Promoting Renewable Energy Development and Deployment through International Cooperation:

Canada's Role in the 21st Century

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Abstract

The development and deployment of renewable energy technologies is increasingly recognized as a necessary action to tackle climate change, advance energy security, and to achieve a transition towards a low-carbon, sustainable economy and society. Despite that, the penetration and commercialization of renewable energy solutions has been hindered, particularly in developed countries, by the existence of market-related, economic, financial, institutional, regulatory, technical, social, cultural, behavioural, and other barriers. Dismantling those barriers will require an in-depth understanding of the challenges faced and the implementation of a variety of tools and mechanisms that are increasingly recognized by energy experts as effective in the facilitation of renewable energy deployment.

In the last decades, international cooperation has played an important role in helping low-income countries increase the penetration of renewable energy sources. Collaboration is key considering that it creates opportunities for transferring knowledge and environmentally sound technologies, for fostering local capacity, for accessing finance and funding to develop new projects, for ensuring that new technical and policy initiatives are informed by know-how accumulated in leading countries, and for guaranteeing that new renewable energy projects are of the highest quality. That said, the purpose of this report is to identify, based on an extensive literature review and interviews, cooperation mechanisms through which Ottawa can help promote the deployment of renewable energy solutions in developing countries where the penetration of these technologies in the electricity mix is low or non-existent. The research question are: 1)Why should Canada collaborate with developing countries to advance renewable energy as a climate change mitigation strategy?; 2)How can Canada help promote the

widespread deployment and commercialization of renewable energy technologies in low-income countries that rely on conventional energy sources; and 3)What must be the focus or targets, financing sources, and mechanisms to foster collaboration?

The report concludes that the Canadian government has an obligation to collaborate with developing countries in the implementation of climate mitigation and adaptation strategies mainly on the grounds that Canada is and has been one the top emitters of greenhouse gases (GHG). Secondly, it suggests that Canada could make a meaningful contribution by focusing its efforts and resources on helping beneficiary countries, through bilateral agreements, enhance local capacity building and improve their policy framework for renewable energy development. Lastly, it recommends that said assistance should be provided by offering training and certification at no cost either on RETScreen or on renewable energy system installation and maintenance for individuals who meet a number or conditions and, furthermore, by connecting local politicians and regulators with a select group of leading renewable energy policy experts from Canada. These and other initiatives could be funded with public money provided that fossil fuel subsidies are reduced or eliminated.

Subsequently, the report demonstrates that Canada's collaboration could help Latin American countries, such as Colombia, diversify their electricity portfolio, reduce GHG emissions, advance long-term energy security and sustainability, and provide economic opportunities for the country's most marginalized and vulnerable populations. Finally, it indicates that additional research is needed to identify countries that would be interested and that could benefit from entering into a long-term collaborative relationship with the Canadian government and, furthermore, to analyse alternative collaboration models and pathways.

Foreword

I began the Master in Environmental Studies (MES) program frustrated and deeply disappointed with Canada's environmental record and performance during the Harper era and, in particular, with the lack of action on climate change. In consequence, I decided to use this educational experience as an opportunity to study policies and strategies that governments can implement seeking to decarbonize the electricity sector, advance energy security and sustainability, and reduce the environmental and social impacts of energy production and use. As millions of other Canadians, I refuse to remain indifferent and to accept the status quo. As such, I am that the knowledge gained in the MES program will be a useful tool to rebuild Canada into the country that it was before 2006. A Canada that had an international reputation for its efforts to address climate change, advance environmental conservation and sustainability, protect human rights, and promote peace and social justice both locally and abroad and not for its commitment to become a climate criminal, a dirty-energy superpower, and a petro-state.

With the federal election around the corner, hundreds of scholars and researchers across the country are speaking out and making recommendations on specific actions and measures that could be adopted to start the necessary transition towards a sustainable, low-carbon economy and society. This report is meant to be a contribution to that ongoing discussion. It brings a new dimension into the conversation taking into account that it looks at the role that the Canadian federal government should play at the international level. Specifically, it identifies cooperation mechanisms through which Ottawa can help promote the implementation and deployment of renewable energy sources, as a climate change mitigation strategy, in low-income nations where the penetration of these technologies in the electricity mix is low or non-existent.

This research project was inspired by a field experience that took place in Mexico as part of the MES program. During the summer of 2014, I had the opportunity of working at the Electric Research Institute of Mexico and at the Institute of Renewable Energies of the National University Autonomous of Mexico in a research project that focused on analysing existing climate mitigation policies, legislation, and strategies within the Mexican electricity sector, the energy reform and its implications for the renewable energy industry, and the overall legal, regulatory, and institutional context for the penetration of renewable energy technologies. In this experience, I realized that Mexico is one of the few developing countries that is taking meaningful steps to reduce GHG and to become an international leader in renewable energy research, innovation, and development. This realization was a powerful source of motivation as it made me recognize that all countries can be part of the solution to climate change and that the lack of political commitment is the major barrier to address this issue.

Perhaps the most important lesson learned during this research project, during field work experience in Mexico, and during my time in the MES program is that governments, particularly in developed nations, have available a wide variety of resources, tools, and policies that they could use to foster renewable energy sources in their territories but also in other countries through international collaboration agreements. This lesson is key given that many nations lack the technological capacity, the resources (both financial and human), the know-how, the institutions, the infrastructure, and appropriate regulations and incentives that are necessary to effectively develop a renewable energy industry capable of competing with conventional power industries. Solving climate change, therefore, not only requires political commitment from all countries but also the establishment of renewable energy collaboration agreements and initiatives.

With that said, I conclude by reiterating that this report is linked to my Plan of Study and area of concentration due to the fact that the establishment of renewable collaboration agreements among counties is a political tool and strategy that has the potential to increase the penetration of renewable energy technologies, advance climate mitigation, and transition towards low-carbon, sustainable, reliable, and resilient societies. This research project is also a means to help me achieve a number of learning objectives. In particular, it helped me gain a general understanding of the impacts of climate change on the electricity sector and, specifically, on Colombia's energy security. In addition, it was a useful tool to develop a comprehensive understanding of the benefits associated with promoting renewable energy and to identify the most prevalent barriers that hinder the deployment of renewable energy technologies. Furthermore, it allowed me to realize that international cooperation could be used as a vehicle to foster energy sustainability. This research, finally, gave me the opportunity to learn different methods and principles with which to evaluate public policies in general, and renewable energy collaboration programmes and initiatives in particular.

