2010). The LSPEE further restricts the national grid exclusively to the flow of electricity (Ibarra-Yunez 2008). To ensure its stewardship over publicly-destined, privately-generated electricity, CFE requires Independent Power Producers (IPPs) to enter into long-term PPAs. The specific provisions of each PPA depend in part on the plant, fuel, and technology types employed by the private producer. Once CFE has determined the long-term profitability of an IPP project, the PPA must then be approved by SHCP and Congress (Mier-y-Terán 2005). Finally, CENACE establishes "right-of-access" tariffs to be levied against the private generator (Ibarr-Yunez 2008). Aside from the inefficiencies associated with CFE's overwhelming market power, the previously-cited author further posits the presence of access discrimination in the electricity market. This structural inequity presents a salient challenge to binational interconnection, and moreover raises questions regarding compliance with NAFTA's National Treatment clause.

6.5.3 Depth and Breadth of CRE's Legal and Institutional Capacities

Whereas CFE operates a virtual shadow market for IPPs outside the jurisdiction of independent regulators, electricity not bound for public distribution—including self-supply and co-generation capacity—was, in the 1992 amendment to LSPEE, not deemed subject to CFE purview (Ibarra-Yunez 2002). Rather, all electricity generated for purposes other than "public service" is regulated by CRE. Although CRE is formally a subsidiary of the Ministry of Energy, accountable to the federal government and allocated an operating budget by SENER, it nonetheless conducts its affairs under "technical and operational" autonomy (Carreón 2003; Andres 2008). CRE maintains a staff of more than 150 and is run by a four-member commission board, nominated by SENER and appointed by the President of Mexico. Among its responsibilities are issuing permits to non-utility producers; analyzing methodologies for market-related activities (including wheeling, fee scheduling, efficiency standards, etc.); assessing the electricity sector's regulatory framework; and enforcing non-compliance with contractual obligations (Ibarra-Yunez 2010).

Given the limits of CRE's regulatory oversight, the effectiveness with which it carries out certain other functions is debatable. CRE purports, for example, to regulate wholesale transactions between private producers and CFE. In practice, however, CRE has limited authority in matters pertaining to energy as a public service. Likewise, CRE provides an assessment of grid expansion projects, but CFE (in collaboration with various ministries) ultimately determines its own infrastructure plans (Ibarra-Yunez 2010). The challenge to CRE, as a quasi-independent regulator, is thus two-fold: (1) CRE relies on other agencies for budget, staff, and interagency protocols, thereby implicitly compromising its relative autonomy; and (2) CFE accumulates certain proprietary information, such as cost estimates and expansion plans, to which CRE is not entitled. The latter consequence has invariably resulted in an asymmetry in information between firm and regulator, a classic example of the Principal-Agent Problem (OECD 2004; Ibarra-Yunez 2008). Ibarra-Yunez contends that the best way for electricity markets that are not deregulated, such as Mexico's, to compensate for such asymmetries is to foster a close dialogue between the regulator and an independent, competition-oriented monitoring agency. While CRE did sign a collaboration agreement with CFC in 2003, the two organizations have never mounted a formal challenge to CFE's comparative information advantage (OECD 2004).

Empirically, CRE's primary influence on the public utility component of the electricity sector has been its ability to issue permits to private generators. As of December 2011, CRE had granted 980 total permits to producers for self-supply, co-generation, sale to CFE, and importation—670 of which are currently active (CRE 2011). Whereas all publicly-distributed electricity and any projects utilizing the national transmission grid necessarily enter into arrangements with CFE, the licensing authority which CRE maintains over the importation and exportation of energy provides a modicum of leverage. The electricity trade between the US and Mexico has remained minimal over the past decade; nevertheless, CRE's role as permit administrator would likely increase its market presence should the number of interconnections expand significantly in the future.

Despite its inherent limitations as the Mexican electricity market's independent regulator, CRE has seen its role expand incrementally over the past decade. Following SENER's promotion of an "Open Season" in 2007, in which new renewable energy projects were given special government treatment, Congress moved to broaden the scope of CRE's regulatory impact. The CRE Law, passed in 2008, allows CRE to set and enforce standards for renewable energy generation. As the nation gradually transitions to a heavier reliance on renewable energy, CRE's influence will inevitably increase in proportion to renewable generation capacity. Congress subsequently passed the Renewable Energy and Energy Transition Financing Law *Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética* (LAERFTE) in 2008. Reaffirming the regulatory authority in alternative energy matters bestowed upon

CRE by the CRE Law, LAERFTE charges CRE with developing a national strategy for the eventual transition to renewable energy (SENER 2010).[4]

The basic strategies outlined in LAERFTE attempt to differentiate specific technologies in order to foster competitive renewable growth, as well as embed alternative energy guarantees into transmission agreements for permit-holders (SENER 2010). While this framework is not substantively different from earlier legislation aimed at promoting renewable generation, two potentially radical regulatory implications stem from LAERFTE's intended implementation strategy. The procedures by which SENER and SHCP have traditionally determined wholesale market prices have tended to minimize CRE's decision-making role. That CRE is authorized by LAERFTE (along with SENER and SHCP) to set wholesale prices for generated renewable energy is not, in itself, an inexorable extension of CRE's influence on the market, according to its breadth and legal endowments. Given CRE's formally codified authority (via the CRE Law) with respect to renewable energy generation, however, there is reason to believe that CRE's new duties project a genuine increase in market presence. Article 10 of LAERFTE likewise establishes programs through SENER that incorporate generation externalities into actual methodologies and development plans (SENER 2010). CRE, in turn, will use said methodologies to formulate contracting rules which compel CFE to enter into long-term PPAs with renewable energy generators.

A second consequence of LAERFTE is that small- and medium-scale renewable energy producers, possessing less than 30 kW and 500 kW in capacity, respectively, can now sign PPAs without receiving a permit from CRE (SENER 2010). This policy follows in the footsteps of *Resolución RES/085/2007*, a federal rule passed in 2007 which formally legitimizes unconventional buy-sell contract models for small-scale generators. Such regulations do not substantially alter the market structure of the Mexican electricity sector in the short-term: CFE retains its monopoly on transmission and distribution, while IPPs have limited contract options and CRE is no less impotent in the public sphere. Nevertheless, the upshot of LAERFTE is that, in theory, CRE has not only inserted itself into the inner-workings of the electricity market, but further expanded its regulatory impact on CFE's contract-negotiation process beyond the perfunctory duty of issuing permits. While it is too early to assess the long-term viability of such claims, especially given the current dearth of renewable energy generators in Mexico, the reforms of the past decade undoubtedly represent a clear increase in CRE's market influence. This should be of particular relevance to any potential discussions regarding expanded interconnection with US firms.

6.6 Political Involvement in the Regulatory Apparatus

Over the past decade, CRE has taken discernible steps toward consolidating a stronger role in the Mexican electricity sector's regulatory process. Nowhere is its nascent influence more apparent than in the emerging field of renewable energy, which embodies

---

[4] Specifically, CRE is to expedite the *Modelo de Contrato de Interconexión para Centrales de Generación de Energía Eléctrica con Energía Renovable o Cogeneración Eficiente y sus Anexos (F-RC, IB-RC, TB-RC).*

the potential counterweight to CFE that, under the right circumstances, CRE could eventually present. Thus far, however, such an outlook is merely speculative: CFE maintains a stranglehold on infrastructure and contract negotiations with IPPs, not to mention a formidable stock of political capital and a constitutionally-guaranteed stake in the market. Comprehensive regulatory reform will ultimately require a multilateral demonstration of political will, which has recently eluded every attempt. In anticipation of the upcoming presidential election in the summer of 2012, however, candidates from both PRI and PAN—two main parties currently vying for the presidency, while PRD opposes any changes—have expressed an interest in further liberalizing the energy sector (Villiers 2011).

The *Código Nacional Eléctrico de 1926* and revisions made to Article 73 of the Mexican Constitution in 1934 represent Mexico's first modern attempts to politicize energy issues (Ibarra-Yunez 2002). The first of these landmark pieces of legislation asserted the government's sovereign right to manage energy destined for public consumption, while the latter formally created CFE as the preeminent steward of public electricity. Other initiatives have likewise upheld the federal government's central role in energy policy, from the 1960 amendment to Article 27 of the Constitution to the various incarnations of the LSPEE. Nevertheless, more recent attempts to reexamine the nature of the relationship between government and industry have invariably been thwarted by unrelenting partisanship and an unsympathetic public opinion (Breceda 2000; Carreón 2003; Mier-y-Terán 2005). The political realities evinced by successive administrations' well-publicized failures were, paradoxically, unexpected in light of the relative liberalization of the 1990s—exemplified by such initiatives as the 1992 update of LSPEE, the creation of CRE in 1993, and the passage of NAFTA in 1994.

Building upon the progressive foundation laid during the early 1990s, the Zedillo administration attempted to enact sweeping reforms in 1999. The administration's scheme, otherwise referred to as the *Propuesta de Cambio Estructural en la Industria Eléctrica de México*, centered on unbundling CFE into separate constituent entities (Ibarra-Yunez 2002). Specifically, CFE and LFC would comprise the generation and distribution market components, while all transmission operations would be delegated to a newly-created ISO—the *Centro de Operación del Sistema Eléctrico* (COSEN). In order to implement such broad structural changes to the electricity sector, President Zedillo called for Articles 27 and 28 of the Constitution to be amended (Breceda 2000). The first of these enumerates the "strategic activities" over which the state exercises sovereign control, while the latter expressly prohibits monopolistic practices (aside from the exempted economic areas). As Breceda (2000) points out, eliminating energy as a strategic enterprise would require the government to deprioritize CFE and its subsidiaries. The generation and retail spheres would consequently be opened to private competition. While distribution and transmission would be dissociated from CFE's exclusive oversight, all distributed electricity would still be subject to the public service obligations established in the Mexican Constitution.

The demise of the Zedillo plan in congress has been well documented, especially by Breceda (2000) and Mier-y-Terán (2005). The amendments to Articles 27 and 28 prescribed by the initiative required successful passage through the senate and chamber of deputies. Public opinion was, at the time, strongly opposed to fundamentally reorganizing the electricity market structure. This inevitably led congress to make a spectacle of the ordeal, repudiating the plan outright in the senate's plenary session (Breceda 2000). Despite the Zedillo plan's overwhelmingly negative reception by congress, subsequent administrations have tried, with equal futility, to push through comprehensive reform plans. The *Iniciativa de Reforma del Sector Eléctrico*, promulgated by *El Partido Verde Ecologista* (PVE) in 2001, similarly proposed that generation and distribution be opened to competition. PVE's proposal assigned final tariffs to the price of combined-cycle and coal-based electricity, which it bound to externality costs (Ibarra-Yunez 2002). The Fox Administration's *Plan de Desarrollo* likewise emphasized vertical unbundling and competitive, deregulated generation and retail markets. Both proposals encountered the same partisan resistance that had confronted the Zedillo plan, and both ultimately succumbed to the same fate as their predecessor, mainly partisan rejections to administrations that did not face congressional majorities in their presidency periods. Following the Mexican Senate's unequivocal rejection of successive administrations' attempts at comprehensive market reform, President Calderón advanced a proposal which advocated a more limited form of unbundling. In particular, Calderón's plan concentrated on corporatization and transparency in decisions by the state-run oil enterprise, PEMEX. Even such a moderate approach was met with nominal congressional enthusiasm.

Aside from the obduracy consistently displayed by the Mexican Congress, comprehensive market reform has been further hampered by unionized pushback from CFE. Indeed, the *Sindicato Unico de Trabajadores Electricistas de la República Mexicana* (SUTERM), CFE's affiliated public union, has tended to monolithically oppose deregulation and public-private competition in the electricity sector (Carreón 2003). One of Mexico's largest and most vocal public unions, SUTERM has exerted significant influence on energy politics and contributed to the Congress's general aversion to substantial reform efforts. This reluctance has been further compounded by the Mexican citizenry's consistent opposition to changes in the electricity market's subsidy structure. Nevertheless, presidential candidates from both the PRI and PAN have recently expressed interest in returning to the issue of energy liberalization.

Two leading PRI candidates, Enrique Peña Nieto and former opponent Manlio Fabio Beltrones, have acknowledged the importance of opening PEMEX to private investment, while PAN has openly backed a similar transition since PAN President Calderón's push for private competition in 2008 (Villiers 2011). Whereas no such consensus has yet been articulated with regard to electricity, the air of bipartisanship that is currently shaping the discourse on private competition in the energy sector potentially lends itself to electricity market reforms. Moreover, the mounting debts associated with publicly-guaranteed entities such as CFE and PEMEX, coupled with persistently high retail energy costs, have led to a rather sudden public opinion shift in favor of privatizing, or at least corporatizing, PEMEX (Villiers 2011). Even if PEMEX should undergo a fundamental reorganization in the near-future, however, commensurate liberalization in the electricity sector would likely still face significant challenges from SUTERM and the Congress, among others.

Moreover, energy reform faces such daunting challenges regarding the oil conglomerate PEMEX, that such an approach to embracing all energy, could have contaminated sound discussion of each parts of the energy sector, negatively affecting electricity restructuring. Political consensus will continue to be difficult to attain, and a major sectoral overhaul would require a sustainable multilateral solution—none of which seem politically viable at the moment.

6.7 Institutional Analysis

The preceding analysis of the regulatory framework and relevant regulatory bodies provides insight into the institutional history and functional pressures on agents that render Mexico's current state of regulations. The developments of the electricity generation industry in Mexico have responded to the restructuring of the economy after the 1982 debt crisis. The crisis forced the adoption of neoclassical market policies that limited the state's intervention in the economy and lowered trade restrictions. The new model, then, ended import-substitution industrialization (ISI), a system embedded in a nationalist economic development agenda that was both resonant with the ideals of the Mexican Revolution and maintained legitimacy and resources for the governing party. The redistributive efforts of the state were evident in the size of the bureaucracy and the state's presence in many sectors of the economy. Beginning in the early 1980s, changing the political paradigm involved inserting market-disciplining forces in order to modernize Mexico. Nevertheless, the government kept control over key sectors in the economy, such as petroleum and electricity, due to the political weight of its labor unions (who would oppose any changes toward market discipline) and the centrality of national ownership of natural resources in Mexico's political culture.

PPAs constitute a mechanism through which the state resolves the contradiction between controlling key sectors and promulgating NAFTA. They could also be considered a stepping-stone toward further liberalization and regional integration. Of significance, however, is that Mexico transitioned from a system (partly) legitimized by the normative guidelines of the revolution, related to the Virginia School's arguments, toward one founded on technical and economic guidelines (i.e. regulatory state) that the OECD and other international bodies promote. Evidence of Mexico's new regulatory efforts includes the inception of COFEMER, CFC, RIA, RFTS, and LAERFTE; however, these measures are not efficient enough in promoting competition in the electricity sector because they clash with remnants of a previous normative economic model. As a result, regulation in Mexico does not attempt to overhaul all economic exchanges, but rather focuses on specific sectors that have already been privatized. This supports Jordana and Levi-Faur's (2005) argument that the diffusion of regulatory regimes in Latin America is sectoral and not conducted on a national basis. It also underscores the fact that any economic performance variable, such as efficiency gains, investment expansion, commitment to a market, or wholesale or retail prices, are not normally treated as performance indicators as one may observe in other parts of the world—or even in Mexico's trading partners in North America and elsewhere.

The decision to regulate, then, is the result of a change in economic models, stemming from the debt crisis and NAFTA. As expected, this set of policymaking processes is not devoid of party politics. Rational Agent Institutionalism (RAI) informs that politicians will choose to (not) regulate in order to show their level of commitment to economic liberalization; alternatively, incumbents could be insulating their political "territories" (i.e. implemented policies) against competitors' potential efforts to overturn them (Gilardi 2004). Mexican politicians have indicated a commitment to harmonize regulation in accordance with international norms by implementing RIA and RFTS, as well as by granting access to transnational generators.

The Mexican Left, on the other hand, is adamant in keeping key sectors nationalized in order to protect the legacy of the state's social responsibilities—a position intrinsic to any leftist party. The PRI party has also been invested in the status quo since state-owned enterprises helped finance the party's electoral dominance between the 1930s and the 1980s, as demonstrated by Greene (2007). Now that the PRI lost dominance after 2000, perhaps an alliance with the PAN would be fruitful in further liberalization and unbundling. However, the rivalry between these parties may prevent an alliance, given that the PAN allied with its ideological foe, the *Partido de la Revolución Democrática* (PRD), in the past round of gubernatorial races in 2010 to ensure PRI losses in Oaxaca, Puebla, and Sinaloa. The PAN-PRD alliance lost to the PRI in Chiapas, Durango, and Hidalgo the same year.

In order to score the performance of the electricity sector in Mexico, it only suffices to say that: (a) efficiency measures, including sales per employee, penetration changes per generating plant, or by worker, are behind US and Canada counterparts; (b) annual expansion investment in transmission-distribution-retailing-generating plants has stalled under SENER's plans, which has concentrated its efforts in renewable energy and plant retirements; (c) performance in price dynamics shows both wheeling and retail prices, mainly to industry, higher—up to 65% greater—than day-to-day ones in the US southern border for 2011; and (d) reliability measures, under OECD observation, place Mexico and its dynamics below par in relation to international counterparts.

6.8 Conclusion

In 2010, Presidents Obama and Calderón met to discuss the creation of a binational "Electricity Task Force," the objective of which would be to explore the obstacles to and opportunities presented by a more tightly-integrated network for electricity trade. Two years later, the solutions prescribed by a cross-border stakeholder forum that evolved out of the presidential task force have been largely neglected, as electricity policy has been increasingly deprioritized by both administrations. This chapter has illustrated the imminent need for short-term solutions in order to foster long-term sustainability in the Mexican electricity sector. It has further characterized the regulatory structure of the market, including potential barriers and non-barriers to further integration with the US. Despite the dearth of tangible strategies that have emerged from diplomatic exchanges between the US and Mexico, the regulatory structure is, with some caveats, conducive to international expansion. What remains to be seen, then, is why so few producers and investors have explored interconnection as a viable short-term option, especially given the clear need for infrastructural expansion.

Following the institution of NAFTA in 1994, signatory countries were permitted to privately generate electricity in Mexico. Article 602.3 of NAFTA stipulated that the government could not prevent foreign companies from constructing generation facilities on sovereign Mexican territory (Degrandis and Owen 1995). Moreover, domestic companies have the constitutional right to import and export electricity, to the extent that it does not constitute a public service (Degrandis 1995; Ibarra-Yunez 2002). All permitted importers and exporters of electricity must, therefore, either provide generation exclusively for personal use or negotiate terms of sale through CFE. When a private company opts to import electricity, it first coordinates a bilateral contract with a foreign generator (North American Working Group 2005). Once it has procured a transaction agreement, it must then obtain permission from CRE to import electricity. Finally, the company must negotiate an interconnection contract with CFE if it plans to utilize the national transmission grid. For their part, IPPs are required to disclose all plant implementation plans to CFE prior to reaching an interconnection agreement (Ibarra-Yunez 2008). Among the additional requirements for permit-holders to import electricity are proof of compliance with emissions standards and settlement of contractual matters with CFE (Ibarra-Yunez 2008; and Chapter 2 of this report).

Interconnection permit discussions occur between CFE and CRE, in which the former analyzes the private company's grid implementation plan and the latter acts as an independent arbitrator (NAEWG 2005). If the two favorably appraise the company's application, the firm then either negotiates an interconnection contract (in the case of self-supply and co-generation) or signs a PPA (in the case of IPPs). An IPP must also navigate competitive bidding proceedings with CFE before being granted a PPA. The process by which rates are determined for imported electricity is roughly equivalent to the analogous system for domestic generation. CENACE collaborates with SHCP and SENER to establish final rates which reflect "economic costs" (Degrandis 1995). In accordance with NAFTA Article 301, SHCP sets identical use and general purpose tariffs for both domestic and foreign generation (NAEWG 2005). Foreign companies that employ the Mexican transmission grid for self-supply and co-generation are additionally subject to wheeling charges. In contrast, IPPs are entitled to rebates on fixed costs from SHCP (Degrandis 1995).

As Ibarra-Yunez (2010) points out, the substantial coordination and investment costs required of binational interconnection necessitate a shared distribution of funds. This has led CFE to explore joint projects with border-region US ISOs, such as ERCOT and the construction part of Sempra energy. A majority of the nine current interconnections between the US and Mexico exist in Baja California and Sonora, but additional interconnections are dispersed along the other grid divisions. Nevertheless, only 29 of the 670 active generation permits apply to importers of electricity (CRE 2011) and only seven permits had been granted to exporters as of 2010 (SENER 2010). These figures starkly illustrate the inability of economic and regulatory theory, in the wake of NAFTA and asymmetric deregulation, to foster transnational growth commensurate with domestic generation expansion. This failure is further accentuated by the fact that only three new import permits have been issued since 2008 (CRE 2011). Thus, not only do import permits represent a trivial proportion of overall generation permits in Mexico, but they appear to have declined significantly during the past three years due to gaming by authorities and CFE.

Given the advances in transnational trade liberalization produced by NAFTA and recent innovations in the Mexican regulatory system, the apparent indifference toward electricity market integration is rather counterintuitive. The confluence of certain interrelated factors may shed light on this economic about-face. At the inception of NAFTA, it was predicted that, within eight years, CFE would allot roughly 70% of its service contracts to US and Canadian competitive bids (Degrandis 1995). In retrospect, this assumption clearly underestimated CFE's constitutional stranglehold on public electricity. Several conditions that have likewise hampered interconnection can be derived from the present analysis: inadequate capacity; lack of incentives; general regulatory impediments (e.g. the legal distinction between utilities and non-utilities); asymmetric cost structures and production scales; cross-border variations in load prices; and the relative impotence of independent regulators.

All of the preceding factors have indeed discouraged firms from pursuing further integration efforts; however, the incompatible interests of CFE, as the incumbent organization, and proponents of regulatory reform present the greatest structural challenge. Not only does the intricacy of the electricity sector's decision-making structure—particularly with regard to infrastructural investment—impose uncertainty on foreign investors, but inefficient administrative practices, such as high residential subsidies and inconsistent tariff policies, have largely been insulated from regulatory reform (OECD 2004). Perhaps most importantly, CFE's continued hegemony over the transmission and distribution of publicly-destined electricity, as well as all electricity imported and exported by IPPs, creates unnecessary logistical and economic costs to binational grid expansion. Whereas the climate in Mexico for small-scale, subsistence-oriented energy producers remains relatively conducive to transnational expansion, wholesale generation continues to face a monopolistic market with myriad regulatory inconsistencies and few incentives.

The most obvious recent culprit behind dwindling import/export permit applications is the 2008 global financial crisis. Since 2008, CRE has granted an average of less than one import permit per year (CRE 2011). This represents a significant drop-off from the annual average of nearly five permits that were granted from 2001 to 2007. Although industrial and commercial consumers might find price incentives to import electricity from US sources, Mexican producers could likewise realize advantages by exporting to US markets—particularly renewable energy. However, a 2009 study by the International Energy Agency (IEA) found that the financial crisis, which yielded tighter credit and volatile market prices, strongly discouraged investment in energy infrastructure. To curb firms' contractionary instincts, conventional fiscal policy stipulates that a government should prop up the market by providing incentives and promoting continued investment. As detailed in a 2004 OECD study, however, the Mexican regulatory regime has created entry barriers to foreign investors by neglecting to sufficiently harmonize domestic regulations with international standards, even in light of the 12 trade agreements that Mexico has implemented beyond NAFTA.

The apparent resistance of the US and Mexican electricity markets to constructing additional interconnections stems largely from diplomatic inertia, which can be deduced from the New Institutional economic analysis applied in the body of the present study. Indeed, relevant sectoral decision-makers have acknowledged the potential benefits of market integration (SENER 2010). Why, then, is electrical interconnection neither articulated as a policy imperative nor pursued more rigorously by firms and ISOs? Aside from the high fixed costs associated with infrastructural investment and economic disincentives imposed by the financial crisis, the regulatory challenges detailed in this chapter are immanently correctable. Nevertheless, the level of diplomatic coordination regarding electricity has virtually disappeared over the past decade. The North American Energy Working Group, a transnational initiative established in 2001 to foster cooperation on energy policy between the NAFTA member countries, was formally dissolved by the Obama administration. In its place, Presidents Obama and Calderón created the Electricity Task Force in 2010 to reestablish a collaborative approach to solving electricity sector issues. Following a stakeholder forum in October 2010, the two governments nominated members to the task force (Biller 2010). Since its initial meeting at the end of 2010, however, the task force has yet to publicly formulate an official plan of action.

The idleness of the Electricity Task Force epitomizes the low priority status afforded electricity policy by the Obama and Calderón administrations. In his 2010 State of the Union Address, President Obama announced the creation of a National Export Initiative (NEI), the purpose of which would be to stimulate the domestic labor market by increasing export margins. A 2011 assessment of the NEI by SENER, however, neglected to detail electricity as a potential source of economic integration, instead focusing on such issues as border security and regulatory coordination (SENER 2011). Moreover, President Obama's 2011 *Blueprint for a Secure Energy Future* expressed electricity sector reforms in a purely domestic context (White House 2011). The noticeable absence of electricity interconnection from such energy reform initiatives implies that the US and Mexico are presently content to focus diplomatic efforts on other related, but tangential, matters (e.g. renewable energy, climate change, and oil), while maintaining the status quo in the electricity sector.

Further binational integration in the electricity sector offers short-term solutions to the high costs and rising demand problems that currently challenge the Mexican retail market. Concerted diplomatic coordination between the two countries will be necessary to reform onerous regulations and reconcile CFE's market power. Possible regulatory-oriented solutions include expanding CRE's authority; increasing the coordination between CRE and monitoring agencies such as CFC and COFEMER; and consolidating CRE's ability to regulate generation imports and exports. Diplomatic efforts will additionally need to incorporate regional ISOs, such as ERCOT, in order to arrange the details surrounding network interconnection. Recent bilateral discussions between the US and Mexico have tended to promote a regional market as a necessary objective. The US-Mexico Framework on Clean Energy and Climate Change, convened by (among others) members of the US State Department, SENER, and the two respective ambassadors, delegated further research of binational market integration to the Electricity Task Force (US Embassy 2011). That the task force continues to be a viable instrument of diplomacy is an encouraging sign of future cooperation between the US and Mexico.

References

Adler, M. and E. Posner. 1999. Rethinking Cost-Benefit Analysis. University of Chicago Law School, John M. Olin Law & Economics Working Paper #72.

Andres, L., J.L. Guasch, and S.L. Azumendi. 2008. Regulatory Governance and Sector Performance: Methodology and Evaluation for Electricity Distribution in Latin America. The World Bank: Policy Research Working Paper #4494.

Austin, A. 2005. *Energy and Power in China: Domestic Regulation and Foreign Policy.* London: The Foreign Policy Centre.

Beato, P., and J. Laffont (eds.) 2002. *Competition Policy in Regulated Industries: Approaches for Emerging Economies*. Washington: Inter-American Development Bank.

Becker, G.S. 1983. A Theory of Competition Among Pressure Groups for Political Influence. *Quarterly Journal of Economics* XCVII (3). August: 371-400.

Biller, D. 2010. Governments Nominate Members for Cross-Border Task Force. *Business News Americas*. Retrieved November 3, 2010, at http://www.bnamericas.com/news/electricpower/Governments_nominate_members_for_cross-border_task_force.

Bonetto, C. and M. Storry. 2010. A Brief History of Mexico's Power Sector. *Power* 154 (5): 66-67.

Bonetto, C. and M. Storry. 2010. A Regulatory Framework with Little Flexibility. *Power* 154(5): 80-84.

Braithwaite, J. 2000. The New Regulatory State and the Transformation of Criminology. *British Journal of Criminology* 40: 222-238.

Breceda, M. 2000. *Debate on Reform of the Electricity Sector in Mexico: Report on its Background, Current Status and Outlook*. The North American Commission for Environmental Cooperation.

Breceda, M. 2002. *Private Investment in Mexico's Electricity Sector*. Commission for the Environmental Cooperation, Environment, Economy and Trade Program.

Carreón-Rodriguez, V.G., A.J. San Vicente, and J. Rosellón.2003. *The Mexican Electricity Sector: Economic, Legal and Political Issues*. Program on Energy and Sustainable Development, Stanford University. Policy Research Working Paper #5.