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Abbreviations and Acronyms

3GF Global Green Growth Forum

APP Asia-Pacific Partnership on Clean Development and Climate

CanSEA Canadian Solar Industries Association

CanWEA Canadian Wind Energy Association

CCCDF Canada Climate Change Development Fund

CDM Clean Development Mechanism

CIDA Canadian International Development Agency

CEA Canadian Electricity Association

CEM Clean Energy Ministerial

CH_4 Methane

CO_2 Carbon dioxide

CTCN Climate Technology Centre and Network

EPA Environmental Protection Agency

EU European Union

FANZI Fund for the Electrification of Non-interconnected Zones

GGGI Global Green Growth Institute

GHG Greenhouse gases

GW Gigawatt

ICEL Colombian Energy Institute

IDBs International Development Banks

IEA International Energy Agency

IGOs Inter-governmental Organizations

IMF International Monetary Fund

IPCC International Panel on Climate Change

IRENA International Renewable Energy Agency

ISA Interconexión Eléctrica SA

kW Kilowatt

kWh Kilowatt-hour

MES Masters in Environmental Studies

$MtCO_{2e}$ Metric Ton of Carbon Dioxide Equivalent

MW Megawatt

N_2O Nitrous Oxide

NASA U.S. National Aeronautics and Space Administration

NES National Electricity System

NGOs Non-Governmental Organizations

OECD Organisation for Economic Cooperation and Development

OPEC Organization of Petroleum Exporting Countries

REEEP Renewable Energy and Energy Efficiency Partnership

REN21 Renewable Energy Policy Network for the 21st Century

REPEG Renewable Energy Policy Expert Group

SE4ALL Sustainable Energy for All Initiative

TEAM Technology Early Action Measures

UN United Nations

UNEP United Nations Environment Programme

UNFCCC United Nations Framework Convention on Climate Change

UPME Mining and Energy Planning Unit

Introduction

Context

During the last few months, over 60 Canadian scholars from every province worked collectively, under the umbrella of Sustainable Canada Dialogues, in the development of a climate change mitigation plan for Canada in preparation for both the upcoming Federal election and the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) that will be held in Paris in December of 2015.[1] Their plan identifies 10 feasible and pragmatic core actions and policy recommendations that could be implemented immediately to begin the necessary transition towards a low carbon and sustainable economy and society. The proposal rests on (1) putting a price on carbon, (2) eliminating subsidies to the fossil fuel industry, (3) committing to generate 100% of the country's electricity from renewable energy

[1] http://www.sustainablecanadadialogues.ca/en/scd

sources by 2035 (4) electrifying transport, and (5) evolving urban design since cities and transportation concentrate the largest component of energy consumption and greenhouse gas (GHG) emissions.

The importance of this initiative cannot be overstated. Today it is clearer than ever, as the United Nations General Secretary Ban-Ki-moon (September 23, 2014) recently emphasized, that all countries in the world must develop strategies, collaboratively and decisively, aimed at reducing GHG emissions so that a global temperature increase of more than 2°C can be avoided by the end of this century. Under the Harper administration, however, Canada has lacked interest and ambition to act on climate change, to implement national policies designed to decarbonize the economy, and to honour the country's international obligations under the Kyoto Protocol. As a matter of fact, the federal government has become a vocal advocate and ally of the oil and gas industry and a prosecutor of individuals, groups, or any organization that criticize and stand against the expansion of the tar sands and associated infrastructure. In that perspective, in the next federal election Canadians have the opportunity to change the direction in which the country is heading by electing a political party committed to advancing climate mitigation and adaptation efforts, for example by implementing the recommendations outlined in the Sustainable Canada Dialogues report, and rebuilding the country's reputation as a global leader in environmental protection.

Research Scope

This research project will attempt to complement the analysis of those 60-plus Canadian scholars of Sustainable Canada Dialogues. Whereas their intention was to identify a possible pathway to a low carbon economy in Canada, the main purpose of this report is to provide an

accessible policy synthesis that the next federal government could use to assist developing countries reduce their GHG emissions. Specifically, it will identify cooperation mechanisms through which Ottawa can help promote the implementation and deployment of renewable energy sources in low-income nations where the penetration of these technologies in the electricity mix is low or non-existent. In that sense, the questions that will guide this research are: 1) Why should Canada collaborate with developing countries to advance renewable energy as a climate change mitigation strategy?; 2) How can Canada help promote the widespread deployment and commercialization of renewable energy technologies in low-income countries that rely on conventional (e.g. fossil fuels, nuclear, large hydro, etc.) energy sources; and 3) What must be the focus or targets, financing sources, and mechanisms to provide said collaboration?

The decision to focus on renewables was based on the fact, as the International Energy Agency (IEA) (2013) points out, that the electricity sector is responsible for a large portion of global GHG emissions. During the last few decades, these emissions have rapidly increased, in fact they almost doubled from 1990 to 2012, as a result of population growth, economic development, and heavy reliance on fossil fuel generation, particularly in developing countries (IEA, 2013). For that reason, increasing the penetration of renewable energy, which is energy that is derived from resources that are naturally replenished on a human time scale (e.g. solar, wind, geothermal, biomass, biogas, hydropower, and ocean power), is an appropriate climate mitigation strategy and an immediate priority given that they have a smaller carbon footprint and lower environmental impacts than conventional technologies (Ellabban, Abu-Rub, & Blaabjerg, 2014). Furthermore, as discussed in Chapter 2, these sources of power offer numerous environmental, economic, social, and political benefits.

Despite the advantages, there are several barriers, which will be explored in Chapter 3, that hinder the diffusion of renewable energy. Some of the barriers may be specific to a technology, while some may be specific to a country or a region. For that reason, this report focuses on investigating how Canada could help Colombia, a developing country that is highly vulnerable to the impacts of climate change and where the participation of renewables (except large-hydro) in the electricity mix is extremely low, overcome the challenges and obstacles that these technologies face. Over the decades, Canada and Colombia have developed a rich history of cooperation on several issues, friendly diplomatic relations, and strong economic, political, and cultural ties. The establishment of a programme of collaboration among the two countries on renewable energy would help the South American nation diversify its electricity portfolio, reduce GHG emissions, advance long-term energy security and sustainability, and provide economic opportunities for some of its most isolated, marginalized, and vulnerable populations. At the same time, it would help Canada rebuild its reputation as a leader in environmental protection.

Methodology

This report was the result of an extensive and comprehensive review of both academic/ peer-reviewed and non-academic literature. The research process was enriched with the 4participation of Dr. Camilo Táutiva and Dr. Henry J. Zapata-Lesmes. Both Dr. Táutiva and Dr. Zapata-Lesmes specialize in renewable energy grid integration and distributed generation and work at the Mining and Energy Planning Unit (UPME) of Colombia's Ministry of Mines and Energy in the Non-Conventional Energy Division. Through phone interviews conducted on March 30, 2015 and April 13, 2015, they provided valuable insights in regards to the barriers that renewable energy technologies face to transcend in the Colombian electricity market. Similarly, they identified key areas and aspects in which international cooperation would be

useful. Finally, they shared their opinions and recommendations about the approach that the Canadian federal government should take if it decides to offer its assistance and collaboration to Colombia or any other developing country interested in promoting renewable energy development and deployment.

Theoretical Framework

Cross-boundary cooperation on renewable energy development has existed for decades. In 1981, as Kozloff (1995) indicates, it was first recognized as an international priority at the United Nations Nairobi Conference on New and Renewable Sources of Energy. Some mechanisms have been more successful than others in helping countries overcome renewable energy barriers and increase the penetration of these technologies in the electricity market. The key to success, as Pansera (2012) argues, is to ensure that the cooperation is conducted in good faith, guided by the principles of honesty, respect, and inclusiveness, and designed to be a *win-win* effort. This means that all participants should be able to obtain tangible benefits from engagement.

It must be recognized that international cooperation mechanisms on renewable energy are, in essence, a type of policy instrument that governments may pursue as a means to advance climate mitigation, energy access, short and long term energy security, economic development, and/or any of the other benefits that these technologies provide. Therefore, in addition to the principles and parameters mentioned above, these initiatives ought to meet the following criteria in order to increase their chances of success: effectiveness, efficiency, fairness, feasibility, replicability, sustainability, and transparency (Gibson, 2006; International Renewable Energy Agency [IRENA], 2012; Pal, 2005; Winfield, 2009).

Effectiveness:

The effectiveness of a program or activity of collaboration between countries refers to the extent to which the intended goals of the initiative are achieved. Measurable indicators of effectiveness are, for instance, the share of renewable energy in the electricity generation mix within a specified time period, the amount of GHG emissions avoided, or the number of jobs created in the renewable energy sector. Arguably, however, a collaboration could be deemed effective if it helps develop local potential instead of simply importing external knowledge and technology, if it supports local institutions in fostering local capability, if it enhances the market conditions and policy framework, and/or if it promotes research, networking, and local and foreign investments.

Efficiency:

In a context of financial and budgetary constraints, it is imperative to ensure that the goals of a renewable energy cooperation program are met at the lowest possible costs to participants and to society as a whole. In that sense, the ministries or agencies that are responsible for planning, implementing, delivering, and evaluating the program or activity must consider and prioritize the most cost-effective approaches and strategies. Common, measurable indicators of efficiency are, for instance, costs per kilowatt (kW) or megawatt (MW) of renewable electricity installed, costs per metric ton of carbon dioxide equivalent ($MtCO_{2e}$) avoided, and/or costs per job created in the renewable energy industry as a result of the cooperation. Under some circumstances, however, it is difficult to determine the efficiency or cost-effectiveness of collaboration programs and initiatives. This is particularly true in cases where the outcomes and/or benefits obtained (e.g. development of local capacity and know-how, improvement of

market conditions and policy frameworks, gains in energy security, etc.) are difficult to measure or quantify.

Fairness:

In the process of negotiating and framing a collaboration, alternatives and strategies that guarantee a fair distribution of costs and benefits must be prioritized. This is an important issue considering that some participants or stakeholders may result marginalized and/or be more vulnerable to face high costs while enjoying little benefits. In that sense, cooperation mechanisms that disproportionately affect a participant or a particular sector of society should be deemed inequitable and, therefore, must either be redefined or avoided. This is the case, for instance, of collaborations in which a donor country provides financial resources to another nation for political interests, such as opening new markets for their products or achieving a privileged access to natural resources (e. g. minerals, oil, etc.), rather than for altruistic reasons or for a commitment to advance solutions to a given issue or challenge.

Feasibility:

Renewable energy cooperation programs and activities must be feasible, possible to complete within a determined period of time, and easy to implement and administer. This requires, amongst other things, to define a clear vision, objectives and targets, provide well-defined guidelines and responsibilities, and guarantee the existence of supporting infrastructure and institutions for the development, execution, and evaluation of the collaboration. In consequence, the feasibility of a given cooperation initiative is assessed qualitatively.

Replicability:

Given that many developing countries would benefit from the implementation and engagement in renewable energy cooperation programs and activities, it is imperative to design them in a way that can be easily and massively replicated. For that purpose, initiatives must strive to be flexible, adaptable, and potentially expandable. Information, in addition, ought to be made available, accessible and understandable. At the same time, it is important to take into account that in order to replicate a successful renewable energy program it is absolutely necessary to tailor it to the specific needs of participants and to a different circumstances as some factors that led to the success in one context may not be present in another.

Sustainability:

Renewable energy collaborations must, above all, help humanity advance social and environmental sustainability. The concept of sustainability has been subjected to different interpretations. However, all interpretations suggest, either directly or indirectly, that achieving a sustainable world requires humanity to figure out how to guarantee decent livelihoods for all people without destroying the planet. In that sense, as Gibson (2006) indicates, ideal initiatives would promote the integrity of the socio-ecological system, livelihood sufficiency and opportunities for all individuals, intragenerational and intergenerational equity, resource maintenance and efficiency, socio-ecological civility and democratic governance, precaution and adaptation, as well as immediate and long term integration of social, economic, and ecological imperatives in the context of community development.

Transparency:

Lastly, it is important to point out that successful international cooperation initiatives always have mechanisms designed to guarantee transparency and accountability. This means, in practical terms, that the operation and administration of those programs is always open to scrutiny, verification and ready to provide information about financial status, performance, objectives accomplished, etc. (in a timely, easy-to-understand, and honest manner). It also means that individuals and/or agencies that are entrusted to deliver and administer the program are responsible to the general public and, furthermore, that they must be prepared to explain, clarify, and justify their actions and decisions.