Comisión Federal de Competencia. 2008. *Informe Anual, 2008*. Mexico, D.F. Retrieved January 3, 2012, at http://www.cfc.gob.mx.

Comisión Federal de Competencia. 2009. *Informe Anual, 2009*. Mexico, D.F. Retrieved January 3, 2012, at http://www.cfc.gob.mx.

Comisión Federal de Mejora Regulatoria. 2009. *Informe Anual, 2009*. Mexico, D.F. Retrieved January 3, 2012, at http://www.cofemer.gob.mx.

Comisión Federal de Mejora Regulatoria. 2010. *Informe de Labores, 2010*. Mexico, D.F. Retrieved January 3, 2012, at http://www.cofemer.gob.mx.

Comisión Reguladora de Energía. 2011. *Tabla de Permisos de Generación e.*

Importación de Energía Electrica Administrados al 31 de Diciembre de 2011. Mexico, D.F. Retrieved December 10, 2011, at http://www.cre.gob.mx/documento/ 1565.pdf.

Cubbin, J. and J. Stern. 2005. *Regulatory Effectiveness: The Impact of Regulation and Regulatory Governance Arrangements on Electricity Industry Outcomes*. World Bank Policy Research Working Paper #3536.

DeGrandis, W. and M. Owen.1995. Electric Energy Legal and Regulatory Structure in Mexico and Opportunities after NAFTA. *United States-Mexico Law Journal* 3*:* 61-68.

Demófilo de Buen, O. 2005. Cogeneration and Self-Supply in Mexico: Opportunities, Constraints and Public Policy. *Cogeneration & Distributed Generation Journal* 20 (1): 71-79.

Dukert, J.M. 2007. North America. In S. Weintraub, A. Hester, and V.R. Prado (eds.), *Energy Cooperation in the Western Hemisphere*. Washington, DC: CSIS Press: 132-160.

Embassy of the United States (2011). *U.S.-Mexico Bilateral Framework on Clean Energy and Climate Change*. Press Release, 2011. Retrieved January 11, 2012, at http://mexico.usembassy.gov/press-releases/ep110523-climate.html.

Gilardi, F. 2004. Institutional Change in Regulatory Policies: Regulation through Independent Agencies and the Three Institutionalism. In J. Jordana and D. Levi-Faur (eds.), *The Politics of Regulation: Institutions and Regulatory Reforms for the Age of Governance*: 67-89.

Greene, K. 2007. *Why Dominant Parties Lose: Mexico's Democratization in Comparative Perspective*. New York: Cambridge University Press.

Halpern, J.D. et al. 2009. Residential Electricity Subsidies in Mexico: Exploring Options for Reform and for Enhancing the Impact on the Poor. World Bank Working Paper #160, Report #47107.

Harrup, A. 2011. Mexico's Senate Approves Changes in Competition Law. *The Wall Street Journal*, Business Section. April 28, 2011.

Hood, C., C. Scott, O. James, G.W. Jones, and A. Travers.1999. *Regulation Inside Government.* Oxford: Oxford University Press.

Ibarra-Yúnez, A.2002. Análisis del Sector Eléctrico de México a La Luz de los Cambios Internacionales de Mercado y Regulación. *Senado de la Republica/ Series Docs. de Investigacion en Mexico y Chile.* México. Abril.

Ibarra-Yúnez, A. 2008. *Structure, Behavior, and Incentives in the Electrical Energy market, Economic Efficiency and Regulations in Mexico: Towards Better Public Policies*. Organization for Economic Co-operation and Development.

Ibarra-Yúnez, A. 2010. Is there an Integrated Electricity Market in North America? Institutional Challenges in Mexico. In Isidro Morales (ed.), *National Solutions to Cross-Border Problems*. London, Ashgate: 2-29.

International Energy Agency (2009). *The Impact of the Financial and Economic Crisis on Global Energy Investment*. Background Paper for G8 Energy Ministers' Meeting, May 24-25, 2009. IEA/OECD 2009.

Jabko, N. 2004. The Political Foundations of the European Regulatory State. In *Politics of Regulation: Examining Regulatory Institutions and Instruments in the Age of Governance.* CRC Series. Cheltenham, UK: Edward Elgar Publishing, 200-17.

Jacobzone, S., C. Choi, and C. Miguet.2007. *Indicators of Regulatory Management Systems*. OECD Working Papers on Public Governance, No. 4. OECD Publishing. doi: 10.1787/112082475604.

Jordana, J., and D. Levi-Faur, D. (eds.) 2004. *The Politics of Regulation.* Cheltenham: Edward Elgar.

Jordana, J. and D. Levi-Faur. 2005. The Rise of Regulatory Capitalism: The Global Diffusion of a New Order. *The Annals of the American Academy of Political and Social Sciences* 598(1).

Joskow, P. and J. Tirole. 2005. Merchant Transmission Investment. *Journal of Industrial Economics* 53(2): 233-64.

Joskow, P. 2008. Lessons Learned from Electricity Market Liberalization. *The Energy Journal*, Special Issue: 9-42.

Kirkpatrick, C., D. Parker, and Y.F. Zhang. 2008. Electricity Sector Reform in Developing Countries: An Economic Assessment of the Effects of Privatization, Competition and Regulation. *Journal of Regulatory Economics* 33: 159-178.

Laffont, J.J. and D. Martimont. 2005. The Design of Transnational Public Good Mechanism for Developing Countries. *Journal of Public Economics* 89: 159-196.

Lock, R. 1993. Mexico-United States Energy Relations and NAFTA. *1 U.S.-Mex. L.J.*:235-254.

Lofstedt, R.E. and D. Vogel. 2001. The Changing Character of Regulation: A Comparison of Europe and the United States. *Risk Analysis* 21: 399-406.

Mashaw, J. 1989. *The Economics of Politics and the Understanding of Public Law.* 65 Chi.-Kent L. Rev. 123.

Mier-y-Terán, A. 2005. *Restructuring the Mexican Electric Industry: An Evaluation of the Use of Financial Transmission Rights*. Dissertation. Centro de Investigación y Docencia Económica.

North American Energy Working Group. 2005. *Guide to Federal Regulation of Sales of Imported Electricity in Canada, Mexico, and the United States.* Washington, D.C. Retrieved October 1, 2011, at http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Guide_to_Sale_of_Imported_Electricity.pdf.

Organization for Economic Co-Operation and Development. 2004. *Mexico: Progress in Implementing Regulatory Reform*. OECD Reviews of Regulatory Reform.

Peltier, R. 2011. CFE Extends CTG Universidad Unit 2's Life with Conversion to Synchronous Condenser. *Power* 155(8): 36-42.

Peltzman, S. 1976. Toward a More General Theory of Regulation. *Journal of Law and Economics* 19(2).

Peltzman, S. 1989. The Economic Theory of Regulation after a Decade of Deregulation. Brookings Papers on Economic Activity. *Microeconomics:* 1-59.

Pineau, P. 2004. Electricity Services in the GATS and the FTAA. *Energy Studies Review* 12: 258-283.

Ogus, A. 2004. W(h)ither the Economic Theory of Regulation? What Economic Theory of Regulation? In J. Jordana and D. Levi-Faur (eds.), *The Politics of Regulation.* Cheltenham: Edward Elgar, 31-44.

Prado, V.R. 2007. Energy Infrastructure in the Western Hemisphere. In S. Weintraub, A. Hester, and V.R. Prado (eds.), *Energy Cooperation in the Western Hemisphere*. Washington, DC: CSIS Press, 405-430.

Secretaría de Energía de México. 2010. *Prospectiva del Sector Eléctrico, 2010-2025*. México, D.F. Retrieved January 3, 2012, at http://www.sener.gob.mx/res/1825/SECTOR_ELECTRICO.pdf.

Secretaría de Energía de México. 2011. *More U.S. Exports and Jobs: Mexico is a Strategic Partner*. NEI Memorandum. November.

Sioshansi, F. (ed.) 2008. *Competitive Electricity Markets: Design, Implementation, Performance.* Amsterdam: Elsevier.

Stigler, G. 1971. The Theory of Economic Regulation. *The Bell Journal of Economics and Management Science* 2(1): 3-21.

US Energy Information Administration. 2011. Electric Power Industry – US Electricity Imports from and Electricity Exports to Canada and Mexico. *Electric Power Annual Report*. Washington, D.C. Retrieved January 3, 2012, at http://www.eia.gov/cneaf/electricity/epa/epat6p3.html.

US Energy Information Administration. 2011. Country Analysis Briefs: Mexico. Washington, D.C. Retrieved January 3, 2012, at http://www.eia.gov/ EMEU/cabs/Mexico/pdf.pdf.

Villiers Negroponte, D. 2011. Could PEMEX Follow the Logic of PETROBRAS? The Brookings Institution. Washington, D.C. November.

Weigt, H. 2009. *A Review of Liberalization and Modeling of Electricity Markets*. Dresden University of Technology, Working Paper WP-EM-34.

Weintraub, S. and R.F. del Castro. 2007. Mexico. In S. Weintraub, A. Hester, and V.R. Prado (eds.), *Energy Cooperation in the Western Hemisphere.* Washington, DC: CSIS Press, 106-127.

White House. 2011. *Blueprint for a Secure Energy Future*. Memorandum: March 30, 2011. Retrieved March 3, 2012, at http://www.whitehouse.gov/sites/ default/files/blueprint_secure_energy_future.pdf.

Wijen, F. and R. Van Tulder. 2011. Integrating Environmental and International Strategies in a World of Regulatory Turbulence. *California Management Review* 53 (4): 23-46.

Woo C., D. Lloyd, and A. Tishler. 2003. Electricity market reform failures: UK, Norway, Alberta and California. *Energy Policy* 31(11).

The World Bank. 2004. *Poverty in Mexico: An Assessment of Trends, Conditions, and Government Strategy*. World Bank Working Paper # 28612-ME.

Zenon, E. and J. Rosellón. 2010. The Expansion of Electricity Networks in North America: Theory and Applications. Munich Personal RePEc Archive. MRPA Paper No. 26470.

Chapter 7. Energy Integration in North America: Politics and Policymaking

by Nora Ankrum, Lun Dai, and Austin Woody

Abstract

Greater integration of the electrical grid, both within the US and across its borders, is no simple task: despite enhanced reliability, economic efficiency, and other potential benefits, regulatory and political challenges remain. Even as utilities, regulators, and regional networks acknowledge the urgency of expanding the transmission network, they do not agree on who should pay for it or what level of cooperation—much less integration—will be necessary. Discussions over interconnections with Mexico reflect the dimensions of this argument while taking on further complications due both to shifting political agendas and differences in regulatory frameworks. This chapter explores these tensions in order to outline the major regulatory and political challenges to greater integration of the North American electricity grid from the United States point of view. The exploration begins with a review of global trade governance, followed by an examination of the current US regulatory and market environment, rooted in the evolution of deregulation since the 1978 passage of Public Utility Regulatory Policies Act. The chapter then examines the relative advantages and disadvantages of greater integration from the varying perspectives of major stakeholders on both sides of the US-Mexico border, again, with the US point of view, and analyzes ERCOT in depth as a unique participant.

7.1 Global Regulation of Electricity Trade

Stakeholder preferences about the importance of energy security limit the global regulation of electricity. Moreover, in many US policy forums in recent months and years, it has been argued that no energy policy has been clearly defined for the United States. The limited regulation creates many grey areas in international trade and provides no cross-border protection for exporters and importers. The World Trade Organization, regional trade agreements, and domestic regulation all influence the regulation of electricity and often contradict each other.

The decentralization of energy markets coupled with a rising demand in emerging economies challenges whether countries will rely on markets to secure access to energy sources, or whether state agencies will assume greater control. Furthermore, climate change and the accession of large energy economies into the WTO place tensions on the grey areas of energy trade.

As this trade becomes more popular, tensions will develop between divided regulatory systems. These tensions may result in international disputes about electricity trade—an area that has little precedence, and where we explore its framework, institutional setting, and dynamics from the US perspective. After discussing multilateral frameworks in trade law and institutions such as GATT and GATS in the next sections, the analysis then goes over a brief history of the US regulations in Section 7.2. Section 7.3 concentrates on analyzing some of the key players and determinants of their political will. Section 7.4 addresses ERCOT, and Section 7.5 concentrates on its main challenges as an autonomous and powerful-successful system operator. Section 7.6 concludes with the challenges to create an integrated electricity vision in the US, affected by the political positions regarding renewables.

7.1.1 Levels of Regulation

Three layers of regulation influence the international trade of electricity. On a global scale, the World Trade Organization (WTO) and its 153 members govern the trade of electricity. On a regional scale, agreements such as the North American Free Trade Agreement (NAFTA) manage the regional trade of electricity. These regional agreements among two or more countries promote inter-regional integration and often include specific clauses regarding energy resources and electricity. Finally, domestic governments maintain the greatest influence over electricity trade as governments protect national sovereignty, energy security, and other political interests.

These levels of regulation are often at odds by contradicting each other's policy goals. The rules governing energy trade and investment vary among regions, creating tensions between the state-dominated versus market-led paradigms (Desta 2003, p. 523). Countries choose to participate in multiple regulatory regimes, creating overlapping and conflicting memberships. For example, the WTO promotes international trade through liberalization, which increases competition in world markets and discourages discriminatory practices. Many members of the WTO also participate in regional trade agreements negotiated with bilateral partners. These regional agreements could become discriminatory in nature and they could reduce outside competition, thus, conflicting with WTO regulations even if GATT articles for trade policy accept regional trade agreements if they make use of "most favored nation," "non-discrimination," and "national treatment" of investments in their clauses (see GATT code of trade, applicable by WTO nowadays; Trebilcok and Howse 2005).

Domestic regulation often restricts electricity trade with high tariffs, intense regulation and bureaucratic procedures. Many countries seek to protect their electricity from outside influence for fear of instability and of situations that are beyond the scope of their control.

When some bilateral agreements are negotiated outside the venue of the global institutions such as the WTO, the larger economy often maintains a negotiating advantage in the regional trade agreements. Oftentimes, smaller economies seek access to larger markets and are willing to offer concessions and preferential treatment to the larger economy for this access. The North American Free Trade Act provides an excellent example of this. Compared to the rest of the world, North American electricity markets are weakly integrated. ERCOT only maintains three connections with outside grids and two of these are with Mexico. The Canada-US border is crossed by more than 37 major interconnections that have a capacity of 18,977 MW, whereas the major interconnections between the US and Mexico are capable of handling only 944 MW (Martinez-Chombo 2011).

7.1.2 Increase of Regional Trade Agreements (RTAs)

Regional trade agreements increase in popularity as the WTO struggles to find consensus in trade negotiations. Developing countries with growing energy demands and weak bargaining power look to the WTO to promote a less discriminatory management of energy resources. However, the WTO is unable to bring about significant improvements in trade for developing countries while it is deadlocked in negotiating the Doha Development round, which began in 2001. The WTO intended for this round of negotiations to address issues of development and market access for developing countries; however, with negotiations continuing for 11 consecutive years there is decreasing confidence that the round will ever close. Emerging markets distrust the ability of the WTO to promote free and equitable trade as larger economies refuse to acknowledge their increased role in the global economy.

Yet, both large and small economies desire greater international trade to support economic growth. Countries find it both easier and faster to negotiate regional agreements with fewer stakeholders involved. As such, the use of regional agreements significantly increased and over 311 regional agreements exist today at different levels of depth and width. Many country cases show exceptions in liberalization when industries or firms are considered national champions, or strategic for their governments (WTO 2012).

7.1.3 The Stakeholders

Trade agreements handle energy products, energy services such as electricity, and energy-related investment activities separately from other goods/services (Victor 2010). The General Agreement on Tariffs and Trade (GATT), now managed at the World Trade Organization (WTO), focused on increasing market access for exporters, as well as on increasing access to energy imports, but some exporters of energy were averse to lose sovereignty of their oil (Desta 2003). This is similar to the treatment arguably applied to “special sectors” such as agriculture or high technology.

Exporters of energy products concern themselves with demand security, transparency of importers policies, and reduced trade barriers (Victor 2010). Exporters seek market access guarantees through both multilateral and regional trade agreements. Importers of energy products desire security of supply. They favor transparency and predictability in their suppliers’ policies and wish to limit their use of quantitative restrictions and export duties. Many importing countries also seek access to new technologies from exporters such as transmission and smart grid technologies.

Non-state actors, including energy firms, play a greater role in energy regulation. They seek laws, both international and domestic, to support investment and reduce risk, such as nationalization. These firms are concerned with transparency and protection of their intellectual property.

Because of energy's importance to every government and the massive influence of energy stakeholders, there is limited regulation of electricity trade on a global level. Individual countries are averse to outside regulators governing their energy trade, implying restraints to the county's freedom to secure energy resources and pursue energy policies. Maintaining energy reliability/security is seen as a delicate and sovereign process, such that outside regulation is often considered to complicate its delivery.

7.1.4 The Grey Areas: Is Electricity a Good or Service?

Within the global regulation of electricity, it is unclear if electricity is to be treated as a good or a service. This ambiguity benefits energy stakeholders, allowing flexibility and autonomy in their activities. Historically, no formidable interests existed in opening markets for energy products. As a result, GATT excluded energy products from tariff reduction commitments (Desta 2003).

Under the General Agreement on Trade in Services within GATT, the well-known GATS, electricity is neither treated as a commodity nor listed as a service (WTO 2010). Recent indications reveal that the leadership at the WTO considers electricity a good—for practical reasons, customs clearance is done after the electricity enters the country according to measurements at the cross-border link (WTO 2010). Some WTO members agree with this classification, while others view the generation of electricity and operation of power plants as a service.

Because of the ambiguous definition for energy and the vested stakeholder interests, rules within the WTO provide significant flexibility for energy. Energy is exempt from WTO regulations for critical shortages of essential products (Article XI:2(a)) and conservation of exhaustible natural resources (Article XX(g)). Electricity producers restrict exports to ensure availability of essential supplies to a domestic industry, for which *de jure* prohibitions for trade are accepted because of the consideration of electricity as an "essential" resource (Article XX(i)).

Although most provisions in NAFTA extend to all three countries, the manner in which Mexico included energy and electricity in the agreement differed significantly from Canada's strategy. Canada granted importers proportional rights to access Canadian electricity in case there is a need to curb exports because of a crisis; Mexico exempted itself from such a clause in NAFTA (Pineau et al. 2004). NAFTA (Article 604) prohibited taxes and duties on energy exports unless similar charges were applied on domestic consumption as well; NAFTA prohibits maximum import and export prices in line with non-discrimination principles and market-driven liberalization (Article 603(2), NAFTA; Article 902, CUSFTA).

Given these exceptions, on their part little guarantee protection exists from cross-border supply. As a result, few disputes reach the WTO and there is sparse precedence governing cross-border energy trade. However, with the decentralization of the global economy it is possible that the number of disputes rising to the WTO may increase, forcing the WTO to provide further clarity on cross-border electricity regulation, as it has already happen in cases of trade of electricity across European countries (see Chapter 1).

Energy markets decentralize with emerging economies taking a greater role and interest in energy trade. This phenomenon along with regulation of energy demands regarding climate change, and large energy economies joining the WTO will likely influence and change current regulation of electricity trade.

The global communities pursuit for solutions to climate change will change regulation on the global venue. Concerns of climate change, we argue that will increase global regulation of energy, putting pressure on governments to alter their energy consumption. Recognizing the importance of alternative energy generation several countries are providing significant subsidies to domestic industries. Other countries dispute the use of subsidies to encourage the development of alternative energies as this gives subsidized industries an unfair advantage in energy markets. New disputes are being brought to the WTO regarding clean energy subsidies. These rulings may have an indirect impact on electricity trade as new forms of generation in border areas come from clean energy sources (Lesage et al. 2010).

Energy exporters who are also members of the Organization for Petroleum Exporting Countries (OPEC) do not follow WTO regulations on energy trade. The export restrictions used by OPEC members could receive more attention as new members join the WTO. While no dispute has been brought to date, new disputes may come to the WTO challenging rules protecting energy exporters as importing members seek increased transparency and guarantee of supply. Saudi Arabia joined the WTO in 2005, Russia joined in 2011, and other oil producers prepare to join soon. These new states with large economies will change the dynamics of WTO and regulations regarding energy.

To close this introduction about main stakeholders and institutional frameworks for energy, traditional economic powers lose dominance of the global economy to new emerging markets, along with a renewables' agenda that is less than clear for the time being. New exporters from emerging economies now controlling an increasing percentage of global trade might be calling for greater influence and concessions from regulatory agreements, both regional and international. These emerging powers, shifting the center of gravity within the WTO, could further challenge the status quo.

7.2 History of Regulation in the United States

The federal government's regulation of electricity utilities is rooted in its constitutional responsibility in interstate commerce. The Federal Water Power Act of 1920 created the Federal Power Commission (superseded in 1977 by the Federal Energy Regulatory Commission) in charge of overseeing the development of hydroelectric power, which is clearly part of interstate commerce. An amendment to FWPA (Federal Power Act of 1935) gave the FPC authority to regulate wholesale electric sales and encourage interconnections within and among power regions. Naturally, concerns arose over states' rights to regulate, but they did not represent a substantial threat because the FPC did not have the authority to establish interconnections. The FPC was only able to exercise regulatory powers by forming regional reliability councils to oversee inter-utility coordination (Pechman 1993).

Government regulation of the electricity sector in the US was a contentious policy issue in the early 20th century, as public utilities expanded and amassed economic and political power while the Great Depression wreaked havoc on other sectors of the economy. A report by the Federal Trade Commission (FTC) revealed holding companies' financial irregularities in income declarations that inflated profits and rendered dividends worthless. President Franklin D. Roosevelt supported efforts to rein in monopoly expansion with government intervention. The 1935 Public Utilities Holding Company Act (PUHCA) was one such measure, intended to simplify utility holding company systems and prevent pyramiding (Pechman 1993).

The Great Northeast Blackout of 1965 constituted an institutional failure for the utilities. The outage affected an area of 80,000 square miles (eight US states plus Ontario) for almost 13 hours. Additionally, the blackout revealed the increasing complexity of transmission systems and a need to redirect investment to upgrade the grid (Munson 2005). In 1968, the nine regional reliability councils along with public authorities and representatives of the federal government formed the North American Electric Reliability Council (NERC), which was charged with establishing reliability standards, such as utility surplus capacities, and collecting and disseminating information about reliability. With coordinated interconnections, NERC was the foundation for the trading of wholesale electricity in the region (Bradley 2008). In 2006, the North American Electric Reliability Corporation replaced NERC yet maintained the same responsibilities of "ensuring the reliability of the bulk power system of North America" (NERC 2012).

In 1977, the Department of Energy Organization Act changed the name of the FPC to Federal Energy Regulatory Commission (FERC) and established its jurisdiction over appeal hearings on Department of Energy (DOE) oil price control determinations and regulation of interstate oil pipelines. The following year, the Public Utility Regulatory Policies Act of 1978 (PURPA) was passed to integrate more efficient generating units from non-utilities, promote cogeneration, and use renewable resources. PURPA also required utilities to buy power at avoided cost and provide back-up prices at non-discriminatory prices (Pechman 1993). Similar policy moves and adjustments occurred in Mexico much more recently with the passage of the Utilities Law in 1992, which maintained a mixed industry in which a vertically integrated state-owned enterprise coexists with marketable generation. (See Chapter 6 on Mexico's state of regulations.)

Conservation as a resource option started gaining traction in the US in the late 1970s, and the Energy Policy Act of 1992 demonstrated the materialization of this commitment. EPACT promoted energy conservation by opening access to the transmission network and making it easier for non-utilities to enter the wholesale market. EPACT also allowed utilities to purchase energy in the open-access national wholesale market by owning "exempt wholesale generators" or establishing subsidiaries anywhere in the country (Ardoin and Grady 2006). These measures were intended to increase efficiency and conservation so that investments in generation, transmission, and distribution capacity would be obviated (Pechman 1993). FERC's Order No. 2000 created Regional Transmission Organizations (Bradley 2008).

Utilities' monopoly power weakened with FERC's Order No. 888, which outlined the conditions for open, nondiscriminatory access to the transmission grid. As a result, wholesale producers that included independent generators, government-owned utilities, and industrial producers could obtain transmission access at just and reasonable rates. Order 889 established transparent pricing of electricity through the Open Access Same-Time Information System (OASIS), a computer network of electricity market information (Koch 2000). President George W. Bush signed the 2005 Energy Policy Act (EPAct 2005). Its objectives were to (1) promote competition in wholesale power markets; (2) strengthen FERC's regulatory authority to help prevent market manipulation and market power abuse; and (3) reinforce the energy infrastructure, particularly the interstate transmission grid (Nunez 2012). As discussed in more detail in the following section, much of the authority granted FERC and DOE in this act has been successfully challenged in court by local stakeholders (Agen 2011).

Today, despite a strong case for the technical feasibility, economic benefits, improved reliability, and overall enhancement of social welfare associated with greater grid integration between the US and Mexico, there is little evidence of momentum toward this goal, especially at the policy level. The two countries have built a foundation of ample and deep cooperation, particularly within the framework of NAFTA, yet electricity remains a relatively weak area of collaborative trade effort. The following section explores the potential regulatory and political explanations for this apparent anomaly.

7.3 Analysis of Political Will

Greater integration of the electrical grid across the US-Mexico border poses a unique solution to grid reliability challenges faced in both countries; nonetheless, there is little evidence that policymakers on either side are giving this approach serious consideration. Why there is not a higher level of commitment?

In exploring this question, the following analysis first looks to the relationship between the US and Mexico, one in which shifting political agendas on both sides of the border create a shaky foundation for ongoing cooperation on electricity policy. Second, this section analyzes the regulatory environment north of the border. Despite little focus on the issue binationally, the opposite is true domestically: in the US, greater regional coordination of transmission planning is the focus of heated debate among stakeholders.

Underlying all the explanations gathered here, it seems apparent that the high priority afforded domestic control of infrastructure guides decisions on both sides of the border, despite abundant evidence of the benefits of ceding some control in favor of greater cooperation. (See Chapter 1 for a more detailed explanation of how the US and Mexico constitute an outlier in this regard.)

7.3.1 US-Mexico Relations: He Said, She Said

On the international stage, among pressing concerns shared by the US and Mexico, electricity takes a backseat to issues such as security and immigration reform. Even among energy concerns, electricity is overshadowed by oil, given that Mexico is the

United States' second largest supplier. Meanwhile the oil sector generates significant income for Mexico, bringing in 14% of its export earnings and 32% of total government revenue as of 2010 (US Department of State 2011). As such, binational efforts focusing specifically on electricity have waxed and waned, dependent largely on each country's shifting priorities and political tides.

According to the United Nations Department of Economic and Social Affairs (UN-DESA), which has conducted a comprehensive analysis of trans-border grid projects around the world, international and regional institutions are a key strategic component of successful implementation of such projects (UN-DESA 2006). However, the US and Mexico have been unable to sustain, over the long-term, institutions with the capacity or mandate to focus specifically on electricity. For example, the North American Energy Working Group—formed in 2001 under the administrations of Presidents George W. Bush and Vicente Fox and Canadian Prime Minister Jean Chretien—unceremoniously dissolved in 2009, just a few months after President Barack Obama took office. The NAEWG worked to "foster communication and cooperation among the three governments" on energy issues, and its most notable accomplishment was the 2002 report "North America: The Energy Picture," which compiled energy data, trends, and projections in one place and provided an overview of regulatory and infrastructure information relevant to all three countries. The group also produced a working paper about electricity imports, exports, and interconnections (Center for Energy Economics 2006).

The Cross-Border Energy Task Force—a joint effort between the US and Mexican governments specifically charged with addressing grid interconnections, among other things—emerged in the NAEWG's stead in May 2010 but has yet to produce public reports of its accomplishments. Two years since its inception, its progress appears to be slow. According to Rachel Poynter, US-Mexico Border Coordinator with the US Department of State, "US invitations to Steering Committee members for the Taskforce went out in December 2011; Mexican invites were sent out March 2012." As of April 2012, the Mexican Steering Committee members were "due to meet in the coming weeks" with hopes of arranging "a meeting of the entire Steering Committee soon" (personal communication, March 30, 2012).