Report Organization

This report is organized in eight different but complementary sections. In Chapter 1, the main purpose is to explore how accelerating the deployment of renewable energy technologies is an urgent priority in order to avoid catastrophic climate change and to advance energy security and reliability. In Chapter 2, I identify and discuss all the benefits and advantages that renewable energy can provide to individuals, communities, cities, and/or countries that adopt them. In Chapter 3, a wide variety of barriers that undermine and impede the widespread implementation of renewable energy solutions are examined. In Chapter 4, I discuss the importance of international cooperation as a strategy to overcome those obstacles. Subsequently, I will review and assess some of the mechanisms, models, and methods that are commonly used to facilitate assistance on renewable energy matters. In Chapter 5, I address the question of why developed countries, specifically Canada, should promote renewable energy collaboration activities with countries where the penetration of these technologies in the electricity mix is low or non-

existent. Similarly, I examine the ways in which Canada could benefit from engaging in those activities. In Chapter 6, the objective is to identify the most appropriate mechanism(s) through which the Canadian federal government, in a post-Harper era, can collaborate with low-income countries seeking to increase the penetration of renewables in the electricity mix. In Chapter 7, I argue that the renewable energy sector in Colombia could a see a substantial growth if this South American nation establishes a long-term collaboration relationship with Canada. In the last Chapter, the Conclusion, the findings of the research questions are summarized and opportunities for further research are identified.

Chapter 1

The Electricity Sector and Climate Change

In September 2013, in its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concluded that the warming of the climate system is unequivocal and unprecedented (IPCC, 2013). It indicated, furthermore, that this phenomenon is a direct result of anthropogenic emissions of greenhouse gases (GHG), particularly carbon dioxide (CO_2), which is associated with deforestation and with the burning of fossil fuels to obtain energy for transportation, manufacturing, electricity generation, heating and cooling, amongst other purposes (IPCC, 2013).

According to the International Energy Agency (IEA, 2013), the electricity and heat generation sectors accounted for 42 percent of global CO_2 emissions in 2012. The United Nations Environment Programme (UNEP, 2012) estimates that the power sector contributes 29 percent of total GHG emissions. In Canada, the generation of electricity is responsible for 12

percent of the country's GHG emissions (Government of Canada, 2013a), which is below the global average due fact that the Canadian electricity mix is dominated (60 percent) by hydroelectricity (Canadian Electricity Association [CEA], 2006). In the United States, in contrast, the electricity sector is the largest source of GHG emissions, accounting for about 32 percent of the total, as electricity demand has grown and fossil fuels have remained the dominant source of generation (Environmental Protection Agency [EPA], 2014). It is also the single largest source of sulfur dioxide (SO_2), oxides of nitrogen (NO_X), mercury, and other toxic substances (Chandramowli & Felder, 2014). As for other regions and countries, GHG emissions from the electricity sector have rapidly increased in the last years, particularly in the developing world, as a result of population growth, economic development, and heavy reliance on coal, oil, and/or natural gas fired generation (IEA, 2013).

Climate Change Impacts

The impacts of climate change are already being felt around the world. In recent decades, virtually every region and country has witnessed unprecedented increases in average temperatures, abrupt changes in precipitation levels and seasonal patterns, multiple impacts on species and habitats, changes to hydrological cycles, ocean acidification, rise in sea levels, loss of glaciers and ice sheets, and an onslaught of extreme weather events (IPCC, 2014a). Under a business-as-usual scenario, there is no doubt that extreme weather events such as hurricanes, storms, floods, forest fires, and droughts will become more frequent, intense, and costly (Luber & McGeehin, 2008; Sena, Covalan, & Ebi, 2014). At the same time, it is reasonable to expect that marginalized communities and those individuals facing poverty or extreme poverty (mostly women) conditions will continue to be disproportionately affected by natural disasters associated to climate change since they have the least amount of resources with which to adapt and they are

the ones living in substandard housing or/and in areas of high risk, including mountain slopes, cliffs, river banks, amongst others (Jones & Hermias, 2015; Leichenko & Silva, 2014). Indigenous populations are also in a vulnerable position due to the fact that their livelihoods generally depend on hunting, gathering, or agricultural activities and, furthermore, that they have strong spiritual and cultural ties to their land and natural environment (Ford, 2012; Ford, Berrang-Ford, King, & Furgal, 2010). Climate change, in short, will exacerbate many current climate risks and impose new challenges, with significant implications for communities, low-income people, women, industry, infrastructure, and ecosystems.

Climate Change Impacts on the Electricity Sector

The electricity sector is particularly vulnerable to the impacts of climate change. This phenomenon affects and will continue to affect electricity markets through both demand and supply. With regards to the latter, there are many factors threatening energy security and reliability. Arguably, the most serious challenge is that the world's electricity production is based primarily on fossil fuels. According to the IEA (2014b), coal-fired plants currently fuel 40.4 percent of global electricity while oil accounts for 5 percent, natural gas for 22.5 percent, nuclear for 10.9 percent, hydro for 16.2 percent, and other sources (including geothermal, solar, wind, heat, etc.) for the remaining 5 percent. The high reliance on fossil fuels, which together generate 67.9 percent of the world's electricity, is dangerous and problematic due to the fact that the use of these resources must be progressively reduced, and eventually eliminated, if humanity is to avoid catastrophic global warming (IPCC, 2014b). As a result, it is important to recognize that failing to promote alternative, non-emitting generation technologies will either accelerate and exacerbate climate change or make the world face an unprecedented energy crisis.

Mideska and Kallbekken (2010) argue, in addition, that that the ability of governments and utility companies to meet society's need for electricity in a reliable and cost-effective manner could be seriously compromised as the production of electric power is dependent on climate variables such as temperature, precipitation, cloudiness, wind speed, wind direction, extreme weather events, etc. In this perspective, numerous studies demonstrate that an increase in temperature is likely to affect the generation cycle efficiency and cooling water requirements of thermal power plants (i.e. coal, natural gas, nuclear, geothermal, and biomass residues power stations) (Chandramowli & Felder, 2014; Schaeffer et al., 2012; Van Vliet et al., 2012). Changes in temperature and precipitation patterns, by the same token, have the potential to affect hydropower production and jeopardize energy security by changing water levels and flows, increasing evaporation, and adding a significant amount of uncertainty to the operation of hydropower systems (Mideksa & Kallbekken, 2010). Finally, it is important to take into account that hydroelectric dams, nuclear reactors, wind turbines, fossil fuel-fired power plants, and other generation assets will likely be exposed to more frequent and violent extreme weather events, which may cause serious damage to the infrastructure as well as environmental and health hazards (e.g. nuclear fallout) (Zamuda et al., 2013).