Business News Americas reported in November 2010 that the task force's "coordination difficulties" were responsible for a pace likely to "appear protracted to outsiders." Elaborating on those difficulties, Rick Van Schoik, director of the North American Center for Transborder Studies, explained "It is not just arranging a meeting to coincide with the availability of the ambassador or the secretary. It is aligning all the machinery on one side and all the machinery on the other side, landing on a big enough window that they can all fly into a place and get all their work done with a substantive agenda, and with all the consultants they need to hire, or recorders, or translators" (Biller 2010). Given the complications inherent in coordinating binational efforts, the stop-and-go nature of grid-focused initiatives over the last decade suggests not so much a lack of political will regarding greater interconnection but a lack of political bandwidth, with competing priorities successfully diverting resources away from an admittedly complex undertaking.

Notably, when asked the reasons behind stalled efforts on grid integration, government officials from both countries point fingers at the other side of the border. In interviews for this research project, a US state department official suggested that from a diplomatic perspective, pressing harder on the issue was likely to be perceived by Mexico as a threat to national sovereignty. Meanwhile, the opposite view emerged in interviews with Mexican officials, who said that from the Mexican government's perspective, integration would be relatively simple, precisely because of the centralized power structure afforded by a nationalized grid. On the other hand, as they pointed out, the US faces a much more difficult task, given the complex regulatory structure and fragmented decision-making authority of its electricity sector (personal communications in Washington, DC, February 8-10, 2011).

Indeed, in the US, each state has in place its own regulatory process for transmission planning, and each of these processes interacts differently with federal regulation when it comes to interstate projects. In addition to the practical and regulatory complexities of transmission planning, there are political complexities as well, because transmission projects don't benefit every constituent equally—and some not at all. Because these issues loom large in the minds of US policymakers as they approach transmission planning projects, they provide a window into the perspectives of state and local stakeholders and decision-makers affected by cross-border grid integration. The following section explores this topic in more detail.

7.3.2 United States: Top-Down vs. Bottom-Up

Transmission planning is a complex, drawn-out process, even for projects built within state lines. In the build-out of the Competitive Renewable Energy Zone (CREZ) transmission lines in Texas, for instance, the "expeditious" manner in which it has been planned has been characterized as "unprecedented" by Federal Energy Regulatory Commission Chair Jon Wellinghoff (Titus 2011). It nonetheless took years to organize, reaching back to the 1999 bill establishing a state renewable portfolio standard of 2,000 MW by 2009. The Legislature eventually passed a bill in 2005 directing the Public Utility Commission of Texas (PUCT) to identify CREZ zones within which to build transmission, but it was not until 2008 that the PUCT issued an order defining those zones and triggering the actual build-out (nearly a decade after establishment of a renewable power standard RPS). That project is ongoing, with completion expected in 2013. The CREZ lines have not been without controversy, as property owners—fearing harm both to property values and aesthetic views—have fought the build-out (Galbraith 2010). The PUCT's attempts to accommodate local concerns by rerouting lines has contributed to ongoing delays and cost overruns (Galbraith 2011).

The problems associated with competing interests are magnified for interstate projects, which must accommodate numerous independent approval processes for all affected jurisdictions and agencies. These projects also fall under Federal Energy Regulatory Commission (FERC) jurisdiction, often pitting regional or national interests against the concerns and legal obligations of state and local stakeholders, who argue that they are more uniquely suited to "weigh the impact of transmission projects on local communities" (Eagle 2005). Such projects often benefit the former more clearly than the latter, a problem compounded by regulatory frameworks with incongruent goals. According to Eagle, "while the need for siting transmission lines is regional and national, courts generally act on the proposition that a State cannot use its power of eminent domain for the benefit of the citizens of another State. In order to approve an interstate project, the courts must find at least substantial intrastate benefits arising from it." Increasingly, as projects become more regional in focus, courts are considering cases in which "few if any direct benefits accrue within the state" (Eagle 2005).

7.3.3 Mismatch: Generation vs. Transmission

This tug-of-war is happening against a backdrop of increasing urgency in terms of grid reliability. The "legacy" transmission systems currently carrying electricity across hundreds of miles were originally intended to support local, primarily retail markets, not wholesale transactions spanning broad regions. Over the last three decades, as deregulation has increasingly made it easier for merchant generators—"built solely for market sales and not to serve the needs of a specific locale"— to compete with incumbent utilities, the grid has accommodated an abundance of generating capacity relative to transmission. As of 2005, some states had actually "imposed temporary moratoria on the construction of new merchant [generating] plants" to avoid further pressure on an overburdened grid (Eagle 2005). Demand growth slowed after the recession of 2008-2009, but given the economic expansion that began in 2010 and picked up steam in 2011, the gap between generation and transmission remains.

Lack of transmission leaves the grid vulnerable to congestion, which at minimum causes wear and tear on electrical equipment; it also creates peak demand prices to be very volatile and dramatically high. At worst, it can contribute to costly power outages (DOE 2009). For companies like Hewlett-Packard, an outage of just 15 minutes at a chip-manufacturing plant can cost $30 million (Franklin 2003). Costs for the blackout that hit Canada and several Northeastern US states in 2003, leaving 50 million customers without power, were estimated between $7 billion and $10 billion (Nunez 2007; Eagle 2005). Making matters worse, the shortage of transmission also renders the grid less amenable to maintenance and repair, due to inadequate redundancy in the system (Bradle 2008). Transmission congestion also leads to high electricity prices: "Because power purchasers typically try to buy the least expensive energy available, when transmission constraints limit the amount of energy that can be delivered into the desired load center or exported from a generation-rich area, these constraints (and the associated congestion) impose real economic costs upon energy consumers" (DOE 2009).

It should be noted that transmission additions and upgrades are not the only solution to congestion problems. For instance, energy efficiency efforts, demand response programs, and distributed generation, all of which curb demand, are playing an increasing role. Indeed, the status of some "congested" areas—classified as such in the Department of Energy's 2006 congestion study—improved through a combination of these methods, according to the DOE's 2009 follow-up study. Transmission projects nonetheless played a key role (DOE 2009).

According to the DOE (2009), in some cases investment in transmission may simply be undesirable because the cost of the build-out may exceed the congestion costs. But as Pfeifenberger et al. (2012) argue, it is likely that the advantages of many transmission projects substantially exceed their estimated value, given the difficulties of assessing financial benefits that are "diverse in their effects on market participants" and span "multiple utility service areas and states." Cost-benefit analyses tend to exclude significant benefits simply because their "broad range" and "long time frame" are difficult to quantitatively capture. Nonetheless, analyses that do include those factors suggest a high return, with benefits exceeding costs by 60% to 70%. Notably, following the California energy crisis of 2000-2001, the chair of the California ISO Market Surveillance Committee estimated that additional transmission capacity during that period could have saved the state as much as $30 billion (Pfeifenberger et al. 2012).

7.3.4 Gridlock: Competing Interests

FERC has attempted to address transmission planning problems by encouraging development of regional transmission organizations (RTOs). In 1999, FERC Order No. 2000 created the RTO designation, and though formation of such organizations was to be voluntary, FERC stated specifically that its "objective is for all transmission-owning entities in the Nation, including non-public utility entities, to place their transmission facilities under the control of appropriate RTOs in a timely manner" (FERC 1999). This expectation "portends a power struggle between the FERC and state regulators" wrote one legal expert at the time, as it "creates conflict" between their "traditional roles" (Koch 2000). Indeed, FERC's objective has not totally materialized. Some RTOs have formed, but overall the grid is characterized by a "hodgepodge of power markets" (Bradley 2008).

The Energy Policy Act of 2005 (EPAct 2005) further challenged state jurisdiction by giving FERC "backstop" siting authority to be exercised within certain areas called National Interest Electric Transmission Corridors (NIETCs). These corridors were to be identified by the Department of Energy. The act gave the DOE the power to conduct congestion studies every three years, based on which it would then establish NIETCs.

These authorities were subsequently—and successfully—challenged in court. In the case of *Piedmont Environmental Council v. FERC*, a Fourth Circuit Court ruling preserved state-level authority to deny permitting. Meanwhile, in *California Wilderness Coalition v. U.S. Department of Energy*, the Ninth Circuit Court vacated the authority of the DOE's 2006 congestion study, citing the department's failure to sufficiently consult affected states and consider environmental consequences. The ruling essentially invalidated the NIECTS designated within the 2006 study, sending both FERC and the DOE back to the drawing board (Agen 2011).

FERC has since issued Order No. 1000, in summer of 2011, which makes further attempts to encourage regional cooperation. According to Agen, "FERC insists in Order

No. 1000 that ‘nothing in [the] Final Rule is intended to limit, preempt, or otherwise affect state or local laws or regulations’” but that “the legal analysis of a state’s authority depends on the specific laws of each jurisdiction.” As such, he writes, “Order No. 1000 might suggest a roadmap for an end run around state siting authority” (Agen 2011).

How states are affected by increased federal oversight and greater regional coordination depends on a variety of factors, ranging from geographic location and resource mix to regulatory structure; therefore, while some states have pushed back against greater FERC and DOE authority, others have welcomed it. For instance, speaking before the DOE at a 2008 Transmission Congestion Study Workshop, North Dakota Public Service Commissioner Susan Wefald said that wind developers couldn’t “move forward because of transmission constraints.” She spoke on behalf of her state as well as the South Dakota Public Utilities Commission in “requesting that the conditional congestion area identified in the Department’s 2006 congestion study between the Dakotas and Minnesota” be designated as an NIETC in the 2009 study (DOE 2008).

Nonetheless, EPAct 2005 “has been vigorously challenged by market participants who expect to lose under a different trading system” (Agen 2011). For instance while some argue simply that it “may not be worth the cost of implementation,” others outright benefit from congestion: “states where low-cost generators are located, which in turn cannot export power due to transmission constraints, benefit from this power being ‘locked-in’ to their regions because this keeps wholesale prices lower” (Agen 2011; Joskow 2011).

As competing interests continue to negotiate these issues, the regulatory landscape remains an unstable backdrop against which investors and policymakers attempt to make potentially costly decisions. As Joskow points out, “Unlike every other energy sector, the electricity sector lacks a comprehensive national policy framework.” Without such a framework, writes Joskow, the US will not achieve its energy goals (Joskow 2009).

Nonetheless, there are some very recent indicators that US policymakers are taking a broader policy approach. In the fall of 2011, the Obama administration established the Interagency Rapid Response Team for Transmission. It is focusing on seven pilot transmission projects around the country, including the SunZia line that runs close to the Mexican border, through Arizona and New Mexico (White House 2011). More recently, in April 2012, following the North American Leaders’ Summit (convened by President Obama, Mexican President Felipe Calderón, and Canadian Prime Minister Stephen Harper), the White House released a joint statement specifically including electricity interconnection as a mutual interest. The statement recognized “the growing regional and federal cooperation in the area of *continental energy*, *including electricity generation* and interconnection and welcome increasing *North American energy trade”* (italics are original) and pledged support for “coordinated efforts to facilitate seamless energy flows on the interconnected grid and to promote trade and investment in clean energy technologies” (White House 2012).

7.3.5 Lessons to Be Learned

No matter how large transmission projects get, or how many geographical—and political—boundaries they cross, local concerns remain the same. As such, the tensions between top-down and bottom-up approaches illustrated here provide a window into concerns US policymakers may bring to the table of any transmission project, be it intrastate or binational. There's relatively little scholarship, from a political economy angle, on such challenges. According to a review of global case studies conducted for the World Bank's Energy Sector Management Assistance Program, "The large body of literature discussing the benefits of regional power system integration is not matched by a similar-sized body of papers specifically discussing possible problems" (ECA 2010).

However, the UN-DESA does identify several potential legal, political, and social downsides, including the inequitable distribution of costs and benefits, political costs to decision makers who defend controversial projects or tariffs, and political corruption. For example, "a government may find it more expedient to explain restrictions on or other moves against local populations in terms of security of the power line than in terms of advancing political goals, even if the latter is the actual overriding concern." Integration also requires some ceding of national control as countries become increasingly interdependent, which "has the potential to give one country unwanted political leverage over another" (UN-DESA 2006).

Importantly, such "liabilities" are "very case-specific," notes UN-DESA. The report recommends key strategies for successful binational agreements, including fair distribution of benefits and costs and efforts to "work with and through international and regional institutions." As the experiences illustrated here show, these strategies may be easier said than done. Nonetheless, further study in this area is likely to shed light on the less apparent challenges and solutions as the US and Mexico embark on cross-border grid efforts.

The Texas grid, which operates independently, is relatively unburdened by the regulatory hurdles other states must manage. As FERC Chief Economic Advisor Richard P. O'Neill put it, "We don't mess with Texas" (personal communication, February 9, 2012). While this autonomy simplifies transmission planning relative to other states, it also represents an asset—control—with which officials have appeared reluctant to part, even for the benefits associated with greater regional cooperation on transmission planning. The following section analyzes this issue in more detail.

7.4 ERCOT: The Price of Autonomy

In comparison with the regulatory bodies of other states, the autonomous model of ERCOT has proven exceptionally successful in its transition to a competitive market. A study of its history and regulatory mechanism could be helpful in understanding the advantageous context of cross-border electricity trade in Texas. ERCOT's success can provide insight for federal or other state regulators in overcoming barriers to cross-border electricity trade.

The following brief description of ERCOT's history is mainly chronological, with categorical discussions followed in accordance with its development progress, which includes the establishment of autonomous jurisdiction, the deregulation of transition, and nodal development.

7.4.1 Brief history of ERCOT

ERCOT is technically a nonprofit corporation under the oversight of the Public Utility Commission of Texas (PUCT). According to the report named *The Story of ERCOT* produced by The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power (2011), ERCOT operates on $191.1 million in annual revenues (up to October 2009), facilitates operations of the wholesale electricity market, supervises transmission planning, ensures sufficient availability of power on the grid, and manages congestion on transmission lines; ERCOT is in charge of the flow of power across 40,000 miles of transmission lines connecting with more than 550 generation units. The transmission line covers about 75% of the state jurisdiction region and serves 22 million Texans (The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power, 2011).

Jurisdiction of Autonomy

As is widely known, ERCOT is generally not subject to the plenary jurisdiction of FERC, because the Federal Power Act (FPA) imparts federal jurisdiction only with respect to the transmission and wholesale of electric energy in interstate commerce. ERCOT, as a concertedly intrastate electrical interconnection, remains beyond the reach of the federal jurisdictions. ERCOT's autonomy can trace its roots to the response from certain principal Texas utilities to the passage of the FPA in 1935. These utilities in Texas "elected to isolate their properties from interstate commerce"[1] so as to place themselves beyond the reach of the Federal Power Commission (FPC), "whose jurisdiction was limited to utilities operating in interstate commerce."[2] During World War II, these and other intrastate utilities interconnected their grids to meet wartime imperatives, forming what was then known as the Texas Interconnected System (TIS).

"After the blackout of 1965—one of the largest in US history—24 utilities set up the National Electric Reliability Council (NERC), a voluntary membership organization dedicated to the creation of standards, guidelines, and criteria to ensure grid security. NERC later changed its name to the North American Electric Reliability Council and eventually to the North American Electric Reliability Corporation—although the acronym remained NERC" (The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power, 2011).

---

[1] W. Tex. Utils. Co. v. Tex. Elec. Serv. Co., 470 F. Supp. 798, 808 (N. D. Tex.1979) (anti- trust action describing the formation of ERCOT).

[2] Cudahy, supra note 8, at 57 (describing how ERCOT members are "binding themselves to intrastate operation").

In 1970, Electric Reliability Council of Texas (ERCOT) was created by TIS. It was a new, independent and not-for-profit corporation, a "regional electric reliability council" that reports to NERC (The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power 2011). In its formation, ERCOT was not an entity exercising delegated state power, but was more akin to a "voluntary membership organization" (Fleisher 2008). It should be pointed out that Texas' PUC was created in 1975, before which ERCOT operated without comprehensive state government oversight.

The famous incident of the "Midnight Connection" almost put ERCOT's independent jurisdiction status at risk. The Central and Southwest Corp (CSW) in Texas set up a substation connection between Vernon, Texas, and Altus, Oklahoma, in order to obtain its status as an interstate electric power holding company, which would allow it to come under integration provisions of the Public Utilities Holding Company Act. By doing so, the CSW could obtain legally advantageous rights, while the entire state and all its utilities would be subject to federal jurisdiction. In 1980 an important agreement established direct-current interconnections between the Texas grid and Oklahoma.[3] The FPA stipulates that federal jurisdiction follows the flow of electricity. In the case of DC ties in ERCOT, the electrons do not "freely" flow across DC ties, so ERCOT (under the FPA) can be kept exempt from FERC supervision, its jurisdictional autonomy being successfully maintained. ERCOT therefore could have its limited connections to areas outside the state while at the same time steering clear of the federal jurisdiction that typically accompanies interstate commerce.

It is generally regarded that the Energy Policy Act 2005 (EPAct 2005) finally settled the ERCOT's autonomous status. In accordance with EPAct 2005, the majority of ERCOT's utilities would, by virtue of their intrastate operation, be immune from any such order that governed the transmission utilities that "own, operate, or control facilities used for the transmission of electric energy (a) in interstate commerce and (b) for the sale of electric energy at wholesale." The word "majority" is purposively used to account for the March 2007 decision approving Brazos Electric Cooperative's request for an order under sections 210 and 211 of the FPA allowing a third interconnection between ERCOT and SPP without otherwise impacting its own, or any other utility's jurisdictional status[4] (Fleisher 2008).

Deregulation Transition: Need of Transmission Line and Lower Price

ERCOT's jurisdictional autonomy exerted tremendous influence in its development. ERCOT's legal autonomy enabled much more nimble policymaking process than found elsewhere in the US. For example, in April 1996 FERC issued Order No. 888, which called for open access to transmission lines; meanwhile, ISOs were considered to be created as one means for US power regions to ensure transmission access (FERC 2012a). In Texas, the approval process took about nine weeks; in contrast, those other regional

[3] "Electric Companies agree on interstate connections," The Malakoff News, Jan. 26, 1980.

[4] Brazos Electric Cooperative, Inc., 118 F.E.R.C. ¶ 61,199 (2007) (Order Directing Interconnection and Transmission Services and Approving Settlement Offer).

counterparts under FERC jurisdiction took years to obtain FERC approval (The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power 2011).

In 1999, the Texas Legislature passed Senate Bill No. 7, to create a competitive retail market and to grant the PUCT the authority to certify ERCOT as the independent organization in charge of supervising network reliability and retail operations.[5] With its clearer mission, ERCOT then played a critical role in the deregulation transition. In the process of transition, ERCOT's stakeholder process was born. Accordingly, the ERCOT protocols as the main tool of stakeholders came to effect. In 2002, one year after its consolidation of its previous 10 control areas to a single control area, ERCOT launched the competitive retail electric market as per Senate Bill 7. With the deregulation transition, new retail market enters can compete for residential and commercial customers. Meanwhile, municipal utilities and electric cooperatives, approximately one quarter of the ERCOT load, remain out of the system unless they would like to choose to get in. According to an analysis of ERCOT data, approximately 35% of the overall electric load within Texas remains outside of competition[6] (The Steering Committee of Cities Served by Oncor and the Texas Coalition for Affordable Power 2011)

Reaching in swing, the deregulation transition had posed important challenges to ERCOT's existing transmission lines. After the deregulation happened, statewide lines were were required to transmit electricity to the far corners of the state. Meanwhile, large amounts of power were also needed to support great-distance transmission. Thus insufficiency of transmission lines along with transmission congestion emerged. Transmission line construction was planned. In 2005, after legislation was adopted to call for the PUC to demarcate so-called "Competitive Renewable Energy Zones" (CREZs), the transmission line construction made substantial progress. These transmission lines would extend to the western part of the state and the Texas Panhandle, providing service to the rapidly expanding wind industry in Texas.

Faced with insufficiency of transmission lines and transmission congestion, ERCOT not only constructed more transmission lines and did continuous system monitoring, but also conducted congestion management by arranging for generators to ramp up or ramp down production during periods of high congestion. In this way, congestion was somewhat relieved. But the cost of such relegation was passed on to market participants, adding on to consumers. Building new lines also drove up prices. As stated in *The Story of ERCOT*, "In 2003, the cost of power from competitive suppliers in the ERCOT region had shot up to a level 11% higher than the national average.[7] By contrast, residential prices in Texas outside deregulation in 2003 remained below the national average" (The Steering

---

[5] Sunset Advisory Comm'n, Staff Report 98 (Apr. 2004), available at http://www.sunset.state.tx.us/79threports/puc/puc.pdf (outlining this sequence of events); see also Electricity in Texas, supra note 7, at 8-9 (outlining this sequence of events).

[6] Calculation based on review of figures included in email correspondence from ERCOT public information specialist Dottie Roark, Jan. 6, 2011.

[7] Form EIA-826 Data, available at http://www.eia.gov/cneaf/electricity/page/eia826.html.

Committee of Cities Served by Oncor and the Texas Coalition for Affordable Power 2011).

ERCOT's Nodal Project

In 2003, the Public Utility Commission of Texas (PUCT) issued an order requiring ERCOT to implement a new wholesale market structure known as the nodal market. ERCOT was scheduled to implement the nodal market on December 1, 2010. The nodal market does not impact the regulated Transmission Distribution and Service Provider (TDSP) delivery rates, the renewable energy obligation for the state of Texas, or the federal, state, and local taxes. It does not impact the state's renewable energy mandate nor does it impact the consumer protection rules that apply to electricity consumers (Direct Energy Business 2012).

The nodal market design includes an ERCOT-sponsored day-ahead electricity market, which will facilitate the purchase and sale of electricity for delivery the next day. The ERCOT day-ahead market provides Direct Energy Business and its customers an additional market from which to procure electricity and provides greater electricity price transparency through ERCOT-published, day-ahead electricity prices.

7.4.2 What can be learned from the ERCOT?

One expert from Analysis Group stated that, "Texas's retail and wholesale markets show strong evidence of many of the basic features of competitive markets: the presence of many buyers and sellers; low barriers to entry; non-discriminatory access of market participants to essential facilities (such as the wires) and other services necessary to participate in markets; rules in place requiring monitoring of market performance and mitigation of the ability of market participants to exercise market power; informed consumers; and transparent and relatively stable market rules" (Tierney 2008).

How can ERCOT get such a successful transition? What other states can learn from ERCOT?

General Structure

As a major participant in the ERCOT market has argued, the success of Texas' competitive electricity market may in large part be owed to the "comprehensive jurisdiction over that market that is exercised by Texas legislatures and regulators," although this argument is not totally accepted (Fleisher 2008). Regardless whether "comprehensive jurisdiction" matters a lot or not, ERCOT's independent, simple and centralized-control structure is an important ingredient in its success of competitive market transition. It should be noted that with a decade of relatively stable and transparent market rules, the investors has become optimistic about prospects in the Texas market. This stable regulatory environment is partly ascribed to the independence of ERCOT (and the PUCT). With a simpler structure of a single regulator, it comes well-structured regulation such as effective separation of the ownership of generation and transmission as well as the lack of complicating interregional issues.

With such a relatively simple structure and planning uncertainty removed, the investor, especially the private sector can respond well, which is consistent with the Latin America model where for some years most new lines have been built by the private sector selected in a competitive process, managed by the national regulators (Burnageis 2009). Another example of ERCOT's simple and nimble regulatory structure is evidenced with the speed with which the transmission expansion project was planned and implemented. In 2007, after a two-years study, the five regions were designated for renewable energy generation, and in March 2009, the final order of the transmission line expansion project was issued.

Wholesale and Retail Market Coordinated, while Customers are Always Focused

As mentioned in Chapters 1 and 2, the CAISO followed FERC severance in wholesale but retail is not regulated, whereas ERCOT has wholesale and retail integrated. The good coordination between the wholesale and retail markets supports the development of efficient markets in each and makes customers well adjusted to transition. Customer orientation is evidenced in the information campaigns, monitoring of customer switching, and service providing. For example, when new service is to commence or locations are changed, customers must select a competitive provider in most areas. The selection process has built up the provider-customer relationship and enhanced the competitive environment. As Tierney (2008) states, "Competitive retailers are allowed to manage their relationship with customers, including charging customer deposits and having the ability to issue disconnect orders for nonpayment for the utilities to carry out under guidelines of the Public Utility Commission of Texas."

Market Entry

Along with its simple and centralized control model, ERCOT has uniform business rules to operate. "The 'Code of Conduct for Electric Utilities and Their Affiliates,' established in 1999, was important to ensure that competitive market participants (i.e., retail electricity providers and power generation companies) received nondiscriminatory treatment by transmission/distribution utility companies" (Tierney 2008). As a result, the market entry threshold was lowered. In the 1990s, for example, ERCOT adopted "deep penetration" integration transmission policy for independent generators requesting connection onto the grid, which means that a new generator need only fund actual (direct) costs to get connected. Furthermore, market power mitigation is well done by ERCOT. It is required that a power generation company may not own and control more than 20% of installed generation capacity in ERCOT. If a generation company owns and controls more than 20%, it must take measures such as auctioning off entitlements to its generation capacity (Tierney 2008). Besides the market power of the competitors, when it comes to the regulatory power of ERCOT itself, it should be noted that the centralized control style of ERCOT is "passively" oriented. For example, it intervenes in planning and scheduling of transmission only in congestion events. This simple control style is of course appealing to market entrants. Altogether, these measures above pull down the market entries and lead to an attractive competitive market environment to investors.

Transmission Expansion Policies

The transmission access and cost allocation policies facilitate ERCOT development (Tierney 2008). Since 1998, generators have taken advantage of a standardized interconnection process that avoids discriminating against new plants trying to connect to ERCOT transmission lines. New generation is only required to pay for the direct costs of interconnecting with the transmission network, while costs for upgrading remote transmission systems to accommodate moving power from the new resource to demand centers are broadly socialized among end-users. Moreover, in developing the Competitive Energy Zone (CREZ), the manner in which new transmission projects are funded is attractive to wind developers.

Developers are not required to make a significant investment in transmission. The individual electric utilities are hence responsible for building the transmission that is needed to interconnect a new generation facility, and the utility then recovers its costs through its postage-stamp rate. The developer needs to post security deposits, but that deposit is returned if the generating plant is completed and ready to interconnect on time, as opposed to the FERC regional developers who usually have to pay a significant share of the cost of the new transmission facilities that are necessary for their plant to interconnect to the grid and transmit energy to market (Differ 2009). With such policies, the markets were broadened geographically, and during the early years of the market incentives were also created for generating capacity additions.

In sum, admittedly all the policies and practices above may only partly account for ERCOT's success, but important features have been covered. The characteristics inherent in its structure have enabled an integrated market design with good customer focus and policies encouraging market participation together provide a fertile ground for ERCOT's transition to competitive markets.

7.5 Challenges for the Cross-border Trade, Applied to ERCOT?

In this section, the disadvantage of ERCOT's own regulatory environment will be discussed first, then key challenges in aspects of transmission and reliability in the context of cross-border trade will be elaborated on based on the outcome of the cross-border electricity stakeholder forum as a guide to the analysis (Institute of the Americas 2010), to see whether ERCOT has these challenges.

7.5.1 Transparency, Challenge to ERCOT Management

The ERCOT scandal in 2004 revealed its mismanagement behavior. As described in the report by the name of *The Story of ERCOT* (The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power 2011), there exists an alarming increase in borrowing and spending by ERCOT and a lack of accountability to state officials and regulators. The self-interested industry players dominate the ERCOT board while Texas consumers, who indirectly or directly pay the entire cost of the organization and the electric market that it helps oversee, have only a limited voice. Meanwhile, the report reveals that "ERCOT still remains exempt from the Texas Public Information Act, and the organization's current disclosure policies provide less transparency than that which is required of state agencies." It is recommended that the PUC should be granted greater authority over ERCOT's borrowing and spending.

The Story of ERCOT also documents that electric generators have sold power at levels well above their marginal cost, a sign that the Texas market is still insufficiently competitive. Some wholesale generators operating within the ERCOT region can engage in activities that likely would be considered anti-competitive in other markets; where anti-competitive behavior has been alleged, minimal penalties have been assessed with no restitution to harmed parties (The Steering Committee of Cities Served by Oncor & The Texas Coalition For Affordable Power 2011). All disclosed mismanagement, if not well corrected, will dampen the confidence of both consumers and new investors, and hamper future trade. Along with mismanagement, the retail electricity price that is always higher than national averages easily invites criticism from consumers on ERCOT capability and credibility.

7.5.2 Transmission Permitting

According to the summary report of the cross-border stakeholder forum (Institute of the Americas 2010), access to proper authorities in the federal and state permitting processes needs to be streamlined to facilitate faster turnaround on both sides of the border. It should be noted that, for cross-border transmission, a presidential permit is needed in the United States. Further, in accordance with E.O. 12038, before a presidential permit may be issued, DOE will use two criteria to determine if a proposed project is consistent with the public interest. One is environmental impact, where DOE must determine the environmental impacts associated with issuing or denying a presidential permit pursuant to NEPA. The other one is the impact on electric reliability where DOE uses NERC and the member regional council (in Texas, the council is ERCOT) standard to consider the effect that the proposed project would have on the operating reliability of the US electric power supply system. After compliance with NEPA and satisfaction of the electric reliability criteria, DOE should obtain concurrence from the Secretary of State and the Secretary of Defense before a permit may be issued. The time required to process an application for a presidential permit is usually determined by the extent of the environmental analysis. A decision on a permit may be reached within six months or it may take 18 months or longer.

The recent case associated with presidential permitting for an ERCOT region is AEP Energy Partner's request of temporary continuation of its authorization of energy exporting to Mexico. The AEP Energy Partner obtained its presidential permit for energy exporting to Mexico in 2007, with an expiration on February 22, 2012. With strong protest filed on February 9, 2012, from the Sierra Club who argued that the AEP Energy Partner threatened the grid reliability, DOE was asked by Sierra Club to impose a lapse of exporting, which would led to disruption in the ongoing cross-border transaction. The AEP Energy Partner requested an expedited process from DOE for a temporary six-month extension of its authorization. The request was finally approved. This case reflected the importance of efficient and timely permitting process in cross-border trade. A streamlined permitting process would be helpful to the cross-border transaction.

Besides the presidential permit, the state regulation of transmission solicitation and permitting procedure is also necessary (PUCT 2012). As discussed in the stakeholder forum, regulatory complexity slows down cross-border transmission proposals and prevents projects from breaking ground, but could also show the desire to maintain control by the system operator, in this case the ERCOT. On the other hand, it is known that the ERCOT regulatory structure is streamlined. One relevant question is whether some jurisdiction of ERCOT on transmission will be affected by cross-border trade with Mexico's CFE, and thereby whether the cross-trade related stakeholders need seek FERC jurisdiction? The answer is "no."

In 2008, FERC granted a request by TexMex Energy, L.L.C. (TexMex) to determine that ERCOT and ERCOT electric utilities and market participants that were not currently subject to the Commission's plenary jurisdiction would not become subject to FERC jurisdiction as public utilities as a result of operating and using the Eagle Pass DC Tie, a transmission interconnection between ERCOT and CFE. FERC explained the power flows and interconnections between the United States and the CFE grids, including: (1) interconnections between the CFE Baja California system and the Western Electricity Coordinating Council (WECC); (2) the interconnections between the El Paso Electric Company (El Paso) and the national CFE grid; and (3) the interconnections between the national CFE grid and ERCOT, including the Eagle Pass Tie. It was physically impossible for electric energy generated within ERCOT and exported to CFE's national grid to reach the WECC interconnection because CFE's national grid and CFE's Baja California system were not connected.

In addition, FERC determined that the only way electric energy could flow from ERCOT across the Sharyland Tie to CFE and then into a state other than Texas is when El Paso imports electric energy from CFE over El Paso's interconnection with CFE through El Paso's Diablo substation in Sunland Park, New Mexico (Diablo Interconnection). The FERC found this rarely occurred, and that, when it did occur El Paso must isolate the part of its system served by CFE, preventing the imported electric energy from flowing into the rest of El Paso's system or into the Western Interconnection. Therefore, with the current configuration and operation of transmission line, the ERCOT and ERCOT electric utilities and market participants could still retain their non-pubic utilities and remained from the FERC jurisdiction. Should the configuration or operation change, the FERC's determination of lack of jurisdiction may no longer apply (FERC 2012b).

7.5.3 Land Use for Transmission

According to the stakeholder forum, large tracts of land will be needed to build this infrastructure, and securing the necessary real estate can be challenging because of zoning issues, land rights issues, federal land use, and the potential for environmental impacts. In the case of Texas, the Trans-Texas Corridor threatened to take massive amounts of land for transportation purposes before the project was abolished. With wind power prospering, the need for transmission lines led to the condemnation of land. Texas wind farms can generate about 8,000 megawatts (MW) and transmission lines can carry approximately 4,500 MW. Plans are underway to build 2,334 miles of lines to transport an additional 18,456 MW. The project anticipates taking over 56,000 acres of land (Fambrough 2010). Whether the handling of land condemnation is successful matters in the construction of transmission lines.

Again it is the example of a project of transmission line expansion. The construction timeline began in late 2009 after the preliminary planning proposal was accepted by PUCT.[8] However, the preliminary construction timeline was protracted in the actual implementation, which required the taking of private land through the use of forced buyouts, or the use of eminent domain, in order to build the actual transmission facilities. Concerns for scenic integrity and the threat of environmental degradation drove land owners and environmental groups to oppose some of the proposed routes. The PUCT had to review the proposed route proposal in July 2010, thereby pushing back its original deadline by several months (Trahan 2010). It could be said that if the future cross-border electricity trade needs secured and sufficient transmission line construction, the legal issue of land use should be carefully considered.

7.5.4 Environmental Regulation Constraint

As mentioned in the previous section, a presidential permit is needed for cross-border transmission originated in the United States, and the permit needs to meet the criteria set by NEPA. The cross-border stakeholder forum suggested that NEPA guidelines be revised to allow the use of substantially equivalent environmental documents from other jurisdictions to reduce the environmental review efforts.

Specific to Texas, environmental constraints carry great weight to the cross-border process, as reflected in the 2012 incident of the Sierra Club protest against AEP Energy Partner's renewal of exporting authorization. In the case of ERCOT itself, it was relieved that the cross-state air pollution rule, which aimed to reduce sulfur dioxide and nitrogen oxide emissions from power plants, that was supposed to take effect on January 1, 2012, and to shutter 8,000 MW of Gas-Fired Generation in Texas, was finally delayed by the federal court. The EPA provided little time for ERCOT compliance so that the rules were not feasible to take effect in 2012 (Green Building News 2012). ERCOT's ongoing operation, including more possible power generation for cross-border trade, would be under pressure until it meets the stipulation of such regulations as the cross-state air pollution rule.

7.6 The Challenges of Renewable Energy

The summary report of cross-border stakeholder forum (Institute of the Americas 2010) states that the stockholders suggested that the United States needs a uniform national policy on promoting renewable generation; a national Renewable Portfolio Standard

---

[8] PUC Docket 35665, *supra* note 55.

(RPS) would enable private developers to make the appropriate investments without the risk of regulatory uncertainty.

Texas is a leader in developing wind energy in US. The Texas Legislature has been very supportive of the wind industry, and in 2005 the Texas Legislature ordered the Public Utility Commission (PUC) of Texas to create Competitive Renewable Energy Zones (CREZs). The Texas RPS is one of the most effective and successful in the country, widely considered a model RPS. The wind power has more than quadrupled since the RPS was established.

However, the central question is whether a national RPS is feasible in the future. Davies (2010) has argued that the current state-based regime threatens to undermine the very goals it pursues. Existing state RPSs prevent the formation of a uniform renewables market because of the difference in definition of “renewable” and “renewable credit,” and the problems were reinforced by the myriad state RPS policy designs. He held that a federal approach could fix the problems the state regime has created. A national approach would create a national market and reinforce the RPS’s own efforts by helping energy and environmental law merge.

Spence (2010) pointed out the political barrier of a national RPS. There are real political impediments to the goal of enacting a national RPS because it requires congressional action that will only be forthcoming if a majority of legislators decide that a national RPS serves their interests. Those interests, in turn, are related (but not necessarily identical) to voters’ interests or the national interest, which make all federal (and sub-federal) decisions politically charged for the time being.

Rossi (2010) also highlighted some of the distributional and operational problems presented by a national renewable portfolio standard in electric power. Market unification of Renewable Energy Credits (RECs) can be disentangled from a nationwide RPS mandate. And even if a national RPS is adopted, renewable projects will continue to face enormous legal and regulatory barriers, particularly relating to project siting, transmission capacity, and cost allocation. Therefore, the prospect of a national RPS still remains uncertain, and affects all efforts arising from the US in binational talks and agreements, not only with Mexico but also with Canada. It may be politically good, but implementation could face a difficult time. A summary of competent opinions is presented in Table 7.1.

One additional point about renewable energy is the Renewable Energy Credit. One major challenge identified in the cross-border electricity stakeholder forum was the differences in incentives such as tariffs and RECs. Tariffs have an intrinsic barrier in that different markets generally indicate different regulations. There is a strong need to integrate RECs across both systems. A deeper assessment of the consequences of tradable RECs must be realized in order to achieve a better incentive system for the industry.

Table 7.1
Different Views on Nationalization of Renewable Portfolio Standard

Lincoln L. Davies	• Evidences overwhelmingly support the need for a national law. The evidences include a multi-state survey of state RPSs; a newly developed metric of state RPS design, RPS's efficacy tendency; and extant data on RPS performance. • A national RPS can help energy law and environmental law merge.
David B. Spence	• Increased reliance upon renewables implies higher electricity rates. While those higher rates will fall on today's voters, many of the benefits of using renewable power will accrue to future generations and to people living outside of the United States. • Some parts of the country are blessed with more renewable energy potential than others, meaning that the national standard would impose more costs on some regions than others. • A national RPS makes supporting a national RPS politically risky and difficult for members of congress.
Jim Rossi	• Some of the distributional and operational problems presented by a national renewable portfolio standard (RPS) in electric power. o Market unification of RECs can be disentangled from a nationwide RPS mandate. o A national mandate has the effect of a tax, which makes it not be the most efficient lever to induce technological change in the energy industry. o Geography matters to any regulatory approach that encourages the development of renewable resources. o Enormous legal and regulatory barriers, particularly relating to project siting, transmission capacity, cost allocation, pricing of carbon. • Addressing climate change will need to involve more systemic and larger scale modifications to regulation of the electric power industry.

Source: Author compilation from opinions by selected policy decision-makers.

Summarily, this description of challenges ERCOT may face only highlights the key issues, not providing comprehensive information. Understanding of ERCOT could be improved in the context of comparative analysis with other states. Moreover, beyond the regulatory structure and specific policies, political willingness or barriers in a macro picture, as in the case of RPS nationalization, could also deepen the knowledge of ERCOT.

References

Agen, M.J. 2011. Transmission Tug-of-War. *Public Utilities Fortnightly*: 46-52 (November).

Ardoin and Grady. 2006. The Politics of Electricity Restructuring across the American States: Power Failure and Policy Failure. *State and Local Government Review* 38(3): 165-175.

Becky H.D. 2009. Competitive Renewable Energy Zones: How the Texas Wind Industry is Cracking the Chicken & Egg Problem. *The Rocky Mountain Mineral Law Foundation Journal* 46(1).

Biller, D. 2010. Governments Nominate Members for Cross-Border Task Force. *Business News Americas* (November 3). Retrieved April 19, 2012, at http://www.bnamericas.com/news/electricpower/Governments_nominate_members_for_cross-border_task_force.

Bradley, R.R. 2008. Over the River and (Around) the Woods to Grandma's House We Go: Long-Term Firm Transmission Rights, Transmission Market Power, & Gaming Strategies in a Deregulated Energy Market—An International Comparison. *Houston Journal of International Law* 30(2): 327-431.

Center for Energy Economics, Bureau of Economic Geology, The University of Texas at Austin and Instituto Tecnológico y de Estudios Superiores de Monterrey. 2006. Guide to Electric Power in Mexico (September). Retrieved April 20, 2012, at http://www.beg.utexas.edu/energyecon/documents/Guide_To_Electric_Power_in_Mexico.pdf.

Davies, Lincoln, L. 2010. (July.) Power Forward: The Argument for a National RPS. *Connecticut Law View* 42 (5).

Desta, M.G. 2003. The Organization of Petroleum Exporting Countries, the World Trade Organization, and Regional Trade Agreements. *Journal of World Trade* 37(3): 523-551.

Direct Energy Business. 2012. *Texas Energy Update.* Retrieved April 20, 2012, at http://www.directenergybusiness.com/energy-insights/texas-regulatory-update.php.

Eagle, S.J. 2005. Securing a Reliable Electricity Grid: A New Era in Transmission Siting Regulation. *Tennessee Law Review* 73 (1): 1-46. Retrieved April 19, 2012, at http://www.heinonline.org.ezproxy.lib.utexas.edu/HOL/Page?page=1&handle=hein.journals%2Ftenn73&collection=journals.

Economic Consulting Associates. 2010. The Potential of Regional Power Sector Integration: Literature Review. *Regional Power Sector Integration: Lessons from Global Case Studies and a Literature Review.*

Fambrough, J. 2010. Shock Treatment: Negotiating Transmission Line Easement, Legal Issuer, January.

Fischer, R., S. Pablo. 2000. Regulating the electricity sector in Latin America. *Economia* 1(1): 155-218.

FERC (Federal Energy Regulatory Commision). 2012a. Retrieved April 20, 2012, at http://www.ferc.gov/students/whatisferc/history.htm.

FERC (Federal Energy Regulatory Commision). 2012b. Retrieved April 22, 2012, at http://www.ferc.gov/EventCalendar/Files/20080731180118-EL08-71-000.pdf.

Fleisher, J.M. 2008. ERCOT's Jurisdictional Status: A Legal History and Contemporary Appraisal. *Texas Journal of Oil, Gas and Energy Law.*

Franklin, J.J. 2004. Upgrading the National Power Grid: Electric Companies Need an Economic Incentive to Invest in New Technology. *Rutgers Computer & Technology Law Journal* 31: 159-186.

Galbraith, K. 2011. Cost of Texas Wind Transmission Lines Nears $7 Billion. *The Texas Tribune (*August 24.) Retrieved April 20, 2012, at http://www.texastribune.org/ texas-energy/energy/cost-texas-wind-transmission-lines-nears-7-billion.

Galbraith, K. 2010. "Fighting the Power Lines to Protect the Hill Country." *The Texas Tribune* (September 9). Retrieved April 20, 2012, at http://www.texastribune. org/texas-energy/wind-energy/fighting-power-lines-protect-hill-country-vistas.

Green Building News. 2012. New Interstate Pollution Laws Delayed, Federal Court Rules (January 18, 2012). Retrieved April 21, 2012, at http://www.green buildingnews.com/articles/2012/01/18/new-interstate-pollution-laws-delayed-federal-court-rules.

Institute of the Americas. 2010. Summary Report U.S.-Mexico Cross-Border Electricity Stakeholder Forum. UCSD. Retrieved April 1, 2012, at http://www.ioa.ucsd.edu.

Joskow, P.L. 2011. Creating a Smarter U.S. Electricity Grid. CEEPR WP 2011-021 (October).

Joskow, P.L. 2008. Technology Policy Institute (September 26). Challenges for Creating a Comprehensive Energy Policy.

Koch, C.H. 2000. Control and Governance of Transmission Organizations in the Restructured Electricity Industry. *Florida State University Law Review* 27:569-613.

Leasge, D., T. Van De Graaf, and K. Westphal. 2010. Global Energy Governance in a Multipolar World. London. Ashgate: 14-127.

Martinez-Chombo, E. 2011. Distortion and High-Cost Sources in State-Owned Electric Utilities in Mexico. *Economia Mexicana Nueva Epoca*. 5 (19):31-89

Munson, R. 2005. *From Edison to Enron: The Business of Power and What it Means for the Future of Electricity.* Westport, Conn.: Praeger Publishers.

Nunez, K.J. 2007. Gridlock on the Road to Renewable Energy Development: A Discussion About the Opportunities & Risks Presented by the Modernization Requirements of the Electricity Transmission Network. *Business, Entrepreneurship & the Law* 1:137-179.

Pechman, C. 1993. Regulating Power: The Economics of Electricity in the Information Age. Kluwer Academic Publishers, Boston.

Pfeifenberger, J.P., D. Hou. 2012. Transmission's True Value. *Public Utilities Fortnightly*: 44-50 (February).

Pineau, P., A. Hira, and K. Froschauer. 2004. Measuring international electricity integration: a comparative study of the power systems under the Nordic Council, MERCOSUR, and NAFTA. *Energy Policy* 32:1457-1475.

PUCT. Proposal for Publication of new §25.216 regarding Selection of Transmission Service Providers. Retrieved April 20, 2012, at http://www.puc.state.tx.us/agency/rulesnlaws/subrules/electric/25.216/34560pub.pdf

Rossi, J. 2010. The Limits of a National Renewable Portfolio Standard. *Connecticut Law View* 42(5).

Spence, D., B. 2010. The Political Barriers to a National RPS, *Connecticut Law View* 42(5).

Steering Committee of Cities Served by Oncor and the Texas Coalition for Affordable Power. 2011. *The Story of Ercot.*

Titus, E. 2011. Jon Wellinghoff: The TT Interview. *The Texas Tribune* (December 7). Retrieved April 20, 2012, at http://www.texastribune.org/texas-energy/energy/jon-wellinghoff-tt-interview.

Trahan, R.T. 2010. Electricity Transmission in the U.S.: Legal Issues and Trends. Center for Global Energy, International Arbitration, and Environmental Law, The University of Texas at Austin School of Law.

Trebilcock, M.J. and R. Howse. 2005. The Regulation of International Trade. London: Routledge.

US Department of Energy. 2009. National Electric Transmission Congestion Study (December). Retrieved April 19, 2012, at http://congestion09.anl.gov/documents/docs/Congestion_Study_2009.pdf.

US Department of State, Bureau of Western Hemisphere Affairs. 2011.Background Note: Mexico (November 16). Retrieved April 19, 2012, at http://www.state.gov/r/pa/ei/bgn/35749.htm.

United Nations Department of Economic and Social Affairs. 2006. Multi Dimensional Issues in International Electric Power Grid Interconnections. Retrieved April 20, 2012, at http://www.un.org/esa/sustdev/publications/energy/interconnections.pdf.

Victor, D. and L. Yueh. 2010. The New Energy Order: Managing Insecurities in the Twenty-first Century. *Foreign Affairs* January/February 2010: 61-70.

Wafeld, S. 2008. Comments at Transmission Congestion Study Workshop, US Department of Energy. Oklahoma City, Oklahoma (June 18). White House, Council on Environmental Quality, Interagency Rapid Response Team for Transmission. 2011. Retrieved April 20, 2012, at http://www.whitehouse.gov/administration/eop/ceq/initiatives/interagency-rapid-response-team-for-transmission.

White House, Office of the Press Secretary. 2012. Joint Statement by North American Leaders (April 2). Retrieved April 3, 2012, at http://www.whitehouse.gov/the-press-office/2012/04/02/joint-statement-north-american-leaders.

Chapter 8. Towards Increased Cooperation in Electricity Transmission: A Mexico-ERCOT Simulation Experiment

by Amin Shams, Josef Varga (and Alejandro Ibarra-Yunez)

Abstract

Modeling the strategic interaction of market participants and regulators is important for policymakers to capture the opportunities and challenges of transitioning markets. Modeling can make use of proxy variables of congestion as triggers for alternative forms of binational cooperation. This chapter gathers and organizes contemporary modeling strategies based on their capabilities and key findings. We gather model conclusions to synthesize what conditions and challenges exist for transmission expansion and restructuring of and equilibrium between partitioned markets that could lead to greater social welfare by integration. Specifically, we look at models of stakeholders of transmission lines and synchronization, as well as national (or transnational) regulators in the case of a Texas/Mexico transition towards a deep market. Using a GAMS simulation exercise, the chapter demonstrates that more integration between Mexico and ERCOT reduces congestion corridors in Texas and Mexico, provokes prices to converge to a lower level, increases consumer surplus in Texas, and increases producer surplus, but transmission lower profitability might require fixed fee adjustments, according to hypotheses tested in other markets.

8.1 Introduction

The liberalization of electricity markets in Europe and the United States is transitioning from theory to reality as policymakers adapt new paradigms concerning network industry efficiency. The United States consists of three independent regional systems. The Eastern Interconnection integrates the central and eastern part of the country, plus Eastern Canada and Quebec; the Western Interconnection integrates all systems west of Texas, Arizona, Colorado, and also includes British Columbia and Alberta in Canada, and Baja California in Mexico; and ERCOT in most of Texas. Within the three regional systems, there are eight control areas of transmission according to NERC: FRCC in Florida, SERC in Southern states, RFC in the plain states and the Great Lakes; MRO in the large mid-west states; NPCC in the northeast; SPP north of ERCOT; and WECC in the west, with the California Independent System Operator being CAISO; and ERCOT in Texas. Congested areas have been detected by FERC that pressure the security and reliability of the grids, and set challenges for expansion.

Problems arise also as regulators from different countries attempt to restructure and integrate electricity markets and infrastructure. Because it is difficult to move backwards from liberalization, efficient policies must be in place to protect consumers from unexpected market failures. Will unbundling lead to increased market power among large generators or transmission companies? Will deregulation lead to insufficient investment in generation or transmission capacity, thereby limiting the benefits to consumers? Will national regulators act strategically in ways that hurt over-all market efficiency? Will open up of wholesale markets open consumers to risky trading policies? These are but a few of the key questions that have stalled market restructuring and integration.

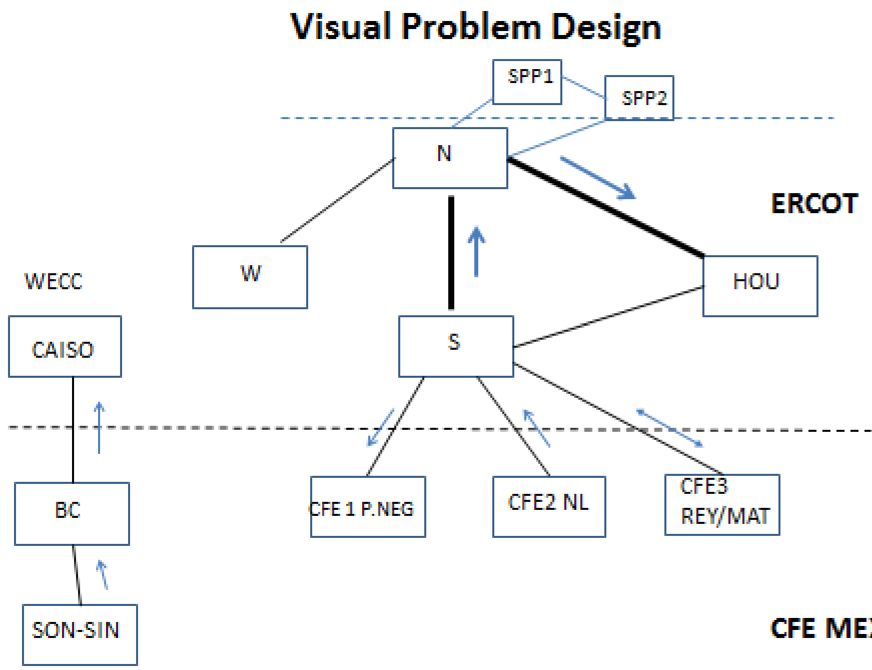
According to Joskow (2008), the overriding goals of market restructuring have been to ensure that competitive wholesale markets for power provide better incentives for controlling costs of new capacity, to ensure innovation, to provide incentives for network operators to provide appropriate levels of service and quality, and to shift risk from consumers to suppliers. The ultimate goal can be summarized as achieving a rational allocation of social resources and to maximize social benefits to expanding regions. Telecommunications is one of multiple industries that have transitioned from an older framework of regulated monopolies. Yet, substantial difficulties and setbacks stymie progress in the electricity industry exemplified in the 2000 California market failure, and other major power outages such as in the northeast United States in 2003. As a result of these difficulties and uncertainty, policymakers as well as critical stakeholders desire sophisticated modeling to support future progress in optimal industry design.

While one observes modeling designs for multiple markets, our focus is to derive conclusions specifically on the Texas-Mexico region, as compared to the California-Baja California more profound coordination for the recent past (Baja California is part of WECC). The Texas market is highly liberalized, and uniquely independent from the rest of the US grid. In Chapter 6, it is shown that he Mexican market is transitional. The parastatal CFE (Comisión Federal de Electricidad) maintains a virtual monopoly in the market with substantial market power under a sole-buyer design. However, beginning in 1993, a non-utilities law liberalized generation to allow private producers under modalities of auto-generation, co-generation in industrial uses of gasification, small-scale producers, importers, exporters, and the so-called Independent Power Producers (IPPs) for exclusive sale of electricity to CFE (Ibarra-Yunez 2008).

With market design and regulations quite different between the two systems, the ERCOT and Mexican grids represent an opportunity for market-integration and restructuring. The two markets are already connected (ERCOT has 13 links), as sub-regional interconnections using DC asynchronous lines: seven are with SPP, three with WECC, and three with Mexico. As of now total Mexican connections amount to only around 286 MW, and are used for emergencies only, yet trade is increasing. Both markets seem to be underdeveloped with room for substantial transmission expansion. Greater trade between Texas and Mexico could theoretically support this investment, while simultaneously decreasing the necessary reserve requirement for the system and increasing reliability. Unfortunately both ERCOT and CFE are relatively happy with the status quo. Also as mentioned in Chapter 6, Mexico lacks a clearly defined set of financial transmission rights and therefore higher risk to investment in transmission persists. Nonetheless, the literature is full of ideas about how such integration would be possible bolstered by a wide array of modeling strategies.

The two countries show a sub-regional network consumer topology that is more similar to a star than a meshed one, as seen in Figure 8.1.

Figure 8.1
US and Mexico's Transmission Connections, with Emphasis on ERCOT



Source: Author's elaboration from connections and congestion areas in ERCOT and Texas Office of Public Utility Council. Retrieved February 17, 2012, at http://www.opc.state.tx.us/ERCOT.html#nodcal,. Note that ERCOT shows only two nodes with more than two connections; eleven main lines; congestion in ERCOT, north and south, and in Mexico.

In the following exercise, a model is developed to characterize alternative results of the challenge for increasing integration at various levels. One option is for the two binational systems to remain with no change, with no connections even for emergency supply; then for increasing coordination, another step could entail interconnection similar to the Baja California through day-to-day flows and participation in WECC for binational, even if independent planning; finally, a theoretical exercise would entail integration. Alternative scenarios are accomplished with simulation trends of two systems as independent from each other and with no links; and when systems are interconnected, even if only for emergencies to reduce critical congestion across the Mexican and ERCOT systems (Rosellón and Weigt 2011; Zenon and Rosellón 2010).

This study is organized as follows: in Section 8.2 a review of bilevel optimization based on key works is presented. In Section 8.3 we refine modeling approaches to the context of US and Mexico. In Section 8.4 the quantitative and block-equilibrium exercise is spelled out. Then a set of challenges and opportunities is presented that includes policy suggestions based on the model. Finally, in Section 8.5 we present a conclusion about the prospects for liberalization in the electricity industry.

8.2 Current Modeling Trends

Weigt (2009) observes a large body of theory from which to draw research on electricity markets. Yet the specific characteristics of electricity greatly restrict the application of that theory to build satisfying models. Non-storability, inelastic demand, and the necessity of physical transmission complicate electricity markets and differentiate them from other liberalized markets. Furthermore, electro-technical, thermodynamic, and mechanical restrictions add to the difficulties of modeling these markets. Nonetheless, a broad spectrum of models has been developed since the 1990s in order to facilitate market restructuring.

We find Ventosa et al. (2005) classification of models as a useful starting point. They take a complicated array of modeling techniques and divide them into three major types: optimization, equilibrium, and simulation models. They argue that these model types can be further divided based on assumptions about market structure and information availability. Building on this, as well as from contributions by Day et al. (2002) and Smeers (1997), Weigt (2009) sub-divides each category further. Notably, Weigt adds welfare maximization as a sub-category of both optimization and equilibrium models. Each of these three broad categories offer advantages to policymakers but also suffers from inherent weaknesses in their development and applicability to market conditions.

8.2.1 Optimization Models

Optimization models address simple, single-firm profit maximization or market-wide welfare maximization/cost minimization. Profit maximization models can assume either exogenous prices or demand-price functions. Furthermore, these assumptions can be deterministic or stochastic (Ventosa et al. 2005). Optimization models benefit from availability of optimization algorithms and the simplicity of adding additional constraints (Weigt 2009). Bi-level optimization models can be used to investigate the strategic interaction between self-interested parties.