The intensification of extreme weather events could also affect the transmission and distribution of electrical energy. As Schaeffer et al. point out (2012), weather phenomena that may cause damage to the transmission and distribution systems include "extreme wind and ice loads, combined wind-on-ice loads, lightening strikes, forest fires, conductor vibrations and galloping, avalanches, landslides, and flooding." (p. 7). Warmer temperatures, in addition, could reduce equipment lifetime, decrease power carrying capacity, and cause outages due to power line sagging (Sathaye et al., 2013). Thus, due to the fact that most electricity is generated in

large facilities (which are often located in peripheral or rural areas) and must be transported over long distances to reach the point of consumption, it is evident that urban centres are at a higher risk of being affected by power outages due to grid failure or disruptions (Umberger, 2012-2013).

Most cities, as a matter of fact, have experienced at some point or another instances of blackouts that have lasted days, weeks, or even months. Those episodes demonstrate that the power grid is susceptible to many factors and, perhaps most importantly, that contemporary societies simply cannot function without electricity. Irrefutably, electric power is an essential service since it is needed to run every single sector of the economy, meet people's basic needs for food, healthcare, education, employment, provide comfort and entertainment, and allow the development and deployment of modern communication and transportation technologies (Kimmelman, 2011). In addition, it is important to remember that power failures not only disrupt all those services and activities, but that they also put the elderly, the urban poor, children, persons in palliative care or with chronic health conditions, and other vulnerable populations at higher risk (O'Neill et al., 2009).

The impacts of climate change on the electricity sector are not restricted to the supply side. In relation to the demand side, there is a high degree of certainty, for instance, that warmer temperatures will increase electricity consumption for cooling in the summer and decrease electricity as well as natural gas, heating oil, and wood demand for heating in the winter (Jaglom et al, 2014; Klein, Olonscheck, Walther, & Kropp, 2013; Pillo-Sihva, Aatola, Ollikainen, & Tuomenvirta, 2010). Under that scenario, there would be an increased usage of air conditioners, particularly during heat waves. This would result in a higher peak demand, for which it may be necessary to build new generation, transmission, and distribution infrastructure (Miller, Hayhoe,

Jin & Auffhammer, 2008). The peak demand would further increase when taking into account population and income growth. It is important to recognize, however, that the impacts of climate change on electricity consumption could vary depending on each country's geographical location and the role of electricity in heating and cooling (Pillo-Sihva et al., 2010).

The Need for an Energy Transition (or Revolution)

Immediate actions must be taken to respond to the challenges raised by climate change, avoid catastrophic global warming, and guarantee long-term energy security. Achieving these objectives requires all countries to transition towards clean, low-carbon, reliable, resilient, affordable, and sustainable energy systems (Myhrvold & Caldeira, 2012; Salomon & Krishna, 2011). This task entails, more specifically, the use of instruments and incentives designed to reduce or eliminate GHG emissions and the unhealthy dependency on fossil fuels by increasing the deployment of renewable energy technologies, accelerating the uptake of energy efficiency, and promoting a culture of energy conservation (Chu & Majumdar, 2012; Droege, 2008).

The transformation of the electricity sector has already started in many parts of the world. By early 2014, over 140 countries from all continents, more than half of them developing countries, had renewable energy targets and policies in place at the national or state/provincial level (Renewable Energy Policy Network for the 21st Century [REN21], 2014). In these places, governments continue to develop and implement a mix of regulatory instruments, fiscal incentives, and public financing mechanisms (e. g. feed-in tariff programs, renewable portfolio standards, net metering schemes, tax reductions or exemptions, grants, low-interest loans, and public competitive bidding/tendering systems) as means to promote increased renewable energy capacity and generation (REN21, 2014). The use of these instruments, policies, and mechanisms

has led, according to the International Renewable Energy Agency (IRENA), to rapidly growing investments in renewables, beyond the traditional hydropower sector, to significant cost reductions of non-conventional renewable energy technologies, as well as to greater economic prosperity (Gielen et al., 2014).

In spite of those achievements, it is important to recognize that transitioning towards renewables is not an easy task. As discussed in Chapter 3, the growth of the renewable energy sector is being undermined by a number of regulatory, financial, economic, institutional, technical, and/or social barriers. One of the most common and challenging barriers is that the majority of countries are stuck with energy technologies and infrastructure (e. g. fossil-fuel power plants, nuclear reactors, etc) built in the past but that influence the decisions of the present by making it easier for governments to perpetuate the status quo than to explore and pursue alternative pathways (Bridge, Bouzarovski, Bradshaw, & Eyre, 2013; Pegels, 2010). Due to climate change, however, governments must find the courage and the vision to overcome path-dependency and, most importantly, make decisions that benefit society as a whole rather than the interests of the fossil fuel or nuclear industries. The bottom line is that without strong political will, commitment and leadership, the renewable energy transition, or revolution, as well as the battle against climate change, are destined to fail.

Chapter 2

The Value of Renewable Energy

The electricity sector, as discussed in Chapter 1, is one of the major contributors to climate change, accounting for 26 percent of the world's greenhouse gas (GHG) emissions. For this reason, climate scientists are calling on governments and the international community to take immediate and meaningful actions to decarbonize the global economy and shift to renewable power generation in order to avoid catastrophic climate change (Intergovernmental Panel on Climate Change [IPCC], 2011; Meinshausen et al., 2009). Even the International Energy Agency (IEA), a conservative think tank founded by the largest industrial countries "to ensure reliable, affordable and clean energy for its 29 member countries and beyond" (IEA, 2015), is an active advocate of renewable energy technologies and recognizes that over two-thirds of today's proven reserves of fossil fuels need to still be in the ground in 2050 so that dangerous and irreversible changes to the climate system can be prevented (IEA, 2012). The IEA also estimates that around

150 gigawatts (GW) of renewable energy generation capacity would have to be installed every year from now until 2050 in order to satisfy the world's electricity needs without exacerbating climate change and its impacts (IEA, 2010). Currently, the world installs 95 GW of renewable energy generation capacity per year (Renewable Energy Policy Network for the 21st Century [REN21], 2015).