Furthermore, bi-level programming is an excellent tool for modeling optimization problems where decision variables are not controlled by the main optimizer but by a second optimizer. This modeling technique is especially useful in unbundled, yet regulated electricity markets, where generating agents and transmission owners desire profit maximization while a system operator attempts to minimize distribution costs and guarantee social welfare. Several scholars have used bi-level programming to model electric power markets, including Fampa et al. (2008) who use it to model strategic bidding under uncertainty in a wholesale energy market in Brazil. Weber and Overbye (2002), and Hobbs (2001) consider strategic bidding as a nested optimization problem, where the generator maximizes its individual welfare subject to an outcome which maximizes the total social welfare based on all bids in the market. These types of models fit best with our research question of optimizing social welfare.

8.2.2 Equilibrium Models

Equilibrium models are advantageous to optimization models in that they allow for several market participants' profit maximization simultaneously (Hogan 2002; Weigt 2009). The major limiting factor in equilibrium models is the necessity to assume convexity, and these assumptions may be too strong in certain cases where market failures persist or in cases where modeling needs meshed systems of AC connections. Day et al. (2002) offer six types of strategic interactions competitors may take in these type of agency models: Betrand Strategy, Cournot Strategy, Collusion, Stackelberg, Conjectural Variations, or Supply Function Equilibrium. In the following section literature on each model will be reviewed.

Cournot Models

These economic models are used for analyzing the quantity and supply behavior of different players in an oligopoly market. The firms have market power, meaning the quantity they produce affects the quantity and price of rival firms. The players, each seeking to maximize their own profit, simultaneously decide on their quantity bid; price is determined as a function of aggregate quantity. Given the structure of the electricity market, this model provides a valuable tool for analyzing the imperfect competition in transmission, capacity, and generation.

Willems (2000) uses Cournot to model competition in an electricity market with transmission constraints and explores the role of an Independent System Operator (ISO) in preventing overload over the transmission lines. In the short-run the ISO can impose quotas on generation, and in the long-run can set the transmission price. Also, Hobbs (2001) models two different electricity market structures based on the Cournot model: a market in which generators sell the electricity to a central auction (POOLCO), and a market in which they bilaterally sell the power to customers. His model goes beyond the earlier simple models (like models of simple radial network) by allowing for the inclusion of many control areas and interfaces. Neuhoff et al. (2005), Jing-Yuan and Smeers (1999), and Bergman (1995) are other examples of implementing Cournot models in electricity markets. Using the Cournot model, we can explore the maximization of social welfare over firm profit maximization with market power. In a broader view, we look at the interaction between a generator, a public/national system operator (this operater for example may regulate transmission) and consumers.

Bertrand Models

Bertrand models allow for differentiated products. Here the main difference with the Cournot model is that the firms simultaneously set the price and then, based on the determined prices, consumers decide on the quantity of each product to buy. In the electricity market, given the homogeneity of a product, if a firm sets its price below the price level of other firms, theoretically, it can capture the entire market by expanding its output. However, in reality, generation capacity cannot be expanded easily in the short-run, making the Bertrand model a less vigorous alternative for modeling the electricity market. There is no general acceptance among scholars in using Bertrand for modeling electricity market.

Stackelberg Models

These models are based on the quantity-setting approach of the Cournot model, but replace simultaneous decision-making with a sequential approach. In this strategic game the leader firm moves first and the follower firms, knowing the action of the leader, move sequentially. The model fits the electricity industry where there are one or more dominant firms in a privileged position and a number of subordinated firms acting as followers. Yu et al. (2000) model the strategic behavior of the players in a deregulated electricity market with one or more leaders and the fringe producers. They assume that the fringe producers adopt competitive pricing strategies similar to what we see in Bertrand models. Also De Lujan and Granville (2003) present a bi-level optimization problem in a leader-follower game in AC power system. "The first-level optimization sub-problem (leader) is defined by active power output, which will maximize strategic firm benefits restricted to given bounds. The second-level sub-problem (follower) can be considered as a particular AC optimal power flow parameterized by first-level variables." As another application of this approach, Dias (2007) models the electricity market in Portugal based on the fact that Energias de Portugal (EDP) produces more than 60% of the total electricity in Portugal and the remaining firms acts as followers of this leader.

Collusion Models

In contrast to the above approach, Collusion models help simulate markets where competitors cooperate for mutual benefit. It often takes place in an oligopoly market where a few firms have market power and by colluding, can significantly affect the market. Bolle (1992) provides a model in which tacit collusion can take place by each firm promising to produce less if the others produce less, leading to price increases. On the other hand, Fabra and Toro (2005) show the case of Spanish electricity market in which collusion does not necessarily result in high price-cost margins. They suggest that daily repetition of auctions in electricity market allows firms to learn to compete less aggressively and avoid price war. The case of the Spanish electricity market during 1998, in which even the over-contracted firms charged above the marginal costs, suggests that producer might have been engaged in a tacit collusion.

Supply Function Equilibrium (SFE) Models

In another level of methodological emphasis, SFE models, developed by Klemperer and Meyer (1989) allow firms to choose a supply function instead of setting a fixed price or quantity as their strategy. Klemperer and Meyer show that under uncertainty there is always a Nash equilibrium in the supply function for a symmetric oligopoly with a homogeneous good. This resolves the competing predictions of Cournot and Bertrand models. Also Baldick et al. (2000) advocate that SFE offers a more realistic view of the electricity market than Cournot do where suppliers typically offer a price schedule rather than simply bidding a set quantity or price. In Cournot models the market price is determined by intersecting the aggregate quantity the suppliers bid and the market demand curve. However the difficulties of estimating the demand curve in the electricity market makes the price predicted by Cournot model less reliable.

Conjectural Variations

These approaches within equilibrium models allow for consideration of competitors' reactions when deciding on optimal production. In fact, the players in an oligopoly market who choose their actions simultaneously assume that their choices will influence the contemporaneous choices of the other players. The reaction to other players can be modeled by a residual demand function, which is obtained by subtracting the supply functions of other players from the demand curve. Garcia-Alcalde et al. (2002) suggest that this approach can overcome the Cournot weaknesses relating to its high sensitivity to the demand elasticity.

8.2.3 Simulation Models

In many cases solutions to systems of equations or differential equations (necessary for equilibrium) are too difficult to solve. Simulation models allow greater flexibility than equilibrium models (Ventosa et al. 2005). Simulation models allow for dynamic market analysis, and agent-based approaches allow for goals and adaption (Weigt 2009). Weigt also points out that while these models allow for flexibility, heterogeneity can limit comparability.

The US Department of Energy (DOE) uses several different models to identify the greatest economic gains for electrical markets. DOE's primary models include the National Energy Modeling System (NEMS), the Policy Office Electricity Modeling System (POEMS), and TRADELEC a computer model developed by private contractors to the DOE.[9] The sections below will review and compare the assumptions and design of each model.

NEMS

Developed by the Energy Information Administration, NEMS models integrate energy markets and economies in the US with supply and demand modules. The model provides policymakers with an integrated framework to evaluate proposed policies and its implication for US consumers (EIA 1999).

NEMS considers four demand modules (residential, commercial, industrial, and transportation), two conversion modules (petroleum and electricity markets), and four supply modules (natural gas, oil, coal, and renewable fuels). NEMS also contains a macroeconomic feedback module representing the effects the energy market has on the overall US economy. Further, NEMS incorporates a module to represent the interaction

---

[9] Energy Information Administration, *The Comprehensive Electricity Competition Act: A Comparison of Model Results*, Office of Integrated Analysis and Forecasting (Washington, DC: US Department of Energy, 1999). Retrieved November 28, 2011, at http://www.eia.gov/oiaf/servicerpt/ceca/pdf/sroiaf9904.pdf.

between domestic and international energy markets. The NEMS generates a solution for general equilibrium using the modules above to find supply/demand of energy in the US.

POEMS

A computer model of the US energy system, POEMS develops a more detailed representation of electricity markets in the US than NEMS yet it has many similarities to the NEMS model, with many of the same components and assumptions. Moreover, NEMS and POEMS use the same data sources from DOE and produce annual forecasts through 2020 with very similar results. The main differences are in the treatment of regions, dispatching, electricity trade, and pricing.

The POEMS model, however, considers electricity modules based on the electric Power Control Areas of the US considering 114 regions. The NEMS electricity model considers only 13 different regions based on the North American Electricity Reliability Council. This difference in regionality causes differences in calculations for regional capacity reserve margins as well as competitive pricing.

POEMS and NEMS calculate competitive prices of generation using the marginal cost of power (i.e. the short run operating costs of the last plant dispatched during each time period). However, the models have different adaptations to the calculation. To the marginal cost of power, POEMS adds a charge for new plants to recover investment costs, if needed. NEMS, however, adds a reliability price adjustment reflecting the value of reserve capacity.

Both models assume that power from federal and state facilities will continue to be priced at the average cost of service. However, reserve margins are imputed assumptions in POEMS, where NEMS solves for reserve margins within the model by finding the balance of cost and additional reliability with adding a new plant to the system against the value consumers place on reliability.

The DOE's analysis of the models, prepared in 1999, finds that despite model differences the two models produce similar results for electricity sales, carbon emissions from the electricity sector, and electricity prices. Looking at the results of DOE's comparison study, the only significant differences between the NEMS and POEMS results are in the western regions: the Northwest Power Planning Council, Rocky Mountain/Arizona, and California-Southern Nevada. For example, in the 1990s NEMS found it economical for California to continue purchasing electricity from the northwest to meet its regions demand for power. However, POEMS concluded that California needed to reduce its purchases from the northwest and build new power generators in California. The above models, even if rather detailed, are concentrated in generation, reserve margins, and flow of electricity.

TRADELEC

TRADELEC, a model developed to capture greater detail and disaggregation of energy markets, is beginning to replace NEMS as it allows for a deeper examination of alternative assumptions in the wholesale electricity markets. TRADELEC is designed specifically for analyzing competition in electricity markets and transitions to deregulated systems in the US.

Designed to explore key policy questions TRADELEC is a network model which considers stranded costs, consumer prices, mix of new construction, impact of increased electricity trading, and interaction with environmental policies to model electricity generation, trade, capacity expansion, and pricing. TRADELEC is a network electricity model considering interregional trade to maximize the economic gains from trade.

TRADELEC begins with electricity trade that brings the largest efficiency gains first. Descending from the largest efficiency gains to point where transmission capacity is reached and possible gains are exhausted. TRADELEC captures economic and physical limits to trade by modeling alternative scenarios for transmission fees, losses, transmission capacity, and hurdle rates. As a result, TRADELEC models integrated interregional trade similar to time-block auctions of electricity.

The model focuses on market-driven electricity trade, while POEMS and NEMS consider the existing electricity transmission system as fixed. TRADELEC quantifies electricity trade as the function of relative prices, transmission capacity, and the assumed miscellaneous costs to electricity market trading. The model identifies potential current and anticipated bottlenecks when operating at full transmission capacity and where they may limit trade flows among buyers and sellers. The bottleneck caused by transmission capacity results in regional price differences exceeding the cost of transmission and trading. As a result of capacity costs, the regional price differences exceed the cost of transmission and trade creating a market for electricity trade. The transmission losses are modeled as a nonlinear, “distance sensitive measure,” which makes the model an advance towards non-linear AC-types, however, with much complexity.

Finally, for TRADELEC, the trade function is used to determine competitive prices for electricity. This function is used to measure efficiency gains from the deregulation and restructuring of the electricity market, solving trade relationships to offer insight into pricing patterns and motivation for electricity trade.

Each of the models reviewed provides an insight into one aspect of the market. Among them, models with partial equilibrium that allows for strategic behavior of the generators are the best fit to the problem at hand. We can use the mentioned techniques to provide a model with single equilibrium. Moreover, as it is highly used in the literature, a Cournot-type model of quantity flows would be the best fit for modeling the competition of generators after integration of US and Mexico electricity market. In the first level, like what is very prevalent in the literature, one can estimate the market power before and after integration based on the difference in the prices that model suggests and prices in a perfect competition market. Our hypothesis is that market powers and prices will decrease and consumption and social welfare will increase as a result of integration. However, transmission capacity is an obstacle in the way of achieving the benefits of integration. Therefore, in the second level an analysis of transmission expansion would be done mainly to solve potentially congested areas on both sides of the border.

8.3 Towards a Workable Approach to the Problem

This analysis will focus on the integration of electrical markets between the US and Mexico. The California energy crisis in 2000 highlights the opportunity for northbound regional electricity exports from Mexico (Joskow 2001). There are several key stakeholders on both sides of the border who will be considered in the modeling. Generators, distributors, and ISOs each have a significant impact on the energy markets. State and federal regulators also represent key stakeholders in the market, and these include Comision Federal de Electricidad (CFE) and Electric Reliability Council of Texas (ERCOT) as a TRANSCO and ISO. Woo et al. (2003) note that greater cross-border energy trades will require extensive system interconnections that do not exist. Commercial growth and integration undoubtedly mean that energy economics will eventually become a common topic in border contexts (Sheffield 1998; Jaafar et al. 2003).

An alternative for modeling an imperfect market is market equilibrium. In this approach, a set of optimization problems is defined—one optimization problem for each player. First order optimality conditions are pursued based on demand, supply, prices, transmission capacities, and market powers, assuming that lines on both sides of the border face congestion as a challenge to integrate. If there is congestion, readily available capacities cannot be used at the least cost, and hence units with higher supply costs need to satisfy loads. Consequently, prices would be higher than other non-congested regions or control areas. This exercise assumes that demands or loads and costs are well behaved. Also, it is assumes that given congestion, transmission expansion does not cause negative externalities and either binational system could end up with negative net capacity. This fact is pointed out by Hogan (2002) and Kristiansen and Rosellón (2010), such that a system operator or Transco has reserve financial rights or incentives for expanding the grid with different scenarios.

Based on the nature of the behavior of market participants, this analysis further classifies the equilibrium models in two categories: Equilibrium Models based on Competitive Behavior and Equilibrium Models based on Strategic Behavior.

8.3.1 Equilibrium Models based on Competitive Behavior

Several electricity market models assume mere competitive behavior rather than strategic behavior among producers. As an example, Boucher and Smeers (2000) model a perfect competition market with a three-node network: two generators competing at two nodes to satisfy the demand in the other node. Based on the demand curve of the consumers and the marginal cost curve of the generators as a smooth function of the generation level, they show that different levels of decentralization lead to the same equilibrium in a perfect market. In our view, the model has two limitations. First, the analysis is in the short-run and long-run characteristics such as generation and transmission capacity are constant. For the purpose of our study, the fact that the model does not allow for enhancement in transmission capacity is a significant weakness. Second, the analysis is based on a perfect competition among players while the assumption of strategic behavior by producers is closer to reality in electricity markets. In our problem with large generator companies, the assumption that a player does not have market power is not a credible assumption. Therefore, this model and other models such as Qi and Harker (1997) with the same assumptions do not fit well to our analysis.

8.3.2 Equilibrium Models based on Strategic Behavior

Cardell et al. (1997) argue "when the incentives are there to exploit market power, elimination of vertical monopoly power is not enough to ensure fully competitive pricing, at least in the short run." Therefore, applying assumptions to the model that allows for imperfect competition and strategic behavior of players—such as what could be seen in Cournot and Bertrand—provides more realistic results, mainly around incentives for capacity expansion and interlinkages.

Stoft (1998) emphasizes that in models with only one Nash equilibrium, the players agree on a particular Nash equilibrium and "then, and only then, game theory predicts this equilibrium will be the game's outcome. Although such predictions are not foolproof, they are often quite accurate." Many models in the literature try to achieve a unique equilibrium with unique solution by techniques such as creating a competitive market for transmission services or simplifying the demand and supply functions. As an example, Hobbs (2001) formulates two Cournot models (one allowing for arbitrage and the other one not) based on a simplified linear demand curve for the consumers. In this model, transmission is charged based on a congestion pricing scheme. The advantage of the model is that it does not have existence or uniqueness problems. Moreover, its simplicity allows for computing imperfectly competitive equilibria for networks with thousands of control areas or busses and large numbers of interfaces, though it might not provide as accurate results as more complicated models. On their part, Boucher and Smeers (2000), argue that given game theoretical behaviors by players, authorities can establish a regulated feasible outcome around the ISOs welfare function maximization.

Jing-Yuan and Smeers (1999) model a power network between Belgium, France, Germany, and Italy with a single utility and two nodes in each country. One node represents generation and the other one distribution and consumption. Generators are geographically dispersed (one in each country) and behave in accordance with Cournot assumptions where transmission prices are determined by regulation. As another example, Cardell et al. (1997) model market power arising in a market with a dominant firm and a set of competitive fringe. They analyze the role of transmission constraints in creating market power: transmission constraints create bottlenecks and isolate markets and provide an opportunity for regional powers to practice market power. They model three conditions: a dominant firm without transmission rights, a dominant firm with tradable transmission rights, and multiple large firms in an imperfect competition. The model shows that network constraints allow the large firm to exercise market power and increase its profit by increasing its production in order to block the network and foreclose competition.

Although many reviewed models to some extent allow for modeling some aspects of transmission expansion across countries and integration of national market, there are some models that primarily focus on modeling a cross-country market. For example, Dias (2007) models integration of two oligopolistic markets that are not symmetric in number of firms, demand, and market structure with focus on the case of Iberian Electricity Market between Spain and Portugal (MIBEL). The model is a partial equilibrium model with a leader with competitive fringe for Portugal and a Cournot model with competitive fringe for Spain. The assumption for Portugal is based on the fact that Energias de Portugal (EDP) produces more than 60% of the total electricity in Portugal and the remaining firms do not have any ability to change prices. The paper suggests that a main reason of this market power is because of limited transmission lines in the Iberian market and between it and its neighboring states.

8.4 Modeling Exercise

8.4.1 Data Gathering

Mexico's CFE is similar to its northern border systems operators CAISO and ERCOT in terms of installed capacity, and they are almost comparable regarding high voltage transmission miles of infrastructure. CFE serves more users than its US counterparts, and experienced in the past higher reserved capacity (un-planned) than its counterparts, for which retirements and modernization efforts are more pronounced south of the border (interviews with F. Aboytes and E. Meraz, January 12, 2012). Average load weighted wholesale prices are indicative of the existence of a daily market, with adjustments of prices to input dynamics. In the table below, only CAISO presents the two comparative prices, being the latter closer to real wholesale prices, given the use of fuels and renewables. On the percentage of renewables out of total generation, Texas stands out with wind energy, while Mexico still has a challenge to bring renewables to its generation and semi-liberalized market portfolio.

Table 8.1
Comparison of US CAISO and ERCOT with Mexico's CFE, 2010

Variable	CAISO	ERCOT	CFE
Installed Generation (MW)	57,124	63,025	60,440
Miles of Transmission (320 and 400 KV)	25,526	40,500	31,187
Population	30 million	23 million	35 million
Planned Reserve Margin	15%	13.75%	13%
Ave. Annual Load Weighted wholesale price/ MWh	$39.91-120	$26.50-170	$12-60*
With Fuel Adjustment	$33.95	n.a.	$12-n.a
Percent of Renewables (MWh)	11%	15.1%	3.5%

Sources: IRC (2009), "State of the Markets Report, ISO/ RTO Council; CAISO data set; ERCOT data; SENER (2011), "Prospectiva del Sector Eléctrico 2010-2025; and Mexico's data on load wholesale prices are gathered from interview (*).

The model studies the limits of transmission infrastructure, as demand is greater than transmission capacity. First, CFE divides Mexico into 9 regions, with 50 generating nodes or regions, from which around 25 show some type of congestion. If one were to take a proxy of the model as a DC topology, then 16 nodes represent Baja California and Baja California Sur connections, plus Sonora, Chihuahua (and Laguna), Coahuila, Nuevo León, and Tamaulipas. Since data sets with such level of disaggregation are not readily available, we need to settle for a more aggregate analysis using the so-called control CFE divisions: BC-BCS; NW; and N-NE areas, with reference to the aforementioned generation nodes.[10] According to Hartley and Martinez-Chombo (2002), 8 out of 15 nodes were importing ones, while the remaining 8 were exporting ones in 1999-2000. For 2009-2010, the distribution is as shown in Table 8.2.

Table 8.2
Mexico's Regional Effective Installed Capacity and Demand at Non-Peak and Peak Loads
Comparison between 2000 and 2010 in GW

			2000			
Regions	**BC**	**NW**	**NNE**	**W**	**C**	**SSE**
Non-peak	1,180	1,526	3,874	4,732	4,885	4,287
Peak	1,899	2,365	5,245	6,062	7,439	5,966
Capacity	1,701	5,309	7,772	5,781	4,067	13,623
	congested	**no**	**no**	**congested**	**congested**	**no**
			2010			
Regions	**BC**	**NW**	**NNE**	**W**	**C**	**SSE**
Non-peak	1,523	1,963	4,938	6,350	6,144	5,719
Peak	2,600	3,617	7,090	8,175	9,000	7,792
Capacity09	2,601	7,025	13,222	8,553	5,229	17,654
	Quasi congested	**no**	**no**	**no**	**congested**	**no**

Source: Sener (2011), "Prospectiva del Sector Eléctrico 2010-2025," and CFE (2011) POISE.

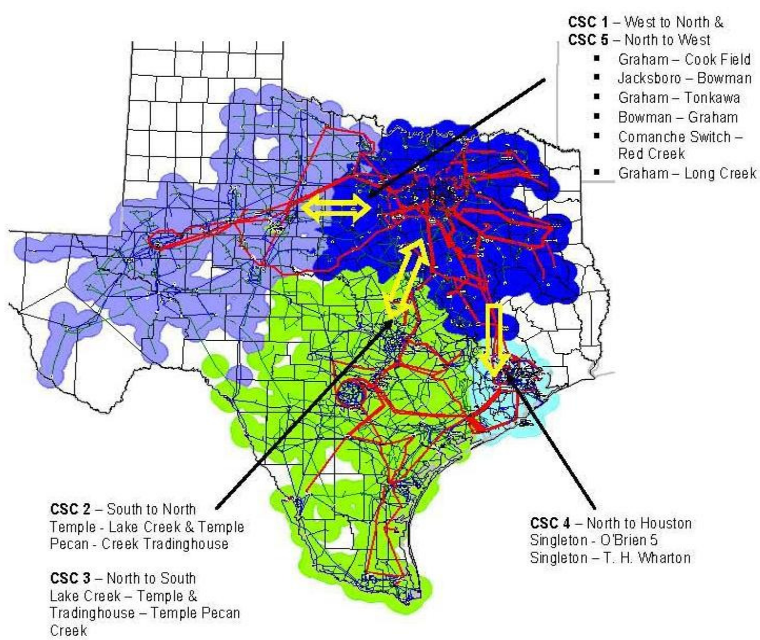
The generation and consumption topology in Mexico shows many interconnections in Central Mexico and the western regions, while it shows a radial structure in both the north and southeastern extremes. Congestion is stark in the central region in 2010, while the west was clearly congested in 2000. Close to congested nodes are apparent in Baja

[10] All data were validated for each node/ zone and made compatible regarding miles of transmission, capacity in GW, loads at peak and base demand in MWh, generation in MWh, prices in US dollar cents per kilowatt hour using Mexico's Central Bank (Bank of Mexico) official fix exchange rate. Data on transmission per generation center were calculated as disaggregated as possible for CAISO, CFE, and ERCOT from 1999 to 2010-2011, or the most recent data available. Only a subset of all the data set is used for the current simulation.

California, potentially in north and northeastern regions due to their higher than national growth rate of consumption, their industrial and mining character, and where prices might show higher levels (CRE 2011; Zenón and Rosellón 2010). For the simulation exercise, data sets were generated for ERCOT and Mexico, around base and peak prices by zone; capacity by zone/node; demand load at base, and demand load at peak by zone/node; and connections, assuming a DC topography and where flows occur in two directions. The data sets allow to simulate independent systems with no interconnection or flows, and then simulate systems with connections and flows that depend on demand, relative prices at peak demand, and congestion corridors.

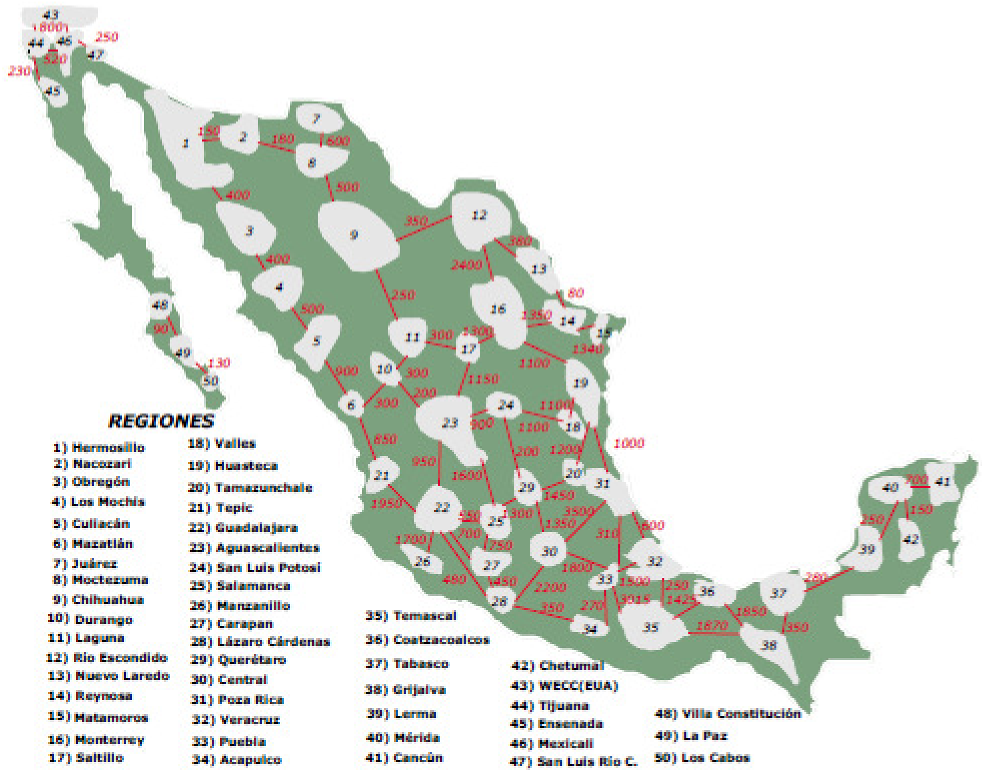
With other relevant data on Mexico the country can be taken as a unit with some nodes connected via more than two lines, while main border regional nodes have a topology of star-like infrastructures, as opposed to truly a meshed system. On its part, both the California ISO and the Texas ERCOT ISO also show connections out of its intra-regional market, of non-meshed nature. For example ERCOT shows four regions and eleven main lines, although it has begun to be organized into more than 4,000 nodes for market clearance. A stylized topology is shown in Figure 8.2.

Figure 8.2
ERCOT's Regional Distribution and Congested Zones, Areas before Nodal Topology, 2010



Source: ERCOT 2011. Retrieved at http://www.opc.state.tx.us/ERCOT.html.

Figure 8.3
Mexico's Regional Distribution of Generating and Transmission Zones, 2009-2010



Fuente: CFE.

8.4.2 Model Description

The model presents analysis of the generators and the integrated incumbents and their incentives to restrict the capacity for transmission. The model is applicable to our interests as it considers the social welfare maximizing variables within the Mexican electrical market and ERCOT's transmission players. Further the model takes the perspective of the critical stakeholders within in electrical transmission cooperation, centered on ERCOT's transmission companies or Transcos impacts.

The model has the following assumptions. The demand for the electricity is a function of the demand in the previous period and the price. In fact, demand in period (t) is related positively with demand in period t-1 and negatively with price at period t-1. The variables α and β determine the coefficients of this equation.

$$q_t = (1+\alpha)q_{t-1} - \beta p_{t-1}$$

In the case of the US and Mexico these coefficients could be estimated based on the longitudinal data of price and quantity over a period of time. Given the different characteristics and preferences of consumers in different regions, more accurate results could be reached by analyzing a panel data over time and different regional areas, but absence of data with such level of granularity was not possible for the present analysis. We settle to analyze the systems in similar fashion as in Rosellón and Weigt (2011) and Zenon and Rosellón (2010).

Given the demand, assume that the topology of the two binational systems is star-like, with DC connections and linear demands as shown. Now assume that for the Mexican case CFE is both a sole buyer but for our purposes, and also is the Transco that seeks to maximize its profits of transmission services in fixed and variable tariffs, net of its costs of transmission and regulatory restrictions. However, the simulation exercise concentrates on congested zones or areas in Texas ERCOT, where CFE could be a supplier in one instance and not a supplier if the systems remain separated. The profit of ERCOT transmission company or Transco, could be determined as follows:

$$\pi_t = p_t q_t + F_t - C(q_t, K_t)$$

Where profit at time *t* is equal to price *p* times quantity *q* plus a fixed fee *F* minus cost *c* as a function of quantity and capacity *k*.

Expanded by congestion, we get the upper level optimization model, as follows:

$$Max\ \{k, F\} = \pi = \sum_{ti}^{T} (p_i^t \quad d_i^t - p_i^t\ g_i^t) + F^t N^t - \sum_{i,j} c\ (k_{i,j}^t) \qquad 1$$

Where $i \neq j$

And where *pd* – *pg* is the congestion rent as the difference between load and generation transmitted, whereas *FN* is a fixed access rate that will be used as a condition with (a) totally binational independent systems CFE-ERCOT (could be applicable also to CFE-CAISO); (b) where markets become interconnected for day-to-day wheeling across the borders; and (c) an extreme hypothetical solution of cooperation is transmission expansion. Costs are related to capacity investment between two nodes or lines *i,j* . Equation (1) is subject to a regulatory condition of price changes to be lower or equal to a price cap, expressed, without the subscripts for ease, as follows in equation *2a*. Alternatively, in cases (b) and (c) price differences across the border would set the price limit as shown in *2b* by a congestion rent rather than set by a regulated wholesale cap.

Conditions *2a*, *2b* are the critical differences for an independent versus an integrated simulation.

$$\sum_i((pd - pg) + FN)/(\sum_i p^{t-1}d - p^{t-1}\ g) + F^{t-1}N)) \leq 1 + RPI - X \qquad 2a$$

$$\sum_i((pd - pg) + FN/\ \sum_i p^{t-1}\ \ d - p^{t-1}g) + F^{t-1}\ N)) \ \leq\ \Delta\ \sum_{i*}(pd^{i*} - pg^{i*}) \qquad 2b$$

Where 2b stands for having a limit established by an extended binational market through prices depending on the congestion change.

The revenue of the Transco is estimated based on the accumulation of a variable charge, which depends on the quantity consumed and is equal to price times quantity, and the fixed charge (FN), which is the fixed amount that consumers pay for just being connected to the network regardless of the amount they consume in the four states of the world just hypothesized. By subtracting the costs of the Texas Transco one gets a function of the quantity and the capacity of transmission lines. The model could be anchored based on the restrictions that the profit of ERCOT is increasing over time. Also the costs are assumed to be the sum of the costs at the previous level and the costs of increasing transmission capacity.

Now, a lower level problem is for the ISO ERCOT to maximize social welfare as follows using Rosellón's model:

$$MAX_{d,a}\ W = \sum_{i,j}(\int_0^{ti} p(dt)\mathrm{d}\ d^t) - \sum_{i,j} mcg \qquad 3$$

(for all nodes *i*). Subject to:

$$g_i^t \leq\ g_i^{t\,max} \qquad \forall\ i,t \qquad 3.1$$

$$|pf_{i,j}^t|\ < k_{i,j}^t \qquad \forall\ i,j \qquad 3.2$$

$$g_i^t +\ q_i^t =\ d_i^t \qquad \forall\ i,t \quad (or\ d - q = g) \qquad 3.3$$

The first restriction 3.1 only indicates that generation is lower and up to capacity in each node at time (t). Restriction 3.2 refers to the power flow across nodes not to exceed the transmission capacity of the line. Finally restriction 3.3 set demand to be satisfied by generation at the local node or produced and injected (q_i^t).

From the lower level, an optimal demand and injections, and zonal or nodal prices, are obtained and then substituted in the upper level problem, to get optimal levels of supply to reduce congestion; the optimal cost of supplying; change in prices by connection. The exercise is created first for no connections, and then for interconnected systems. For the simulation, there are six nodes/zones: North ERCOT zone in the Dallas Fort Worth area

(N), Western ERCOT (W), Houston (H), South ERCOT including San Antonio (S), and two CFE nodes/zones: Nuevo Leon's and Piedras Negras (CFE1), and Reynosa-Matamoros (CFE2). Note that ERCOT moved to nodal markets in late 2010. However, we still use the zonal congestion corridors for the present analysis.

In total, we use the six nodes and 14 flow or connection lines. Using GAMS as the simulation package, we let it run the simulation on lines flows, costs, and prices to converge. The model converged in six runs, optimizing the flows, their direction, price alignment to the lowest costs (linear), and energy balance at the zonal levels. Since original price differences are higher in the binational systems than regulated price caps in models in isolation, the runs assume perfectly competitive markets to check for price alignments. Although we have annual data from 1999 to 2010 for the simulation exercise only two years are used: 2005 (economies were expanding), and 2010 (the most recent period). Two conditions are also modeled: ERCOT in both periods with no CFE capacity to export, and ERCOT and CFE with capacity to export and import electricity to optimize flows solving for congestion.

8.4.3 Model Results

Beginning with 2005, analysis of data in the referred nodes shows congested areas in nodes S and H. In contrast, N shows excess capacity, and W, staying as a marginal zone, shows no congestion. On the Mexican side, CFE1 is congested, while CFE2 shows excess capacity. Now regarding prices in the systems as being independent, base prices per KWh were lower in S, W, N, than CFE1 and CFE2, while H was higher. At peak prices, ERCOT shows higher prices than regulated Mexican ones in CFE1, but not in CFE2.

The results of the simulation for the year 2005, at peak prices, are as follows:

1. For independent, not connected systems the GAMS model assumes zero flows from CFE1 or CFE2 to S. After six runs towards model stability, reduced costs are obtained on W to N, and N to W (US$14.78 per KWh); S to W (14.78); and most dramatically N to H ($22.0); H to S and S to H ($22.0).

2. For price alignment between ERCOT nodes, the dual price change was reduced in W by US$7.22, while both nodes S and H experienced price reductions of US$11 each.

3. On their part, since CFE1 (Piedras Negras and Monterrey) are importer zones, they showed price reduction of -US$22.00 due to self-supply (no export flows).

4. Now in the second simulated case of inter-connected systems, the GAMS model shows that flows occur from S to CFE1 and from CFE1 to S, while there are flows from CFE2 to S, with cost reduction after reducing congested zones W to N and N to W (US$6.8 and $7.98, respectively); S to W ($14.78); N to H ($22.0); and S to H, and H to S ($6.8 and $15.2, respectively). The CFE cost reduction from selling to S is $22, the largest reduction from all pairs.

5. As for price alignment, between ERCOT nodes including CFE1 and CFE2 as back-up exporters, price reduction occurred in all cases, ranging from -US$11.00 in H, to -US$6.80 in S; to -US$3.02 in N, while CFE1 experienced a noticeable price reduction of -US$17.8, all in MWh.

The analysis then makes use of GAMS simulation applied now to 2010, or simulating the case of most recent data availability. Data analysis shows that now all W, N, H, and CFE1 are congested, and S is not congested. Again, CFE2 (Matamoros-Reynosa-Nuevo Laredo connection) shows no congestion. Now regarding prices in the systems, if taken as independent, base prices per KWh are lower in all ERCOT zones than CFE1 or CFE2, but H is higher than CFE1 or CFE2. At peak prices, ERCOT shows similar prices than CFE1, but CFE2 shows lower prices.

The results of the simulation for 2010 at peak prices shows the following findings:

1. For an isolated, not-connected ERCOT with CFE1 or CFE2, the GAMS simulation gives an infeasible optimization solution, as all nodes in ERCOT solving the congested transport cannot sustain the system, given capacity, and the cost differences and electricity flow balances. The finding proves the hypothesis that non-interconnected systems are not optimal.

2. Now in the case of inter-connected systems, the GAMS model shows that flows occur from S to CFE1, and from CFE2 to S, while CFE2 now shows flows to slack or a dummy node because of over-capacity. For other nodes in ERCOT, S supplies electricity to all other nodes in W, N, and H. Cost reduction results after reducing congestion W, N, and H from S came to US$4.3 in W; $12.3 in N, and H, respectively. CFE2 reduction in cost after the optimization is again the largest, although smaller than in 2005, with $12.3, the largest jointly with the S-N, and S-H pairs.

3. Finally, as for price alignment between ERCOT nodes including CFE1 and CFE2 as backup exporters, price reductions occurred the following cases only: N (-$12.3) and H (-$12.5), while CFE2 and S showed price increases after six runs.

8.5 Conclusion

In this chapter we have synthesized findings from contemporary modeling techniques regarding electricity market restructuring and integration. Though a vast array of approaches exist, we have focused on a bi-level optimization approach taken by Rosellón et al. (2011); Rosellón and Weigt (2011); and Zenón and Rosellón (2010). In our opinion this approach represents the most contemporary and promising avenue to produce practical market policies from modeling. The complexity of such endeavors is immediately apparent however, not only because of the mathematical process required and the need to balance elegance with real-world representation, but also because these models are meant to mimic an atmosphere of competing and often myopic interests.

It is important to reiterate that such models are not necessary to show the utility of market restructuring and integration. ERCOT has shown how deregulation can work in Texas for example, and could be a source of inspiration for the Mexican market. Markets in Europe as well as the Canada-US market have shown how integration can be welfare enhancing as well and could be a source of replication for the Texas-Mexico region. As we stated in the introduction, however, these successes must be balanced with major market failures. It is this dilemma that has encouraged our research in modeling to bolster previous initiatives in such market reorganization.

The models we have explored show how modern electricity markets can be adapted to produce greater total social welfare. This should be a major take-away for policymakers and market participants and stakeholders. Nonetheless, such model implications are not perfect. We share some of the major concerns of Rosellón et al. (2011). For instance, by its very nature our models represent a greatly simplified scenario, therefore strict implementation of policies suggested by such a theory will inevitably face a sort of friction that must be anticipated and overcome. Second, unlike the market Rosellón et al. (2011) examines for the case of Germany, France, and the Benelux, the Texas-Mexico market we consider maintains exceptional political differences. Most notably, the Mexican market remains in transition with a parastatal, CFE, in control. Furthermore, FTRs do not yet exist in Mexico, but are assumed in both Rosellón's model and our adaptation. Third, exemplified in interviews with ERCOT executives, integration also comes with a level of political uncertainty that is unavoidable with market integration and mutual dependency. Though we avoid AC ties in favor of DC ties as they exist nowadays (which cause significantly less interdependency) market integration in general requires a letting go of autonomy, which is understandably difficult for organizations such as ERCOT.

The previous concerns highlight a major hindrance to market integration—namely alternative regulation regimes that may act strategically against one another. Tangeras (2010) explores different scenarios involving regulators and system operators in search of a welfare optimum combination in integrated markets. He finds that, "no network governance structure does uniformly better and no governance structure performs universally worse than all others…" He goes on to highlight four crucial elements that affect optimal outcomes:

1. How well a common regulatory agency balances the interests of member states.
2. How the benefits of energy market integration vary across member states.
3. The characteristics of the market network (complementarity vs. substitutability).
4. The social cost of the operator's rent.

Although somewhat out of the scope of our research, this paper nonetheless suggests the next step in implementation of a welfare-maximizing set of policies that we derive from our models. The results of the GAMS simulation in two comparative periods in time (2005 and 2010) proves the hypothesis that interconnected systems in both selected years show welfare gains regarding congestion reduction, cost savings, prices reductions, and bi-directional electricity flows. Moreover, in the ERCOT case in 2010 and given congestion and capacity for internal flows from the zones under study with no connections with CFE, render an unfeasible optimization solution for ERCOT. In case of interconnections with CFE2 and CFE1, the model can be optimized with congestion reductions, cost savings, and price convergence. With the findings, we demonstrate the economic benefits of the shared optimization, even if Texan and Mexican operators and decision-makers find it easier to stay not coordinated.

With this, not only will Mexican and Texas policymakers need to advance market restructuring, but policymakers on both sides of the border will eventually have to negotiate the best combination of regulation and system operation for a more integrated market. For a fully integrated market to success, this negotiation will be extremely important. We leave it to other chapters to pursue this dilemma further.

References

Baldick, R., R. Grant, and E. Kahn. 2000. Linear Supply Function Equilibrium: Generalizations, Application, and Limitations. *University of California Energy Institute.*

Bolle, F. 1992. Supply Function Equilibria and the Danger of Tacit Collusion: The Case of Spot Markets for Electricity. *Energy Economics.* 14: 94-102.

Boucher, J., and Y. Smeers. 2000. Alternative Models of Restructured Electricity Systems, Part 1: No market power. *Operations Research* 49: 821-838.

Cardell, J. B., C.C. Hitt, and W.W. Hogan. 1997. Market Power and Strategic Interaction in Electricity Networks. *Resource and Energy Economics* 19: 109-137.

CRE. 2011. Comisión Reguladora de Energía data sets provided by the Commission and also added by the website CRE. Retrieved January 10, 2012, at http://www.cre.gob.mx.

Day, C.J., B.F. Hobbs, and P. Jong-Shi. 2002. Oligopolistic Competition in Power Networks: A Conjectured Supply Function Approach. *IEEE Transactions on Power Systems* 17: 597-607.

De Lujan, M. L., and S. Granville. 2003. The Stackelberg Equilibrium Applied to AC Power Systems—a Noninterior Point Algorithm. *IEEE Transactions on Power Systems* 18: 611-618.

Dias, M.F. 2007. Market Power and Integrated Regional Markets of Electricity: A Simulation of the MIBEL. *Mimeo.*

Energy Information Administration. 1999. *The Comprehensive Electricity Competition Act: A Comparison of Model Results.* Office of Integrated Analysis and Forecasting.

Fabra, N., and J. Toro. 2005. Price Wars and Collusion in the Spanish Electricity Market. *International Journal of Industrial Organization* 23: 155-181.

Fampa, M., L.A. Barroso, D. Candal, and L. Simonetti. 2008. Bilevel Optimization Applied to Strategic Pricing in Competitive Electricity Markets. *Computational Optimization and Applications* 39: 121-142.

García-Alcalde, A., M. Ventosa, M. Rivier, A. Ramos, and G. Relaño. 2002. Fitting Electricity Market Models. A Conjectural Variations Approach. Proceedings, PSCC 2002, Seville.

Hartley, P., and E. Martinez-Chombo. 2002. Electricity Demand and Supply in Mexico. Working Paper, Rice University.

Hobbs, B. E. 2001. Linear Complementarity Models of Nash-Cournot Competition in Bilateral and POOLCO Power Markets. *IEEE Transactions on Power Systems* 16: 194-202.

Hogan, W. 2002. Financial Transmission Right Formulations. Kennedy School of Government, Harvard University. *Mimeo.*

Ibarra-Yunez, A. 2008. Puntos Críticos en el Modelo Eléctrico Mexicano Mixto [Critical Aspects in the Mexican Mixed Electricity Market], Comisión Federal de Competencia/OECD Mexico 2008.E.05.

Jaafar, M.Z., W.H. Kheng, and N. Kamaruddin. 2003. Greener Energy Solutions for a Sustainable Future: Issues and Challenges for Malaysia. *Energy Policy* 31: 1061-1072.

Jing-Yuan, W., and Y. Smeers. 1999. Spatial Oligopolistic Electricity Models with Cournot Generators and Regulated Transmission Prices. *Operations Research* 47: 102-112.

Joskow, P.L. 2001. California's Electricity Crisis. *Oxford Review of Economic Policy* 17: 365-388.

Joskow, P.L. 2008. Lessons Learned from Electricity Market Liberalization. *The Energy Journal* 29: 9-42.

Klemperer, P.D., and M. Meyer. 1989. Supply Function Equilibria in Oligopoly under Uncertainty. *Econometrica* 57: 1243-1277.

Kristiansen, T., and J. Rosellón. 2010. Merchant Electricity Transmission Expansion: A European Case Study. *Energy Journal* 35: 4107-4115

Neuhoff, K., J. Barquin, and M.G. Boots. 2005. Network-Constrained Cournot Models of Liberalized Electricity Markets: The Devil is in the Details. *Energy Economics*. 27: 495-525.

Qi, R., & P. Harker. 1997. Generalized Spatial Price Equilibria with Semicontinuous Market Structures. University of Pennsylvania.

Rosellón, J., & H. Weigt. 2011. A Dynamic Incentive Mechanism for Transmission Expansion in Electricity Networks: Theory, Modeling, and Application. *The Energy Journal* 32(1): 119-148.

Rosellón, J., Z. Myslikova, & E. Zenon. 2011. Incentives for Transmission Investment in the PJM Electricity Market: FTRs or Regulation (or Both?). *Utilities Policy* 19: 3-13.

SENER. 2011. Secretaría de Energía *Prospectiva del Sector Eléctrico 2010-2025*. Mexico, D.F. Retrieved November 22, 2011, at http://www.energia.gob.mx/portal/publicaciones.html.

Sheffield, J. 1998. World Population Growth and the Role of Annual Energy Use Per Capita. *Technological Forecasting and Social Change* 59: 55-87.

Smeers, Y. 1997. Computable Equilibrium Models and the Restructuring of the European Electricity and Gas Markets. *Energy Journal* 18: 1-31.

Stoft, S. 1998. Using Game Theory to Study Market Power in Simple Networks. in H. Singh (ed.) Game Theory Tutorial, IEEE Winter Power Meeting, IEEE, Parsippany, NJ.

Tangeras, T.P. 2010. Optimal Transmission Regulation in an Integrated Energy Market. IFN Working Paper, No. 838.

Ventosa, M., A. Baillo, A. Ramos, and M. Rivier. 2005. Electricity Market Modeling Trends. *Energy Policy* 33: 897-913.

Weber, J.D., and T.J. Overbye. 2002. An Individual Welfare Maximization Algorithm for Electricity Markets. *IEEE Transactions on Power Systems* 17: 590-596.

Weigt, H. 2009. A Review of Liberalization and Modeling of Electricity Markets. Technische Universität Dresden Working Papers No. WP-M-34. October.

Willems, B. 2000. Cournot Competition in the Electricity Market with Transmission Constraints. Center for Economic Studies. Environment Working Paper Series ETE 0004. Katholieke Universiteit Lueven.

Woo, C.K., D. Lloyd, and A. Tishler. 2003. Electricity Market Reform Failures: UK, Norway, Alberta and California. *Energy Policy* 31: 1103-1115.

Yu, Z., F.T. Sparrow, T.L. Morin, and G. Nderitu. 2000. A Stackelberg Price Leadership Model with Application to Deregulated Electricity Markets. *Power Engineering Society Winter Meeting, 2000. IEEE* 3: 1814-1819.

Zenon, E. and J. Rosellón. 2010. The Expansion of Electricity Networks in North America: Theory and Applications. MPRA November. Working Paper No. 26470.

Chapter 9. The Green Revolution: Renewable Energy and its Future

by Oscar Padilla and Kaye Schultz

Abstract

As concerns of climate change and energy security receive increasing attention, government and industry are looking to alternative energy sources to integrate into the existing energy portfolio. However, even in developed countries, most renewable energy sources remain cost prohibitive for widespread use. This chapter identifies current renewable energy capacity in each of the three North American countries and where future potential lies. We then discuss trade barriers between the three countries and possible market mechanisms that could be used to incentivize renewable energy by examining relevant case studies of countries that have successfully implemented renewable energy policies. Although coal and natural gas remain the most cost-effective and reliable sources of electricity generation, subsidies and regulations can be implemented to facilitate renewable energy generation and integration within the North American electricity market.

9.1 Introduction

9.1.1 Setting of Renewable Energy in the United States

As a starting point, worldwide, wind energy continues to be the fastest growing renewable energy technology sector. Following the global trend, between 2000 to 2009 wind energy generation in the United States increased by a factor of 14. This is slightly more than the global increase which grew by a factor of 9. The compounded annual growth rate between 2000 to 2009 wind was 27.3% (US EIA 2010). This growth has in large part been a direct result of increased levels of investment in wind energy projects as well as market incentives arising from multilateral objectives to reduce the carbon footprint in the planet, but also from national plans and strategies. In 2001, investments in wind energy projects stood at $250 million, and by 2009 investments grew to more than $2 billion (US EIA 2010). Globally, 2009 also marked China's ascension as the world leader in installed wind capacity, surpassing the United States with installed capacity levels in excess of 43 GW. The United States installed wind capacity levels currently stand at slightly more than 40 GW (American Wind Energy Association 2011). Figure 9.1 shows details regarding installed capacity.

Table 9.1
Current Renewable Energy Capacity in North America 2011-2012

	Wind	Solar
United States	40,000 MW	2100 MW
Mexico	500 MW	25 MW*
Canada	4,500 MW	100MW

Source: Authors' generation with data from the Wind Energy Association 2011.

*Expected 2013 capacity.

In 2009, the levelized cost of energy (LCOE) for wind ranged from 8-13 cents per KWh for offshore wind and 6-12 cents for onshore wind (US EIA 2010). With the production tax credit, the cumulative capacity-weighted average price of wind power was about 4.4 cents per kWh during the same timeframe, which came very close to non-renewable gas or combined cycle energy costs (US EIA 2010). The top five states with installed wind generation in the United States measured by installed nameplate capacity are Texas, Iowa, California, Washington, and Minnesota. In 2008, Texas led the country with the most renewable electricity (excluding hydropower) of any US state, with installed cumulative capacity exceeding 9,400 MW. Iowa, California, Washington, and Minnesota have cumulative capacities of 3,670 MW, 2,794 MW, and 1,980 MW, respectively. Preliminary national data indicate that energy from wind production accounted for 11% of total consumption for 2010, a rather large figure if compared to many economies in the world. In terms of installed renewable electricity capacity, wind energy accounted for approximately 92% of annual installed renewable electricity capacity in 2009 (excluding hydropower) in the United States.

Regarding solar energy, in 2009 cumulative solar photovoltaic (PV) capacity grew by nearly 52% from the previous year and followed an increasing global trend as a viable alternative to fossil fuel generation. Current installed capacity in the US is approximately 2,103 MW. In comparison, Germany and Spain lead the world with an installed capacity of 9,677 MW and 3,595 MW, respectively. Not surprisingly, US leaders in installed nameplate capacity solar PV are California, New Jersey, Colorado, Arizona, and Florida, where the number of sunny days are the highest according to the Energy Information Administration (US EIA 2010). California's installed capacity accounts for more than half of the total installed capacity among the top five states. In 2010, new financial investment in solar technology was $5.5 billion, accounting for slightly more than 18% of total new investment in renewable energy technologies in North America (Bloomberg New Energy Finance 2011). As of 2009, LCOE for solar PV ranged between 18 and 43 cents per kWh, making solar not cost competitive with alternative generating fuels, namely coal and natural gas. However, the behind-the-meter capacity-weighted average installing cost fell by 17% from 2009 to 2010 and by 43% below 1998 costs (Lawrence Berkeley National Laboratory 2011). As prices continue to fall particularly at the utility-scale, generation level investment in solar PV technologies will undoubtedly increase.

Other important renewable energies that this chapter analyzes are biomass and geothermal energy. Despite the 5% decrease in global new investment in biomass and waste-to-energy in 2010, global investment in geothermal saw an increase of 44% from 2009 investments. New investment levels in the US were $1.4 billion for biomass and $700 million for geothermal. Currently installed capacity for geothermal generation in the US is approximately 3,087 MW, with California leading all other states with 2,565.5 MW of installed capacity. Biomass nameplate capacity and generation levels have remained flat, totaling approximately 12,727 MW in 2009. Both geothermal and biomass generation have among the highest capacity factors in the renewable energy space, ranging from 80-85% for geothermal and 85-90% for biomass (US EIA 2010). Both technologies also have a low LCOE, ranging from 8-12 cents per kWh for biomass and 6-13 cents per kWh for geothermal. Currently biomass accounts for 38% of renewable electricity generation in the US.

9.1.2 Renewable Energy in Mexico

Although still trailing behind the level of capacity of the United States and Canada, Mexico is a regional leader in wind energy in Latin America, with a current capacity of over 500 MW. Thus far, Mexico has the second highest amount of installed wind capacity in all of Latin America, thanks in large part to La Venta II wind energy park, which is the largest wind energy park in Latin America, with 98 wind turbines producing a total capacity of 83.3 MW (Cancino-Solorzano et al. 2011). The estimated potential energy from wind in Mexico has been increasing in recent years, but is currently estimated at over 70 GW (Wood 2010).

The estimates of wind potential in Mexico have increased due to increases in available information regarding the wind patterns and wind strength throughout Mexico. A detailed study of the state of Oaxaca funded by USAID in the United States and Mexico, the Department of Energy (DOE), the Bureau of Economic Growth and Trade of the Mexican Secretary of the Environment and Natural Resources, the National Renewable Energy Laboratory (NREL), and other Mexican government organizations developed both national and US data and resulted in a detailed “wind atlas” of the area. This report increased previous estimates of wind energy potential. The increased estimates are largely due to the constant supply of wind and mountainous terrain resulting in a natural wind tunnel in the mentioned state of Oaxaca, as well as favorable wind patterns in other states. Oaxaca has areas that have been identified as class 2, 4, and 5 on the NREL scale, indicating that certain areas have wind power strengths that can support the development of wind energy on a commercial scale (Cancino-Solorzano et al. 2011). The data estimates that Oaxaca contains about 6,600 km^2 of land containing good to excellent potential for wind energy. The report estimates that this area could supply about 33,000 MW of potential power, based on a conservative estimate of MW per km^2 (Wood 2010).

The USAID and NREL have also funded studies of potential wind energy resources in the Baja California Norte Border Region, Western Chihuahua Border Region, Northwestern Mexico Border Areas, Eastern Sonora Border Region, Western Sonora Border Region, Baja California Sur, and Quintana Roo and the Yucatan. Interest in developing wind energy in other areas in Mexico is increasing, specifically in the Baja California Norte Border Region, due in part to these reports. The vertically integrated utility Comisión Federal de Electricidad (CFE) has also taken steps to integrate wind energy in the Baja region to the national grid, which should be completed in 2014 (Wood 2010).

USAID has also worked with the Mexican government to develop a strategy promoting the production of wind power in Mexico, and has helped produce another report assessing US and Mexico's regulatory policies related to wind energy production. Several issues were identified in Mexico's regulatory framework, including transmission infrastructure, environmental issues, and missing economic incentives for wind energy production. At the present time, the cost of increasing transmission capabilities connecting Mexico to the United States would outweigh the gains in revenue for the electricity industry. However, if economic incentives similar to those provided to wind producers in the United States were provided to producers in Mexico, prices would decrease making electricity from wind energy a more attractive option.

However, wind energy is not the only renewable option in Mexico. Mexico also has high solar potential with nationwide predictions for 5 KWh/day/m^2. The amount of solar energy potential is even higher when focusing on the northwest region of the country as well as in states close to the Pacific, which receive approximately 7 KWh/day/m^2 (Cancino-Solorzano et al. 2011). Solar energy generation in Mexico has been impeded by CFE's requirement to purchase the cheapest electricity available, but the addition of government or private subsidies could make solar energy competitive.

However, CFE did invest in one solar project that combines solar thermal panels with natural gas generators. This project is located in northern Mexico and had a predicted capacity of 31 MW, but capacity was later reduced because of high energy costs, and ended up producing a plant with only 10 MW of capacity (Wood 2010). Even with these difficulties, Mexico is still expected to generate 14 GWh/year from 25 photoelectric MW by 2013 (Cancino-Solorzano et al. 2011). Although solar energy costs are still higher than wind energy, the added cost of necessary infrastructure to expand wind capacity could eventually make solar a viable alternative. Increased demand for solar energy in United States markets will also cause increased incentives for solar production in Mexico, which can be traded with the US.