The adoption of renewable energy technologies has proven to be an effective climate change mitigation strategy because they minimize or, in some cases, even prevent the burning of fossil fuels. Instead, they generate electricity from natural regenerating resources such as the sun, wind, water (streams and oceans), biomass, and Earth's internal heat or by using municipal solid waste, animal manure, waste heat, and other residues (IPCC, 2011). As a result, renewable energy technologies are cleaner than other technologies, particularly those run by fossil fuels. This claim is supported by evidence from various studies that compare life-cycle GHG emissions for all energy sources (e.g. Hertwich et al., 2013; Ou, Xiaoyu, & Zhang, 2011; Weisser, 2007). In a recent study, the International Renewable Energy Agency (IRENA) demonstrates that solar, wind, hydroelectric, and geothermal are, across their lifetime, 10 to 120 times less emitting than natural gas, the cleanest fossil fuel, and up to 250 times lower than coal, which is the dirtiest (Gielen et al., 2014). Furthermore, the GHG emissions associated to renewables do not occur during the generation of electricity per se, but rather, during the manufacturing of the equipment, transportation to the site of installation, and decommissioning (Weisser, 2007).

In view of the evidence, it is clear that a serious mitigation strategy ought and needs to incorporate policies designed to promote renewable energy penetration. Furthermore, according to Etcheverry (2011), it must provide additional benefits to ensure that it receives sustained

political attention and strong political support. Taking that into account, in this chapter I will identify and discuss the main benefits that renewable energy can provide.

Renewable Energy Benefits

Environmental Protection

Under the business-as-usual scenario, the impacts of the electricity sector on the environment are profound due to the excessive reliance on fossil fuels, nuclear, and large-hydroelectric generation.

The environmental impacts associated to fossil fuels are particularly important to consider because, as indicated in Chapter 1, about 68 percent of the world's electric power is generated through the combustion of petroleum, coal, and natural gas. In addition to contributing to climate change, fossil fuels are responsible for other forms of environmental degradation throughout their life-cycle. Some of the impacts include ecosystem and habitat destruction during the extraction phase (Finkelman & Stracher, 2011); soil and water contamination as a result of spills or leaks during both extraction and transportation activities (Vallero & Letcher, 2013); and acid rain and air pollution resulting from the emission of sulfur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons, and other particles and toxic metals (e.g. beryllium, arsenic, cadmium, and lead) during combustion (Nicoletti, Arcuri, Nicoletti, Bruno, 2015).

Nuclear power plants can provide energy without the air pollutants and GHG emissions produced by fossil fuels. For this reason, several voices, including the IPCC (2013), advocate for expanding this technology in order to advance and strengthen climate change mitigation efforts (Van der Zwaan, 2013). In spite of the urgency of implementing measures intended to reduce GHG emissions, building nuclear power stations to replace fossil fuel generation would have

negative, long-term environmental impacts. The largest and currently unresolved environmental problem with this technology, which accounts for roughly 11percent of global electricity generation, concerns nuclear waste. Each stage of the nuclear energy production process generates large amounts of highly radioactive, uniquely difficult-to-manage waste that will require care and management over hundreds of thousands of years, imposing costs and risks arising from current energy consumption onto future generations (Winfield, Jamison, Wong, & Czajkowski, 2006). The nuclear cycle also has severe impacts on surface water and groundwater quality due to leaks and releases of a range of radioactive and hazardous pollutants (Winfield et al., 2006). Finally, after the nuclear accidents of Three Mile Island (USA, 1979), Chernobyl (Ukraine, 1986), and Fukushima (Japan, 2011), which are some of the biggest environmental disasters in recent history, it is evident that nuclear-fired plants are a risky source of power.

Hydroelectric plants also provide energy without the air pollutants and GHG emissions produced by fossil fuels. In spite of that, there are serious environmental concerns with respect to the construction and operation of large hydro facilities, which are those projects with a capacity of 25 megawatts (MW) or higher. It has been recognized, for instance, that hydroelectric dams do release GHG emissions in the form of carbon dioxide (CO_2) from decay of above-water portion of trees that are left standing in the reservoir as well as methane (CH_4), a GHG that is34 times more powerful than CO_2 in its global warming potential (Shindel et al., 2009), from soft vegetation that decays under anaerobic conditions on the bottom of the reservoir (Fearnside, 2005). It is also feared that hydroelectric dams may release nitrous oxide (N_2O), another powerful GHG that is 300 times more powerful than CO_2 in its global warming potential (Guérin, Abril, Tremblay, & Delmas, 2008). These projects, in addition, can significantly affect natural river systems as well as fish and wildlife populations by altering the flow of rivers,

flooding land that may once have served as wildlife habitat or farmland, imposing barriers and killing migrating aquatic animals, changing water temperature and chemical composition, causing erosion of the riverbed upstream and downstream, among other environmental stresses (Premalatha, Abbasi, Abbasi, & Abbasi, 2014; Qiu, 2012; Ziv, Baran, Nam, Rodriguez-Iturbe, & Levin, 2012). Lastly, it must be recognized that the construction of hydroelectric dams causes great trauma and adversely affects those who are forced to leave their homes and lands (Ortolano & Cushing, 2010). The number of people displaced due to hydroelectric facilities runs to several millions in countries like China, Brazil, and India (Fearnside, 2012; Grumbine & Pandit, 2013; Qiu, 2012).

This short discussion demonstrates that the world's main sources of electricity are neither clean nor sustainable. For this reason, renewable energy is an interesting proposition. Technologies that harness renewable resources to generate power, excluding large hydro, are widely recognized as clean sources of energy because they minimize environmental burdens, reduce GHG emissions and air pollution, produce minimum secondary waste, and are sustainable based on current and future economic and social needs (Panwar, Kaushik, and Kothari 2011). The adoption of these technologies, as a matter of fact, is becoming more politically acceptable globally, especially in developed countries as communities and societies are recognizing the environmental externalities of conventional generation technologies and increasingly supporting sustainable production methods that minimize GHG emissions, pollution, waste, wildlife mortality and habitat destruction, and other environmental impacts and risks (Sims, 2003).

Public Health

The adoption of renewable energy technologies also offers opportunities to improve public health. In this regard, it must be indicated that combustion of fossil fuels for electricity generation and other purposes adversely affects human health as it releases high volumes of pollutants , including sulfur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons, and other particles and toxic metals such as beryllium, arsenic, cadmium, and lead (Nicoletti, Arcuri, Nicoletti, Bruno, 2015). These emissions are responsible for acid rain formation and air pollution, which is linked to respiratory diseases (e.g. asthma, pneumonia, bronchitis, lung cancer, etc.), cardiovascular, nervous, urinary, and digestive illnesses, premature mortality, and reduced life expectancy (Kampa & Castanas, 2008; Mabahwi, Leh, & Omar, 2014).

The burning of fossil fuels also releases significant quantities of CO_2, aggravating climate change. This phenomenon may affect health as a result of, for instance, increased frequency and intensity of heat waves, rising sea levels, changes in precipitation and availability of water, higher incidence of extreme weather events, changes in the distribution of vector-borne diseases (e. g. malaria, dengue, yellow fever, etc.), and food scarcity (Haines & Patz, 2004). The health effects associated with climate change are likely to disproportionately affect low-income countries as well as marginalized populations in middle and high-income countries (Haines, Kovats, Campbell-Lendrum, & Corvalan, 2006). Therefore, the implementation of renewable energy systems in those places, along other mitigation actions , should reduce climate risks and vulnerability, enhance adaptive capacity, and improve health both in the short and the long term.

Intergenerational and Interspecies Justice

In addition to environmental and health benefits, renewable energy technologies provide sustainable, long-term energy solutions because they depend on resources that are constantly replenished. Fossil fuel and nuclear-powered generation technologies, in contrast, cannot offer those advantages to society due to the fact that petroleum, coal, natural gas, and uranium are scarce and exhaustible resources. As a result, it is fair to claim that the implementation of energy systems that encourage energy efficiency and rely less on carbon and more on renewable energy sources is an important step towards ensuring the conservation of valuable non-renewable resources and, furthermore, giving future generations the opportunity to access modern energy services (Karlsson-Vinkhuyzen, Jollands, & Staudt, 2012). It is also an important step towards protecting and promoting future environmental integrity as well as the right of human and non-human beings to exist and thrive.

Energy Security

In the face of climate change and resource scarcity, energy security is one of the greatest challenges of the 21st century. Fortunately, renewable energy can offer a reliable, long-term energy supply for developed and developing nations taking into account that these resources are non exhaustible over time, if properly managed, and much more geographically spread, in contrast to fossil fuels. This provides all countries an opportunity to harness and develop the resources that are locally available and, through the appropriate policies, to become energy independent (Valentine, 2011). Achieving energy sovereignty is a significant gain, particularly for poorer nations. This would, according to Escribano-Frances, Marin-Quemada, and Gonzales (2013), diminish or even eliminate their dependency on energy imports and minimize the

economic risks associated with the price volatility of fossil fuels. Nonetheless, it would also benefit rich countries and the world in general as reducing reliance on scarcer fossil fuels would also reduce competition, geopolitical tensions, and wars over access and control of these resources (Karlsson-Vinkhuyzen et al., 2012). In this manner, renewable energy could play a significant role in contributing towards world peace and harmony.

Resilient Energy Systems

Climate change, as discussed in Chapter 1, threatens electricity production and supply in most countries due to variations in temperature and precipitation patterns, availability of energy resources, and the potential impacts of more frequent and intense extreme weather events. Under this scenario, policymakers and utility companies need to find ways in which to make electricity systems more resilient and reliable so that societies can continue to enjoy an uninterrupted power supply. This task entails, according to Rifkin (2013), to transition from the current model, one that is highly centralized and largely based on the combustion of fossil fuels, towards a decentralized system in which energy is produced from clean sources and close to the point of its consumption. In that sense, renewable energy technologies, such as rooftop solar panels and small wind turbines, are a suitable alternatives since these allow individual households and businesses to generate electricity to meet their own demands with a low environmental footprint (Umberber, 2012-2013). Therefore, the implementation of distributed renewable energy generation systems is a climate change mitigation strategy, since it reduces GHG emissions, but also an adaptation measure because it results in a more efficient, reliable, and secure source of energy.

Employment Creation

One of the most desirable social and political co-benefits of developing renewable energy sources as a climate change mitigation strategy is employment creation. In this respect, Demerse (2011) argues that the renewable energy sector contributes to the development of a strong green economy by creating five times more employment for every dollar invested, MW installed, or kilowatt-hour (kWh) generated than conventional sources of energy. Germany provides one of the strongest empirical evidence of the connection between renewable energy and jobs. The latest figures indicate that in 2013 the country had 371,000 direct and indirect jobs attached to the sector (O'Sullivan et al., 2014). In Canada, similarly, according to recently published report by Clean Energy Canada (2014), about US$25 billion has been invested in the clean energy sector in the past five years. Today, there are over 23,700 people who work in the sector, outnumbering the 22,340 whose work relates to the oil sands. Globally, in 2013 the renewable energy sector reached US$214 billion of annual investment, which represents an impressive economic gain from the US$150 billion invested in 2009 (McCrone, Usher, Sonntag-O'Brien, Moslener, & Gruning, 2009). The IRENA estimates that renewable energy direct and indirect jobs reached 6.5 million worldwide in 2013 and that China, Brazil, the United States, India, Germany, Spain, and Bangladesh are the countries where most of these jobs are located (Ferroukhi, Khalid, Lopez-Peña, & Renner, 2014).

Access to Energy

According to the IEA (2014b), nearly 1.3 billion people are without access to electricity worldwide. Most of them live in rural and remote areas of developing countries in Africa and Asia, 3 percent live in Latin America and the Middle East, and less than 1 percent in isolated

and/or marginalized areas of transition economies and Organisation for Economic Cooperation and Development (OECD) countries. Taking action on this matter must be a priority for governments because electricity is an essential service that improves the quality of life of populations, generates economic activity and prosperity, and promotes a better education, health, security, gender equality, sustainable development, and societal wellbeing (Kaseke & Hosking, 2013). In other words, electricity is a critical enabler for almost every aspect of modern life as well as a means to overcome poverty, marginalization, and exclusion.