9.1.3 Renewable Energy in Canada

Currently, Canada's most developed form of renewable energy is hydropower. Canada is abundant in hydropower capacity that has been used both for domestic consumption and also for trading "green energy" with the United States. However, this has not precluded Canadian authorities from exploring other sources of renewable generation. When considering wind energy, Canada currently has around 4,600 MW of installed capacity, over a third of which is located in Ontario. Almost 700 MW of this capacity was installed in 2010, and over 1,000 MW of power is projected to be installed in 2011. Wind energy currently powers over 1.2 million buildings throughout the country and capacity is rapidly increasing (Canadian Wind Energy Association 2011b). Some of this increase is due to federal and province renewable energy goals. Several provinces in Canada have set targets for wind power, including 7,500 MW of wind energy by 2018 in Ontario, 4,000 MW of wind energy in Quebec by 2015, and 1,000 MW of wind energy in Manitoba by 2016. Although not all provinces have set specific targets for wind energy, most have set standards for renewable energy in general. Canada's federal government has also set a goal of using renewable energy for 90% of all electricity generation by 2020 (Canadian Wind Energy Association 2011a).

As for solar energy, since the country is located in higher latitudes, and thus received less direct sunlight compared to the US and Mexico, Canada is not as well positioned for solar energy. However, Canada is still developing some solar capacity, which totaled around 100 MW in 2009. A majority of the solar energy used in Canada is used for space heating, water heating, and drying crops and lumber, as opposed to being used for electricity. Where solar is used for electricity, it is most commonly used as individual panels in sparsely populated areas that are not connected to an electricity grid (Centre for Energy 2011).

Although Canada does not have the same potential for solar energy as Mexico and the United States, its installed capacity has increased over the past few years. This is in part due to Canada's goal for renewable energy use and in part because of Ontario's Feed-In Tariff (FIT) Program. The FIT program is the most comprehensive pricing program for electricity generation from renewable energy seen in North America (Ayoub and Bailey, 2009). The program sets prices based on the amount of investment required for the type of energy being generated, and has become a powerful incentive that is not totally replicated in the US or in Mexico. Since solar generation requires higher implementation costs than most other forms of renewable energy, this scaled program is likely to incent increased development of solar energy (Ayoub and Bailey 2009). The Canadian government is also taking steps to improve domestic research and development efforts to better understand the PV systems and how to integrate solar energy into the existing electricity grids.

To sum up this introduction, a private parties and governments continue to invest in alternative energies for the purpose of reducing emissions and meeting increasing electricity demands, certain technologies will undoubtedly lose favor. As such, a standing concern will be the potential for state actors to crowd out certain technologies with high levels of investments and/or combinations of incentives. As the cost production models with respect to certain technologies decreases, irrespective of incentives, technological breakthroughs with less favorable technologies might be delayed or might not occur at all. The North American experience demonstrates that governments can positively influence technological advancements of multiple technological platforms without necessarily choosing winners. At this level, further investigation is necessary to quantify the potential impacts governments have if one technology is abandoned in favor of another. However, in the present introductory framing of the problem, it seems apparent that the quest towards increasing renewable sources of energy arise both from exogenous pressures towards a better planet, but also from technological developments and pragmatic business models that set both challenges and opportunities for binational and trinational cooperation.

9.2 Literature Review and Theoretical Framework on Renewables

9.2.1 NAFTA Implications for North American Trade

Prior to the Canada-US Free Trade Agreement (FTA) and the North American Free Trade Agreement (NAFTA), North American trade was primarily multilaterally governed by the General Agreement on Tariffs and Trade, which was a general agreement to reduce trade barriers and develop world trade regulations. Mexico became a member in the mid-1980s, while the US and Canada have been signatories since the beginning of the Agreement in 1948. This agreement held 117 signatory countries in 2009 and eventually created the World Trade Organization in 2001 (Duke University 2010). After this initial step toward increased global trade, the United States entered into a separate trade agreement with Canada (FTA) in 1988, and finally, the United States and Canada joined Mexico in NAFTA in 1992, to be launched on January 1, 1994. NAFTA included objectives to eliminate trade barriers, promote free competition, and increase opportunities for investment in North American countries. In signing this trade agreement, the three countries committed to "national treatment," which prohibited all countries from discriminating between goods and investments produced in the other two countries and goods produced in their own. This agreement was designed to eliminate all North American trade barriers, leading to increased trade and regulatory and institutional convergence amongst the United States, Canada, and Mexico.

Although some analysts did not predict a significant trade increase to result from the trade agreement (Gandara 1995), evidence has shown that there has been considerably more trade between the three NAFTA countries since the agreement was signed. Between 1993 and 2005, the ratio of exports to GDP increased more than 100% in Mexico, and around 30% in Canada and the United States (Caliendo and Parra 2009). Although not all increases in trade can be attributed to NAFTA, the Caliendo model finds that NAFTA accounts for 91% of the increase in Mexico's ratio of manufacturing exports and imports to GDP, whereas 61% of the increase for Canada and 46% of the increase for the United States can be attributed to the trade agreement.

While the agreement did in fact cause an increase in overall trade, with respect to the electricity market there were still certain provisions in the agreement that allowed for restrictions on imports and exports as well as certain forms of price controls (Fisher 1994). There were also other provisions that vary by country. When Mexico was added to the agreement, it did not institute all of the same provisions that Canada had instituted in the first agreement. Some of the differences to which Canada and Mexico agreed may have had or may still have future effects on the amount of electricity trade between the three countries. For example, Canada allowed for proportional access to US electricity importers, whereas Mexico did not assure this right. Mexico also did not extend national treatment to foreign energy corporations, and CFE has the authority to provide electricity services in Mexico as a parastatal utility incumbent (Pineau et al. 2004).

The fact that each country has its own federal regulations could also cause a barrier to electricity trade. In the United States, DOE controls cross-border transmission lines and electricity exports, and the Federal Energy Regulatory Commission (FERC) controls transmission and wholesale electricity rates for many operators and across states. The National Energy Board (NEB) in Canada also regulates exports, but provincial utility commissions control supply. In Mexico, the Comisión Reguladora de Energia (CRE) has authority to regulate electricity imports and exports permits, as well as operators within Mexico, but the parastatal CFE operates as a unified utility outside of CRE's control. Not only are all electricity markets regulated by different entities, Mexico's regulations are more centralized whereas Canadian and US regulations tend to be more decentralized (Pineau et al. 2004). However, although CFE still has control over a large portion of the electricity market in Mexico, NAFTA did allow for US and Canadian investment in self-generation, small power generation facilities, co-generation facilities, and independent power production facilities (DeGrandis and Owen 1995). For the case of Mexico, the Ley del Servicio Público de Energía Eléctrica (LSPEE) in 1993 provided allowances for private investment in the generation side. However, there are more European interests in Mexico than operations by Canadian or US companies, a phenomenon not totally explained by the market and permit opening in Mexico (CRE 2012).

With regard to renewable energy, there are additional factors that could cause possible trade barriers. The nature of the electricity market and renewable energy are hindrances purely because energy generated from electricity is relatively difficult to store, and because transmission costs increase as the distance of transport increases. When renewable energy is used to generate electricity, energy storage becomes even more of an issue, as do the transmission costs, because many forms of renewable energy are somewhat geographically limited, but renewable energy assumes from the outset the need for storage and batteries to reduce volatile (intermittent) supplies. This adds a level of complexity to integrating renewable energy into the electricity market even within one nation. Adding foreign trade into the equation makes renewable energy integration even more complex. This issue was not originally treated under NAFTA provisions and the chapter on environmental protection, for instance.

When looking at renewable energy in the North American electricity market, another complication spurs from the fact that Canada, the United States, and Mexico have all begun implementing various renewable energy requirements at federal and statewide levels, but that the definitions of renewable energy are not uniform across country lines. The Commission on Environmental Cooperation noted that all countries agreed that solar and wind energy qualified as renewable, but that there was considerable debate among various entities as to whether other forms of energy, such as biomass and hydropower, could be classified as renewable (Rowlands 2009). Because of countries' renewable energy standards and increasing demand for renewable energy overall, these varying definitions could cause a trade barrier between these North American countries.

However, while there could be trade implications for various renewable energy sectors, Canada, the United States, and Mexico have begun entering into agreements to coordinate more sustainable energy efforts. For example, the three countries developed a

Trilateral Working Plan on climate change and clean energy at the North American Leaders' Summit in 2009 that promotes similar reporting methods, the reduction of greenhouse gas emissions, aligning efficiency standards across countries, and collaborating on specific emissions reducing projects such as a North American smart grid and joint carbon capture and storage projects (Schott and Fickling 2010). There have also been bilateral agreements between the United States and Canada, as well as the United States and Mexico, to develop clean energy technologies and promote renewable energy markets.

Due in part to these additional cooperative initiatives, energy trade between North American countries has increased alongside that of overall trade since the creation of NAFTA. Energy trade between the United States and Canada amounted to almost $100 billion in 2007, and energy trade between the United States and Mexico totaled almost $10 billion (Schott and Fickling 2010). Although trade has increased, North American countries are still lagging behind some other electricity integration initiatives globally. While there has been initial electricity trade among North American countries, the trade remains mainly bilateral, instead of trilateral, involving only US-Canada and US-Mexico relationships (Pineau et al. 2004). Further cooperation and infrastructure will be necessary to better integrate North American markets, both bilaterally and trilaterally.

In conclusion, where the research has examined in detail the successes of various strategies, the literature has scarcely examined how North America can cooperatively design a system that takes advantage of this knowledge for the development of alternative technologies. In other words, there exists a gap in the literature for the North American experience. Although Canada, Mexico, and the United States have unilaterally been successful in the development of alternative energies collectively, a unified scheme could force markets to develop more quickly and more efficiently. This chapter presents a general background that could lead to addressing this gap and the potential development of a framework to address both the advancement of alternative energy technologies and the reduction of carbon emissions.

9.2.2 Why Countries Are Investing in Renewable Energy

As anthropogenic climate change becomes more of a reality and an increasing global concern, governments all over the world have begun devising strategies to reduce greenhouse gas emissions in order to combat the negative effects of climate change. However, individual federal governments face difficulties in dealing with climate change because greenhouse gas emissions are a global issue. Greenhouse gases emitted in foreign regions contribute to the same amount of climate change and the same negative consequences globally as those emitted in the home country. In order to address climate change on a global level, many countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 (UNFCCC 2011a). The UNFCCC came into effect two years later, in 1994, and is currently ratified by 195 countries, including the European Union. The main outcomes of the Convention were establishing a specific goal for greenhouse gas concentrations, placing responsibility on developed countries, adding a focus on adaptation, and directing funds to developing countries for climate change initiatives (UNFCCC 2011b).

Subsequent to the original Convention, participating governments developed terms for the well-known Kyoto Protocol, which came into effect in 1997. The main difference between the original Convention and the Kyoto Protocol is that the Kyoto Protocol made reduction targets legally binding for all ratified countries, opposed to the Convention under which reductions were voluntary. The Kyoto Protocol defined legally binding emission reduction targets for 37 developed countries and the European Union, which totaled to an overall emissions reduction of 5% of greenhouse gas emissions based on 1990 levels. Each country was given an individual target, and the countries agreed to reduce emissions between 2008 and 2012 (UNFCCC 2011c). The countries in the European Union at the time of ratification committed to 8% reductions; the United States (although it has not ratified the Kyoto Protocol) committed to 7% reductions; Canada, Hungary, Japan, and Poland committed to 6% reductions; and Croatia committed to 5% reductions from 1990 levels. New Zealand, the Russian Federation, and Ukraine also made commitments not to increase their emissions level over that of 1990 levels, whereas Norway, Australia, and Iceland committed to limiting their emissions levels to a 1%, 8%, and 10% increase above 1990 levels, respectively (UNFCCC 2011c).

Also, in 2010, countries further agreed that overall emissions need to be reduced to a level that ensures global temperature increases do not exceed 2 degrees Celsius (UNFCCC 2011a). This will most likely require even more ambitious targets than those required by the Kyoto Protocol. Participating countries have also begun discussing the best course of action for after 2012 when the current Kyoto commitment period is no longer in effect. The Bali Road Map was adopted in 2007 and includes the Bali Action Plan, which takes into consideration shared vision, mitigation, adaptation, technology, and financing while discussion implementation of the Convention through and beyond 2012 (UNFCCC 2011d).

Because these binding agreements to reduce greenhouse gas emissions are currently in effect, and because future and ongoing agreements are likely to form, many countries have developed federal policies to meet their required reductions and to help prepare industry to take necessary steps for the future. Some countries that are not currently legally obligated to achieve specific amounts of emissions reductions have developed reduction strategies in anticipation of future agreements and because they feel a responsibility to thwart potential negative effects of climate change, both in their own territory and around the globe. Many of these emissions reductions strategies include provisions regarding renewable energy. For example, the Mexican government established renewable energy targets even though it is not one of countries with a binding reduction commitment. Renewable energy tends to emit far fewer greenhouse gases than legacy fuels, such as coal and oil, making them an obvious component of emissions reductions plans.

Although increased widespread use of renewable energy will indeed help the effort to reduce the negative effects associated with climate change, renewable energy is also appealing because it is sustainable, because it runs on resources that are naturally replenished within the environment. Because of sustainability, renewable energy is a longer-term solution to energy needs, but it also has the potential to increase a country's energy security by decreasing their reliance on finite sources that may only be available in certain regions.

Concerns related to energy security have varied in recent decades, and are generally related to petroleum. As the possibility of discovering new oil reserves wanes, it has become increasingly clear that a small number of counties throughout the world have the majority of the oil reserves, giving them a degree of economic and political leverage over other countries. Because so much of the current technology in the developed world requires oil to operate, there is the potential to create inefficient market pricing of the commodity. This was demonstrated during the oil crisis in the 1970s, during which many countries became more concerned about their energy security, or their ability to provide sufficient amounts of energy to maintain current operations in their country.

The oil crisis in the 1970s was spurred by the Organization of Petroleum Exporting Countries (OPEC) oil embargo of 1973. Before this time, many developed countries relied heavily on oil for fuel and gave little concern to the quantity of oil consumed and the amount of oil necessary to maintain their current conditions. However, after the oil embargo, many countries began to doubt the availability of oil for the first time, which caused them to place restrictions on oil consumption, leading to a dramatic spike in oil prices (State Energy Conservation Office 2011). In response to this global crisis, another autonomous international organization was formed. The International Energy Agency was founded after the oil embargo, and its initial purpose was to assist participating countries with formulating a response to oil crises by providing emergency oil stocks to countries in need. The IEA currently has 28 member countries and has expanded its mission to include energy security, sustainable economic development, environmental awareness, and worldwide engagement (IEA 2011). In order to obtain energy security and be able to meet energy needs during a crisis, IEA promotes the development of renewable energy generation because renewable energy sources are naturally replenished (IEA 2010). If countries can develop the required infrastructure and regulations needed for renewable energy, they will be better equipped to deal with a crisis and will not be forced to rely on imported fuels. Thus, energy security is another reason more and more countries have begun incentivizing the growth of renewable energy.

9.2.3 How Emissions Permitting and Trading Ties in to Renewable Energy

The European Union's tradable permit scheme (EU ETS), which attempts to both address climate change concern and spur economic development, has been deemed successful to varying degrees (Ellerman and Joskow 2008). Regardless, the EU ETS still stands as the world's largest market for greenhouse gas emissions (Ellerman 2008). Although problems associated with global trading schemes, such as lack of institutional preparedness and international financial flow, have posed challenges in the past, the EU ETS appears to have overcome these challenges. However, issues still exist. (Ellerman 2008). The current challenges are associated with coordination among participating countries and differentiation and harmonization. The first challenge is well understood, but issues related to differentiation and harmonization are unique and are being dealt with accordingly as the EU ETS matures.

The concepts of differentiation and harmonization will invariably play a unique role should an emissions trading scheme emerge as a feasible policy action through a North American partnership, or even as the Kyoto Protocol sees its second phase die out at the end of 2012 to rekindle emission reduction offerings and strategies in 2013. At its core, the degree of fairness among similar industries in different countries could lead participating members to question whether a trading scheme is at all beneficial as a matter of economic policy. The success of a trading scheme is contingent on its members actively participating in concert to reduce emissions overall. In other words, partners must work in good faith to ensure that their actions move the program forward rather hinder it with unanticipated challenges. Although agreements are legally binding, a member state could very well weigh the consequences in favor of not equitably sharing in the success of the program. This sets qualifications to commitment by countries, under a stakeholder theory approach or a new Institutional Economics approach, that evaluate the degree of risk-taking by large and powerful decision-makers, as well as weighing in all actors (agents in game theoretical approaches) and their interests (Beato and Laffont 2001; Laffont and Martimort 2005; Wilson 2002).

Nevertheless, what can be gleamed from EU ETS is that alternative energy technologies are very much a part of the solution to address climate change as the Spanish and German experiences, to be discussed later, show. The growth in alternative energies in much of the rest of Europe has also coincided with the EU's ambitious plans to reduce the region's carbon footprint. As a matter of economic theory, it could be argued that in a vacuum, electricity producers would not have adopted alternative energy technologies in favor of legacy fuels for generation strictly on the basis of cost. Moreover, national policies to incite alternative energy technologies could have faced challenges associated with competing economic interests with neighboring trading partners and competitors. Therefore, emission trading platforms can indeed have a promising role in the adoption and promotion of alternative energy technologies because they are the tools that help achieve goals set by participating members.

9.3 Relevant Case Studies

This section examines four countries' policies regarding renewable energy and the policy strategies used to incentivize renewable energy generation. The four case studies discussed include the United States, Spain, Germany, and China. They coincide with analyses elsewhere in the present overall research project, with regulatory upgrading related to electricity. As a result of the unique combination of federal and state incentives, state renewable portfolio standards, and government funded research, the US serves as an ideal model for examination. Despite the fact that the US Senate never ratified the US's agreement to participation in the Kyoto Protocol, the federal government and state governments have worked to support the development of alternative energy technologies. Similarly, Spain has become one of Western Europe's greatest producers of alternative energy in large part due to aggressive renewable energy polices supported through government subsidies. For that reason, Spain's upward momentum merits further examination. Like Spain, Germany is one of Europe's largest producers of alternative energies and was one of the first countries to institute feed-in tariffs for renewable energy generation with measured success, making their policies noteworthy. Lastly, as China has continued to grow both industrially and economically, its government has been extremely successful in spurring production in the solar sector and other alternative energies. As the technological knowledge gap has narrowed, China has had the advantage of observing which policies and technologies work best from the global community. For these reasons, China also merits closer examination.

9.3.1 United States

The path the United States followed is not unlike that of other economies across the globe. Following the oil crises of the 1970s, the federal government determined that it needed to invest in alternative energy fuels such as nuclear power and renewables, as well as increasing their efficiency standards (Norberg-Bohm 2000). At its peak, around 1978, research and development in energy technologies such as alternative fuels and wind turbines by the federal government exceeded $6 billion. Yet, by the 1980s changes in the political landscape as well as lower oil prices led to a dramatic decrease in government research and development. By 1998, R&D funding amount to a little over half a billion dollars (GAO 2008). Collectively, over a 30-year period (ending fiscal year 2008) the federal government had invested over $57.5 billion in advanced energy technologies (GAO 2008). Despite this level of invest over three decades, the US energy portfolio has not changed much from 6% in 1973 to 8% in 2009 (US EIA 2010).

Nevertheless, the US has experienced growth in the development of alternative energy technologies and the energy industry has of late invested considerable time and resources to roll out large-scale projects. As observed by the National Research Council (NRC) in their report *Electricity from Renewables: Status, Prospective, and Impediments,* the United States has much to gain through the development of alternative energy technologies. Whether the aim is to reduce carbon dioxide or to promote a "green economy" renewable energy development continues to offer tremendous promise.

Even though the United States heavily relies on fossil fuels to provide energy, technological advancements continue to accelerate growth in the green energy space. The NRC estimates that the US could increase its renewable energy portfolio to 10% of total generation produced by 2020 and in excess of 20% by 2035, which coincides or even surpasses the United Nations or Kyoto targets. The panel notes that in order to reach such levels there will have to be a combined effort from government to provide a policy platform that is flexible yet predictable, and government must be willing to invest considerable resources.

Actions taken by individual states have also advanced the development of alternative energies. Currently, 29 states and the District of Columbia have mandated certain renewable standards for utility generation. Among the most aggressive is California's 2002 Renewables Portfolio Standard which required at least 20% of electricity generation to come from renewable energy by the end of 2010. Also in 2002, the California state government signed Executive Order S-14-08 requiring at least 33% of electricity generation to come from renewable energy by 2020 (Wood 2010). Like California, Minnesota is requiring utility generation using renewable energies to reach 25% by 2025. Most recently, through legislation passed by the California Legislature, California will create the first state cap and trade system in the US. Even though the bill was passed into law in 2006, it was not until early December 2011 that the administrative body, California Air Resource Board, was given the permission to proceed with the program (Egelko 2011).

Prior to these most recent developments, the various government incentive policies set in place during the late 1970s and early 1980s demonstrated that indeed supply-push efforts can also lead to an increased rollout of alternative energy technologies. For example, the successful development of wind energy is in large part the direct result of the level of investment made by the federal government. Through funds made available to NASA and DOE, wind technology advanced dramatically, although not precisely as either agency had predicted (Norberg-Bohm 2000). Although NASA and DOE's Mod Program did not lead to the commercialization of large-scale wind turbines, advances were made in understanding the mechanics of medium-scale wind turbines as well as operational efficiencies.

Nevertheless, through public funding made available to the DOE and to the predecessor of NREL, researchers have determined that of the 12 key innovations made in the wind turbine component space, seven of them depended wholly or partially on public funds (Norberg-Bohm 2000). Most recently, the Federal Renewable Electricity Tax Credit (PTC), which has been extended beyond its original end date, has resulted in additional development of alternative energy technologies, most notably wind energy. In 2010, the PTC provided a 2.2 cent per kWh credit for all wind facilities in operation by the end of 2012 and closed-loop biomass facilities operating by the end of 2013. All other remaining technologies such as geothermal energy, open-loop biomass, and landfill gas, among others, received a 1.1 cent per kWH credit. With the PTC, generators receive a tax credit of $19 per MWh. Adjusted for inflation the PTC is roughly 2.1 cents per kWh, which makes it competitive with fossil fuels.

Aside from the PTC, other incentives for renewable energy alternatives include the Energy Investment Tax Credit and the Renewable Production Incentive. Although the federal Investment Tax Credit was modified by the Energy Improvement and Extension Act of 2008 and the American Reinvestment and Recovery Act of 2009, it gives companies (taxpayers) an option for project development in lieu of the PTC. The offering of options seems to be a characteristic ingredient to many successful programs where the emitter is given options to disclose its preference for incentives. This in industrial organization and game theory is called "second degree price discrimination" where the agent is not-separable and needs optional incentives for it to show its preference to the policymaker or regulator (Church and Ware 2001).

In general the credit allows for a 30% deduction of project expenditures made by a company. The Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 also provided an incentive by extending the US Treasury Grant program. As a result, projects that are under construction by 2011 and projects that are in service are eligible. The cash grant is worth up to 30% of the capital investment. In contrast, the Renewable Production Incentive (REPI) provided a 2.2 cent per kWH incentive payment for new eligible facilities in operation before October 2016 and owned by local, state, and tribal governments, municipal utilities, rural electric cooperatives, and native corporations that have no tax liability. It is paid subject to availability of appropriations in each federal fiscal year of operation. Collectively these incentives serve to entice market participants to develop the technologies of the future while supporting those that that have yet to mature as commercially viable.

9.3.2 Spain

The Spanish experience is one that has been characterized by some as a great success and by others as an overly ambitious experiment that led to market disruptions and near failure (Perez and Ramos-Real 2009; Alvarez 2009). All things considered, the growth alternative energies in Spain have experienced has been dramatic, but at a cost some consider to be far too high. Much like fossil fuel-depended economies across the globe, the Spanish government began to support certain alternative sources of energy in the late 1970s, most notably through its National Energy Plans (Perez and Ramos-Real 2009). Following the 1991 National Energy Plan, it called for increased support and investment in alternative energies ranging from thermal energy, biomass, small hydropower, solar, and wind development increased.

In 1999, the Spanish government also adopted its Promotion Plan for Renewable Energies, which aggressively pushed for further development of alternative energies. Since then, gross electricity generation in Spain has increased from 25.98 TWh in 1990 to nearly 73.57 TWh in 2009 (European Commission 2011). In 1990 only 17.1% of total generation in Spain was from renewable sources, compared to nearly 25% in 2009. Spain's remaining generation comes mostly from imported natural gas and nuclear power, which account for 38% and 18%, respectively (Eurostat 2011).

It should also be noted that Prime Minister Jose Luis Rodriguez Zapatero was a proponent for increased development of alternative energy sources and had established a phase-out of nuclear energy generation. In that spirit, Spain's efforts to further increase electricity generation using alternative energies were demonstrated by its aggressive policy actions, most notably the Royal Decree 661/2007 of May 25, 2007. Under the provisions set forth by the decree, new generating facilities were given an option to receive tariffs and premiums to remunerate for electricity generated by alternative energies including waste to energy, hybrid systems, and cogeneration plants (IEA 2009). The cost the grid operator bears is subsequently passed on to consumers. Additionally, the Royal Decree set limits that capped the maximum and the minimum prices that could be set by investors (Perez and Ramos-Real 2009).

However, as the economy began to weaken and governments across the globe collected less in revenue from taxes, the Spanish government was forced to reconsider its aggressive policy aims that had committed resources well beyond a sustainable range. The average annuity payable to renewables in Spain is estimated to be equivalent to a little over 4% of all value-add taxes collected, nearly 3.5% of household income tax (Alvarez 2009). As such, the Spanish government amended its initial plan to be more consistent with the economic and political realities of recessionary cycles. However, these changes were done cognizant of the reality that investors had committed tremendous resources and needed to be fairly compensated for their efforts to promote alternative energies.

The Spanish experience is telling in two ways. First, when a governmental body offers substantial resources in the form of incentives, the private sector can respond in-kind and develop technologies as prescribed by government mandates. However, there are always tradeoffs that must be considered. Presumably, the Spanish government did not consider the probability of a severe global recession that touched all corners of government and industry. As a consequence the government made commitments that simply could not be sustained in a responsible manner despite the overwhelming growth of alternative energies. What can be gathered then is that governments must plan and/or insure against potential economic shocks in the market that could disrupt current programs. Spain's response to adverse economic conditions could have very well led to the end of incentive policies to the detriment of alternative energy development programs in Spain.

What the Spanish example also demonstrates, much like the US example, is that governments have a significant role in accelerating the development and promotion of alternative energy technologies. However, the Spanish government used a feed-in-tariff scheme to promote alternative technologies, whereas the US used a strong research program to first entice technological advancement, and then supplemented that by strong tax support for the subsequent generation of electricity by those technologies. The Spanish experience as a case model points to the difficulty of balancing the appropriate measures when promoting alternative energy technologies. By guaranteeing above market rates for 20 years for electricity generated by alternative energies Spain incentivized an overabundance of solar projects to the detriment of taxpayers who in effect subsidized their development (Market Meltdown 2011).

9.3.3 Germany

The majority of Germany's renewable energy initiatives can be at least partially attributed to the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG), which was signed in 2000 and amended in 2004. The initial goal of the EEG was to achieve 12.5% production of energy from renewable sources by 2010, which was achieved in 2007 (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2007). The next phase of the goal is set at achieving 27% of electricity from renewable energy in 2020, and 45% by 2030. Types of renewable energy that are prioritized include wind, solar, hydroelectric, geothermal, biomass, landfill gas, sewage treatment plant gas, and mine gas.

Under the Renewable Energy Sources Act, Germany has thus far reached its targets and intends to continue reaching the proposed targets through facilitating the market for renewable energy in electricity production by giving priority to renewable sources through feed-in tariffs. These feed-in tariffs require grid system operators to prioritize purchasing electricity generated from renewable energy and mine gas over electricity generated using legacy fuels. Under this system, plant operators are guaranteed a certain amount of money from the grid system operators, therefore ensuring there is a market for renewable energy production. The amount paid to each plant operator depends on the type of technology used, the installation year, and the plant size. Although most plant operators are guaranteed fixed tariffs for at least 20 years, which is designed to facilitate long-term investment in renewable energy (Frondel 2010), new tariff rates are subject to changes by Germany's government in order to maximize cost-effectiveness in the evolving energy market.

Since its creation in 2000, the Renewable Energy Sources Act has amounted to a savings of 45 million tons of CO_2 emissions, and a net benefit of 6.1 billion euros. Other than helping Germany meet its emissions reductions targets, the Renewable Energy Sources Act also benefited Germany by increasing the number of jobs in Germany. Between 2004 and 2006, the number of people employed in the energy sector increased from 157,000 to 230,000. Much of this increase can be attributed to the Renewable Energy Sources Act, and it is estimated that up to 500,000 individuals will be employed in the energy sector by 2020. Furthermore, electricity generation from renewable energy is expected to double between 2010 and 2020, allowing Germany to meet and even exceed its renewable energy targets (Traber et al. 2011). However, although Germany's policy has more than doubled renewable energy generation between 2000 and 2008, and generation from renewables is expected to continue growing at high rates, this increase came at the expense of electricity generation from non-renewable fuels, specifically nuclear power (Frondel et al. 2010).

After Germany's success, many other countries have followed Germany's example and set feed-in tariffs to incent the development of renewable energies. Feed-in tariffs similar to those implemented in Germany could be a viable option for North American markets, because they do not require funds from the government, which may not be a viable option in the US and Mexican governments at this point in time. However, they do have the potential to place an economic burden on the grid system operators, specifically in cases in which electricity generation from renewable fuels is more costly than that from current operations. The fact that many authors have criticized feed-in tariffs as done in Germany seems to arise from an interested political system, rather than from the incentives or dis-incentives these tariffs generate. This would most likely be the case for both wind and solar generation, although prices for both forms of energy are decreasing and prices for wind are quickly reaching that of legacy fuels. However, increased costs for grid system operators could translate to increased consumer prices, which should be taken into consideration when implementing feed-in tariff policies. Other effects seen in Germany, such as reduced use of other non-renewable energy types should also be considered when implementing feed-in tariff policies, as this could result in higher costs to other sectors.

9.3.4 China

China has become an increasing concern when it comes to potential greenhouse gas emissions in the past decade. Their industry is growing at a fast rate, and most of the electricity generation is still produced from fossil fuels, from which open-mouth carbon is massively used (Dincer 2011; Dussel-Peters 2008). However, China is taking steps toward cleaner methods of generation. In 2006, renewable energy made up about 8% of China's total primary energy consumption, most of which came from hydropower. Hydropower accounted for 130 GW, wind power accounted for 2.6 GW, biomass accounted for 1.0 GW, solar photo-voltaic (PV) accounted for 0.08GW, and solar water heaters accounted for 100 million m^3 (Shuiying et al. 2011). China has set targets for these numbers to increase to 190 GW for hydropower, 5 GW for wind power, 5.5 GW for biomass, 0.3 GW for solar PV, and 150 million m for solar water heaters by 2010, and further increase to 300 GW for hydro power, 30 GW for wind power, 30 GW for biomass, 1.8 GW for solar PV, and 300 million m for solar water heaters by 2020. If these targets are reached, renewable energy will account for 15% of total primary energy consumption in China by 2020 (Shuiying et al. 2011). These targets were set in 2007, and strides have already been made in many renewable energy fields since that time. By 2009, many of the targets had already been surpassed. In that year, total renewable power reached 226 GW, 197 GW from hydropower, 25.8 GW from wind power, 3.2 GW from biomass, and 0.4 GW from solar PV. Although installed solar capacity had one of the smaller increases relative to each renewable energy origin, growth in solar production in China has been tremendous. By 2009, China was the largest solar producer in the world, supplying about 40% of all solar PV worldwide (Martinot 2010).

China has only stepped onto the solar energy scene in recent years, but their recent renewable energy commitments and policies are quickly allowing them to dominate the market, and their PV industry has grown more rapidly than any other country (Dincer 2011). China's geography and large size allows for great potential in the solar industry. Although the solar radiance varies greatly, about two thirds of the country received over 5,000 MJ/m2yr, and the country receives an average daily radiation of 4 KWh/m2day (Liu et al., 2011). Due to these high potentials, China is expected to meet their 2007 targets and announce new targets in 2011, and many believe China will be able to surpass their target to meet 1 GW of potential solar energy in 2011. By 2020, renewable energy is expected to make up 15% of China's total energy supply, and renewable energy is expected to account for 30% of electric power capacity by 2050 (Dincer 2011).

Much of the advancement in renewable energy can be attributed to the Renewable Energy Promotion Law, which came into effect in 2005. Although China established renewable energy programs during the 1990s, the government became more serious about the issue after China's rapid industrial and economic growth in the early 21st century (Wang et al. 2010). This 2005 Energy Promotion Law requires power operators to purchase resources from registered renewable energy producers, and offers additional financial incentives for renewable energy, such as tax preferences and a national fund dedicated to renewable energy development (China Passes 2005). Before this law passed, only two of the top ten worldwide solar cell producers were Chinese companies. After the law passed, the number of Chinese companies in the top ten has risen from two to six (Lacey 2011). Since the creation of the law in 2005, there have been additional updates that went into effect in 2010, including additional planning and coordination when integrating renewable energy in local and federal plans, additional guarantees for purchasing renewable power, and strengthening of the renewable energy fund. Specifically, the update requires electric utilities to purchase all of the renewable power generated, as opposed to only purchasing renewable energy when there is significant demand (Martinot 2010). The price at which grid operators must purchase renewable energy is also determined by the government, and varies by energy type. These prices are still significantly higher than that of fossil fuels, but the set prices guarantee the use of renewable energy (Wang et al. 2010).

There was also a "Golden Sun" program initiated in 2009 that provided subsidies for certain solar PV installations through 2011. Under this program, grid-connected installations received 50% subsidies if they had a peak capacity of at least 300kW. Thus far, this program has funded over $29 billion in investments. The Ministry of Finance and the Ministry of Construction also provide subsidies for solar PV installations that are at least 50 kW and use PV modules with a minimum efficiency level of 16% for mono-crystalline modules, 14% for poly-crystalline modules, and 6% for amorphous modules. Tariffs are also in place for solar PV, in the form of a new competitive bidding program for benchmark tariffs, and new preferential tariffs at a provincial level (Martinot 2010).

Another major component of the increase in renewable energy investment in China is the creation of the Chinese Development Bank. The bank was established as an arm of the Chinese central government, but now operates as a separate entity that provides loans for Chinese companies. The Chinese Development Bank raises most of its money from long-term bonds, thus enabling it to provide low interest rates to investors, making investing in Chinese companies a much less risky venture (Lacey 2011). Many solar companies in China have taken advantage of the loans provided by the Chinese Development Bank when financing their solar initiatives in China. For example, some of the larger solar companies in China, including Trina, Suntech, JA Solar, and Yingli Solar, received loans between $4 and $7 billion from the Chinese Development Bank in 2010 alone (Lacey 2011). For solar companies, whose startup costs are generally much larger than that of other energy generation companies, these large loans can make all the difference of whether to invest in solar, and where to invest.

China's significant subsidies and financial support for renewable energy have contributed to much of its recent growth in the renewable sector and have allowed it to surpass other countries in terms of its renewable energy portfolio. However, applying China's policies to other countries is difficult because China has a larger amount of available capital than many countries, including Mexico, plus little opposition in congressional games make the Chinese objectives easier to implement. Also, their policy of providing large amounts of financial aid to renewable energy companies may not be viable if the companies are unsuccessful. Therefore, although China's policies seem to be effectively increasing the renewable energy market, especially in the case of solar energy, China's policies may not translate well to that of the United States and Mexico.

9.4 Conclusions and Future Developments for Policy Making in North America as a Region

As the leader in alternative energy development in North America, the policies adopted by US will continue to have profound consequences both positively and negatively for the region. As such a standing challenge that remains, which could potentially slow future growth and development of alternative energies, is the political climate in Washington, DC. This is evidenced by the US Congress's inability to commit to any long-term climate change mitigation program or protocol. More troubling is the prospect that in the near term the US Congress will not pass any type of legislation relating to the reduction of greenhouse gases (Weissman 2011). Although in 2009, the US House of Representatives was able to pass comprehensive climate change legislation, the measure failed final passage due to insufficient support in the Senate.

The key provision and most contentious part of the bill was an attempt to create a cap and trade system that would have limited the amount of greenhouse gases emitted by industries. The legislation intended on reducing greenhouse gas emissions to 17% below 2005 levels. Equally important the legislation would have set a national renewable energy standard of 20% by 2020. These measures would have undoubtedly had a measurable effect on the level of investment in alternative energies from both the public and private sector, most notably across North America.

As has been documented, the debate as to what tools work best to encourage behavioral change within an industry is ongoing and the various conclusions are mixed. Depending on the type of market response that is desired, different responses are given as to how to best achieve that change (Jaffe and Stavins 1995). At the center of the economic debate will continue to be whether "market-based" or "command-control" approaches are more appropriate in promoting the development of alternative energies. Whether feed-in-tariffs, tradable permits, renewable energy standards, or mandatory industry-wide restrictions are used, each country will inevitably have to face challenges unique to it.

The US experience for instance serves as a model in which both the utilization of renewable energy standards along with government subsidies has led to successful development of alternative energies (Norberg-Bohm 2000). The development of the modern wind turbines, for example, shows that while demand-pull strategies were effective, alone they were not enough to sustain change. However, with responsive governmental policies that attempt to create a balance between policy aims and sustainable development of alternative energies, countries can be effective in growing their respective energy portfolios.

In the context of mitigating climate change and the reduction of greenhouse gases, the case models of the US, Spain, Germany, and China each illustrate varying outcomes of success and potential failure as a result of different strategies used to incent market behavior. With regard to the type of technologies that are adopted, what has been characterized as the "valley of death" and the "mountain of death" along the technology innovation process will continue to stand as a challenge in the roll out of promising technologies (Norberg-Bohm 2000). This notion is of interest because it helps illustrate the challenges firms, countries, and policymakers face when deciding the appropriate tool, mechanisms, or technology to address policy aims and goals.

As alternative energy technologies become more commercially viable, Canada, Mexico, and the US will continue to play a crucial role in accelerating growth patterns of certain technologies globally. For that reason they each independently play an active role in the development of alternative energies and must continue to aggressively invest in research and development to further advance existing technologies. Although not the panacea for reductions in greenhouse gases, renewable sources of electric power generation are a critical component in reducing emissions. Although the cost-production models for solar, wind, and biomass platforms as well as their respective trading models have unique characteristics, they share in common the potential to become viable competitive alternatives to fossil fuels.

The opportunity to trade electricity on a much larger scale between the US and Mexico remains challenging yet promising. Without a doubt, the political climate and appetite for cooperation between countries will dictate whether any agreement or partnership can be made to develop modern infrastructure to facilitate the trade. One obstacle and profound challenge is Mexico's strong attitude toward electricity generation as a symbol of national pride and sovereignty (Carreón-Rodriguez et al. 2003). From a historical context, following decades of generation capacity developments by CFE, Mexico experienced a period of diminished foreign investment that led to the formal nationalization of the electricity industry in 1960 (Carreón-Rodriguez et al. 2003). As result, CFE's political positioning grew stronger and along with strong unions in the electricity sector, reforms have been difficult if not impossible.

Similarly, different jurisdictions of regulation of electricity, most notably in Texas, pose a challenge to integration. As one of ten independent system operators in the US, the Electric Reliability Council of Texas has the authority to ensure the reliability of electricity in the region. ERCOT covers approximately 75% of the state of Texas and almost the entire US-Mexico border except for El Paso County. The remainder of the US-Mexico border is under the jurisdiction of the Western Electricity Coordinating Council (WECC). As ERCOT is wholly within the Texas Interconnection it does not fall under the jurisdiction of federal regulation. On the other hand, because WECC spans multiple states and thus abides by the interstate commerce clause, their organization is required to comply with federal regulations. Even though there are only two electricity reliability organizations along the US-Mexico border, each state along the border has the authority to modify their existing electricity sectors. As a consequence, coordination to integrate systems would have to be done at the federal, regional, and local levels.

Nevertheless, one advantage to Mexico's vertically integrated energy sector is that negotiations would be easier to engage because the US would exclusively negotiate with one party, the Mexican government. However, all interested parties responsible for trade, electricity reliability along the border, and other appropriate entities in the US would first have to determine how to facilitate any new developments or policy changes of consequence. This might very well prove to be the most difficult challenge to overcome as each state is unique and their respective legislative bodies might have different opinions on how to best integrate our electricity sectors.

Notwithstanding these challenges, the most promising opportunity would emerge if both countries were to engage in bilateral negotiations exclusively on the integration of alternative energies of production and also trading by seasons and emergencies, as was evident in other commodities' trade in the past, and also electricity backup in 2011 (see Chapter 4 on consumption trends, and also Chapters 6 and 7 on regulations). If anything, renewable forms of energy production could serve as the catalyst that will move both countries to open the dialogue for much greater trade of electricity. This could help push for reforms in Mexico's electricity sector, and for increased cooperation and reliability of the electricity grid in the United States.

References

Alvarez, G.C. R. Merion Jara, and J.R. Rallo Julian. 2009. Study of the Effects on Employment of Public Aid to Renewable Energy Sources. King Juan Carlos University.

American Wind Energy Association. 2011. 2010 U.S. Wind Industry Annual Market Report: Rankings. Retrieved November 1, 2011, at http://www.awea.org/learnabout/publications/factsheets/upload/2010-Annual-Market-Report-Rankings-Fact-Sheet-May-2011.pdf.

Ayoub, J. and L.D. Bailey. 2009. Photovoltaic Technology Status and Prospects: Canadian Annual Report 2009. Natural Resources Canada.

Beato, C. and J.J. Laffont. 2001. *Regulations for Development*. MIT Press.

Bloom, D., J.P. Forrester, N.C. Klugman. 2011. State Feed-in Tariffs: Recent FERC Guidance for How to Make Them FIT under Federal Law. *The Electricity Journal* 24: 26-33.

Bloomberg New Energy Finance. 2011. UNEP Global Trends in Renewable Energy Investment 2011.

Button, J. 2008. Carbon: Commodity or Currency The Case for an International Carbon Market, *Harvard Environmental Law Review* 32(2): 571-596.

Cacino-Solorzano, Y., A.J. Gutierrez-Trashorras, and J. Xiberta-Bernat. 2011. Current State of Wind Energy in Mexico, Achievements and Perspectives. *Renewable and Sustainable Energy Reviews* 15(2011): 3552-3557.

Caliendo, L., F. and Parro. 2009. Estimates of the Trade and Welfare Effects of NAFTA. *Mimeo.* University of Chicago, Department of Economics.

Canadian Wind Energy Association. 2011a. Federal/Provincial Initiatives on Wind Energy. Canadian Wind Energy Association.

Canadian Wind Energy Association. 2011b. Powering Canada's Future. Canadian Wind Energy Association.

Carreón-Rodriguez, V., A. Jiménez San Vicente, and J. Rosellón. 2003. The Mexican Electricity Sector: Economic, Legal and Political Issues, Stanford University Institute for International Studies.

Centre for Energy. 2011. Solar Power in Canada. Centre for Energy. Retrieved September 23, 2011, at http://www.centreforenergy.com/AboutEnergy/Solar/Overview.asp?page=5.

Church, J. and G. Ware. 2001. *Industrial Organization: A Strategic Approach*. Boston, MIT Press.

CRE. 2012. Data on Mexican non-utility permits. Retrieved January 10, 2011, at http://www.cre.gob.mx.

DeGrandis, W.D., and M. L. Owen. 1995. Electric Energy Legal and Regulatory Structure in Mexico and Opportunities After NAFTA. *United States-Mexico Law Journal* 3: 61-68.

Dincer, F. 2011. The Analysis on Photovoltaic Energy Generation Status, Potential and Policies of the Leading Countries in Solar Energy. *Renewable and Sustainable Energy Reviews* 12(2011): 712-720.

Duke University School of Law. 2010. GATT/WTO. J. Michael Goodson Law Library Research Guides. Duke University School of Law.

Dussel-Peters, E. 2008. Economic Opportunities and Challenges posed by China for Mexico and Central America. Studies of the German Development Institute Berlin, DIE, Mimeo.

Ellerman, D. and P.L. Joskow, 2008: The European Union's Emissions Trading System in Perspective, Pew Center on Global Climate Change (May). Washington, DC.

Ellerman, D. 2008. The EU's Emissions Trading Scheme: Prototype of a Global System? Paper prepared for the Harvard Project on International Climate Agreements.

Egelko, B. 2011. S.F. Judge OKs Cap and Trade for Emission Law, *San Francisco Chronicle.* Retrieved December 9, 2011, at http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2011/12/07/BA481M9NPV.DTL.

EIA. 2010. *Annual Energy Review 2009*. Table 1.3. US Energy Information Administration.

European Commission. 2011. Countries Fact Sheet. Retrieved March 17, 2012, at http://ec.europa.eu/energy/publications/statistics/doc/2011-2009-country-factsheets.pdf..

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. 2007. EEG – The Renewable Energy Sources Act: The Success Story of Sustainable Policies for Germany. Berlin, Germany.

Fisher, J. 1994. NEPA, NAFTA and Cross-Border Electric Generating Projects. *Georgetown International Environmental Law Review* 277(7): 277-307.

Frondel, M., N. Ritter, C.M. Schmidt, and C. Vance. 2010. Economic Impacts from the Promotion of Renewable Energy Technologies: The German Experience. *Energy Policy* 38(2010): 4048-4056.

Gandara, A. 1995. United States-Mexico Electricity Transfers: of Alien Electrons and the Migration of Undocumented Environmental Burdens. *Energy Law Journal* 16(1): 1-63.

Government Accountability Office (GAO). 2008. Testimony before the Subcommittee on Energy and Environment, Committee on Science and Technology, *Advanced Energy Technologies: Budget Trends and Challenges for DOE's Energy R&D Program.* House of Representatives.

Haas, R., G. Resch, C. Panzer, S. Busch, M. Ragwitz, and A. Held. 2011. Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources – Lessons from EU countries. *Energy* 36(4): 2186-2193.

IEA. 2009. World Energy Outlook: Feed-in tariffs for electricity from renewable energy sources (Special regime). International Energy Agency. Retrieved December 9, 2011, at http://www.iea.org/textbase/pm/?mode=weo&id=3648&action=detail.

IEA. 2010. Overview of the IEA. International Energy Agency. OECD/IEA.

IEA. 2011. About the IEA. International Energy Agency. Retrieved December 3, 2011, at http://www.iea.org/about/index.asp.

Jaffe, A. and R.N. Stavins. 1995. Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion, *Journal of Environmental Economics and Management* 20(3): S43-S63.

Klaassen, G., A. Nentjes, and M. Smith. 2005. Testing the theory of emissions trading: Experimental evidence on alternative mechanisms for global carbon trading. *Ecological Economics* 53(1): 47-58.

Lacey, S. 2011. How China Dominates Solar Power. *The Guardian.* Retrieved November 7, 2011, at http://www.guardian.co.uk/environment/2011/sep/12/how-china-dominates-solar-power.

Laffont, J.J. and D. Martimort. 2005. The Design of Transnational Public Good Mechanisms for Developing Countries. *Journal of Public Economics* 89: 159-196.

Lawrence Berkeley National Laboratory. 2011. Tracking the Sun IV: A Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998 to 2010. Lawrence Berkeley National Laboratory.

Liu,W., H. Lund, B. Vad Mathiesen, and X. Zhang. 2011. Potential of Renewable Energy Systems in China. *Applied Energy* 88(2011): 518-525.

Market Meltdown. 2011. *ASHRAE Journal* 53(4): 12.

Martinot, E. 2010. Renewable Energy Policy Update for China: China's Latest Leap: An Update on Renewables Policy. *RenewableEnergyWorld.Com.* Retrieved November 7, 2011, at http://www.renewableenergyworld.com/rea/news/article/2010/07/renewable-energy-policy-update-for-china.

Norberg-Bohm, V. 2000. Creating Incentives for Environmentally Enhancing Technological Change: Lessons from 30 Years of U.S. Energy Technology Policy *Technological Forecasting and Social Change* 65(2000): 125-148.

Perez, Y. and F.J. Ramos-Real. 2009. The public promotion of wind energy in Spain from the transaction costs perspective 1986–2007. *Renewable and Sustainable Energy Reviews* 13: 1058–1066.

Pineau, P.-O., A. Hira, and K. Froschauer. 2004. Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA. *Energy Policy* 32(2004): 1457-1475.

Rowlands, I.H. 2009. Renewable Electricity Politics Across Borders. In Selin, H., and VanDeever, S.D. (eds.). *Changing Climates in North American Politics: Institutions, Policymaking, and Multilevel Governance (American Comparative Environmental Policy)*. MIT Press.

Schott, J.J., and M. Fickling. 2010. Revising the NAFTA Agenda and Climate Change. *Peterson Institute for International Economics Policy Brief* Number PB10-19. Peter G. Peterson Institute for International Economics, Washington, DC.

Shuiying, Z., L. Chi, and Q. Liqiong. 2011. Solar Industry Development and Policy Support in China. *Energy Procedia* 5: 768-773.

State Energy Conservation Office. 2011. The Oil Embargo of 1973. Texas State Energy Conservation Office. Retrieved December 3, 2011, at http://www.seco.cpa.state.tx.us/seco_about-embargo.htm.

SustainableBusiness.com. 2005. China Passes Renewable Energy Law. Retrieved November 7, 2011, at http://www.sustainablebusiness.com/index.cfm/go/news.display/id/5679.

Traber, T., C. Kemfert, and J. Diekmann. 2011. German Electricity Prices: Only Modest Increase Due to Renewable Energy Expected. *German Institute for Economic Research Weekly Report* 6(7): 37-45.

UNFCCC. 2011a. Background on the UNFCCC: The International Response to Climate Change. United Nations Framework Convention on Climate Change. Retrieved December 3, 2011, at http://unfccc.int/essential_background/items/6031.php.

UNFCCC. 2011b. First Steps to a Safer Future: Introducing The United Nations Framework Convention on Climate Change. United Nations Framework

Convention on Climate Change. Retrieved December 3, 2011, at http://unfccc.int/essential_background/convention/items/6036.php.

UNFCCC. 2011c. Kyoto Protocol. United Nations Framework Convention on Climate Change. Retrieved December 3, 2011, at <http://unfccc.int/kyoto_protocol/items/2830.php.

UNFCCC. 2011d. Now, Up to, and Beyond 2012: The Bali Road Map. United Nations Framework Convention on Climate Change. Retrieved December 3, 2011, at http://unfccc.int/essential_background/bali_road_map/items/6072.php.

US EIA, Energy Information Administration. 2010. *2009 Renewable Energy Data Book.* US EIA: Washington, DC.

Wang, F., H. Yin, and S. Li. 2010. China's Renewable Energy Policy: Commitments and Challenges. *Energy Policy* 38: 1872-1878.

Weissman, S. 2011. Effective Renewable Energy Policy: Leave It to the States? Center for Latin American Studies University of California, Berkeley, 10.

Wilson, R. 2002. The Architecture of Power Markets. *Econometrics* 70(4): 1299-1340.

Wood, D. 2010. *Environment, Development and Growth: U.S.-Mexico Cooperation in Renewable Energies*. Woodrow Wilson International Center for Scholars Mexico Institute.

Appendix A.
List of People Interviewed for the Research Project

(in alphabetical order)

Florencio Aboytes (Ph.D.), Vice President, Power Transmission Planning, Comisión Federal de Electicidad, México

Ing. Manuel Alanís Sieres, Coordinator General, National Electric System, Comisión Federal de Electricidad, México

Lic. Luis Arias Osoyo, Director General, Dirección Genral de Generación, Conducción y Transformación de Energía Eléctrica, Secretary of Enerfy SENER, México

Lauren Azar, Senior Advisor to the Secretary, US Department of Energy, Washington, DC.

Bill Bojorquez (P.E.), Vice President Planning, Hunt Transmission Services, Austin, Texas

John C. Butler, Associate Director, Center for Energy Finance Education and Research, McCombs School of Business, University of Texas at Austin

Ing. Federico Carranza Almaguer, Director Gestión de Energía, Iberdrola México, S.A., de C.V., Pesquería, Nuevo León, México

Robert F. Cekuta, Deputy Assistant Secretary for Energy, Sanctions, and Commodities, Bureau of Economic, Energy, and Business Affairs, US Department of State, Washington, DC.

Mike Cleary, Chief Operating Officer, Electric Reliability Council of Texas, Inc., ERCOT, Taylor, Texas

Benjamín Contreras Astiazarán (Ph.D.), Director General, Dirección General de Estudios Económicos, Comisión Federal de Competencia, México

Gary J. Gibbs (P.E.), Manager of Governmental and Environment Affairs, Southwestern Electric Power Company, a unit of American Power Electric, Austin, Texas

Jeff DeGraffenried (Ph.D.), Environmental Program Officer, US Embassy Mexico, Mexico

John Dumas, Director, Wholesale Market Operations, Electric Reliability Council of Texas ERCOT, Taylor, Texas

Ing. Rubén F. Flores García, Comisionado, Energy Regulatory Commission, Comisión Reguladora de Energía CRE, México

Ing. Marco Antonio González Martínez, Asesor, Comisión Reguladora de Energía CRE, México

Ing. Nemorio González Medina, Gerente de Operación del Mercado, Comisión Federal de Electricidad, México

Charles (Chip) Groat (Ph.D.), Associate Director, Energy Institute, The University of Texas at Austin

Ali B. Haddou Ruiz, Secretario Ejecutivo, Comisión Federal de Competencia COFECO, México

Israel Hurtado, Comisionado, Energy Regulatory Commission, Comisión Reguladora de Energía, Mexico

Mtro. Fernando A. Kohrs Aldape, Director de la División de Planeación, Gestión de la Estrategia y Comercialización, Instituto de Investigaciones Eléctricas, México

Enrique Marroquin, Vice President, Hunt Transmission Services, L.L.C., Dallas, Texas

Matthew T. McManus, Deputy Director, Public Diplomacy and Policy Analysis, Bureau of Energy Resources, US Department of State, Washington, DC

Ing. Eduardo Meraz Ateca, Subdirector del CENACE, CFE, México

Richard P. O'Neill, Chief Economic Advisor, Federal Energy Regulatory Commission FERC, Washington, DC

Raymond L. Orbach (Ph.D.), Director, Cockrell Family Regents Chair in Engineering, Energy Institute, The University of Texas at Austin

Antonio Ortíz Mena, Head of Section Economic Affairs, Secretaría de Relaciones Exteriores, Embassy of Mexico, Washington, DC

José Luis Paz Vega, Minister/ Representative, Secretaría de Economía, Washington, DC

Dr. Alejandro Peraza García, Director General de Electricidad y Energías Renovables, Comisión Reguladora de Energía CRE, México

Ruth E. Reyna Caamaño (Ph.D.), Sustentabilidad y Energía, Secretaría de Desarrollo Sustentable, Gobierno de Nuevo León, Monterrey, México

Raúl Rodríguez, Benson Chair of Banking and Finance, HEB School of Business and Administration, University of the Incarnate Word (former Director NADBANK), San Antonio, Texas

Ing. Irazú I. Rodríguez Garza, Subgerente de Distribución (E.F.), Comisión Federal de Electricidad, CFE, Monterrey, NL, México

Prof. Juan Rosellón (Ph.D.), Profesor Investigador, División de Economía, Centro de Investigación y Docencia Económicas, A.C., CIDE, México

Ing. Jaime Luis Saldaña Méndez, Director General, Sistemas de Energía Internacional, S.A. de C.V., SEISA, Monterrey, NL, México

Juan Luis San José Alcalde, Director Energía Alfa, Garza García, NL, México

Paul Schulze, Director, Government Affairs, Hunt Transmission Services, L.L.C., Dallas, Texas

Ing. Pedro G. Sepúlveda Salinas, Corporate Development Vice President, Xignux, S.A. de C.V., Garza García, NL, México.

Ing. Victor M. Serdio Calderón, Director de Ingeniería, Cervecería Cuauhtémoc Moctezuma, Monterrey, NL, México

Soll Sussman, Program Specialist, Alternative Fuels, Border Energy Forum on Renewable Energy, Texas General Land Office, Austin, Texas

Prof. Sheridan Titman, McAllister Centennial Chair in Finance, Executive Director, Energy Management and Innovation Center, McCombs School of Business, The University of Texas at Austin

D. Rick Van Schoik, Director, North American Center for Transborder Studies, Arizona State University, Tempe, Arizona

Ing. Martín Maximino Vivar López, Sudirector del CENACE, Comisión Federal de Electricidad, CFE, México

Christopher E. Wilson, Program Asociate Mexico Institute, Woodrow Wilson International Center for Scholars