Increasing access to electricity services, although desirable, could also be counterproductive since it may exacerbate climate change and lead to further environmental degradation. For this reason, the source (s) of the energy required should be clean and sustainable rather than dirty and/or risky technologies (e. g. fossil fuels, nuclear, large hydro) (Ferrey, 2007). In this regard, Deichmann, Meisner, Murray, and Wheeler (2007), as well as Pansera (2012), explain that distributed renewable energy generation is an ideal and cost-effective solution for most remote areas due to the fact that other alternatives, such as expanding the national or regional electricity grid, have proven to be challenging from a technical point of view, expensive, and highly controversial as a result of environmental and social concerns and impacts. As a result, renewable energy technologies have the potential to play an important role in providing energy with sustainability to isolated communities in both developing and developed countries. As a matter of fact, the United Nations (UN), under the umbrella of the Sustainable Energy for All initiative (SE4ALL), is advocating and seeking to mobilize action from all sectors of society in support of providing universal access to energy services by 2030 through the use of renewable energy resources and technologies, whenever feasible (UN, 2012).

Cost-Effective Technologies

The cost-effectiveness of renewable energy power generation technologies has reached historic levels. Today, technologies such as biomass, small- hydro, geothermal, and onshore wind can provide electricity competitively compared to fossil fuel-fired generation in both off-grid and on-grid applications (Taylor, Daniel, Ilas, & So, 2015). Onshore wind, in particular, is now one of the most competitive sources of electricity available due to technology and efficiency improvements and declining installation costs (McKenna, Hollnaicher, Leye, & Fichtner, 2015). Other renewable technologies have also experienced impressive price reductions in the last few years. Between 2010 and 2014, the installation costs for solar photovoltaic (PV) systems, for instance, have fallen by 29 percent to 65 percent, depending on the region, while their performance has improved substantially (Taylor et al., 2015). The increase in the share of renewable energies in the global electricity mix will likely accelerate technological progress and enhance economies of scale in the manufacture of associated equipment (Rao & Kishore, 2010). This, in turn, will further increase the cost-effectiveness and competitiveness of renewable technologies.

Democratization of Energy

The cost-effectiveness of distributed renewable energy generation systems enables the democratization of energy production and ownership. Traditionally, the generation, transmission, distribution, and commercialization of electricity have been carried out by large, vertically integrated companies, either public or privately-owned, in which end users do not have any power whatsoever to make decisions, for instance, on matters related to the operation of the company or on how and where the electricity that they consume and buy should be produced

(Riesz, Hindsberger, Gilmore, & Riedy, 2014). The increasing affordability of renewable energy, especially wind and solar power, is challenging the status quo and changing the power dynamics. More specifically, it is empowering citizens and communities by allowing them to become energy prosumers (i.e. producers and consumers) and, furthermore, to own and have control over the means of production (Rifkin, 2013). This structure enables the creation of value locally, minimizes capital outflows from a community or region, and increases public acceptance and support towards renewable energy technologies.

So Why Should the World Pursue a Renewable Energy Future?

The widespread deployment of renewable energy technologies is necessary to avoid catastrophic climate change. Luckily, the use of these technologies has a number of additional advantages for society. Other than GHG emissions reduction and climate stabilization, renewable energy minimizes the environmental effects of the electricity sector and improves public health. Increasing the use of renewable energy also promotes the conservation of valuable non-renewable resources, advances energy security, and encourages employment creation and economic development. Most renewable energy technologies, in addition, are cost-effective and competitive generation sources, which makes them ideal for bringing electricity to isolated and/or marginalized communities in both developing and developed countries, for improving the resiliency of energy systems, and for reducing the vulnerability of the electricity sector to climate change and extreme weather events. And last but not least, it is important to recognize that distributed renewable energy systems promote energy democratization since they allow citizens and communities to adopt an active role as energy producers and not only as consumers. In view of all that, it is fair to conclude that the world should pursue a renewable energy future because this would be an effective strategy to respond to climate change and the challenges it imposes,

improve the quality of life for hundreds of millions of people who do not have access to electricity, and empower individuals and communities in both economic and political terms.

For this strategy to succeed, it is key that renewable energy projects and supporting policies are designed with a strong local community focus. Evidence from around the world demonstrates that local acceptance and support for renewable energy projects is greater when the means of energy production are locally owned, when community members are meaningfully consulted and engaged throughout the different stages of the initiative, from planning to operation and maintenance, and when they can obtain economic benefits from it (through employment, royalties, benefit sharing agreements, etc.) (Gipe, 2009; Hentschel, 2012). Failing to take into account this valuable lesson triggers local discontent, opposition, and resistance. The renewable energy revolution, as any other revolution, simply will not succeed without active engagement and genuine support from majority of the population.

Chapter 3

Obstacles to Renewable Energy Penetration

Renewable energy resources are abundant throughout the world. A number of studies have consistently found that the total global technical potential for renewable energy is substantially higher than both current and projected future energy demand (Intergovernmental Panel on Climate Change [IPCC], 2011; Johansson, McCormick, Neij, & Turkenburg, 2004; Resch et al., 2008).[2] Over the last decade, continuing technology advances and rapid deployment of many renewable energy technologies have demonstrated that their potential can be achieved (Renewable Energy Policy Network for the 21st Century [REN21], 2014). However, a wide variety of barriers undermine and impede the widespread implementation of renewable energy solutions. These obstacles need to be identified in order to develop innovative policy approaches to overcome them and, furthermore, to help realise the potential and opportunities of renewable

[2] The technical potential refers to the amount of renewable energy output obtainable by full implementation of demonstrated technologies or practices given system performance, topographic limitations, environmental, and land-use constrains (Lopez, Robers, Heimiller, Blair, & Porro, 2012)

energy sources. This chapter identifies and discusses the most prevalent and salient of these barriers.

Barriers to Renewable Energy Deployment

Market Failures

Several market imperfections undermine the deployment of renewable energy technologies. A highly controlled energy sector, for instance, may lead to a lack of investment in the renewable energy industry since it creates difficult, if not impossible, conditions for private sector participation and competition while also promoting inefficiency in the use of resources (Painuly, 2001). The lack of knowledge and information about renewable resources, their potentials, and distribution is another factor hindering the development of the industry. This, according to Mirza, Ahmad, Harijan, and Majeed (2009), increases investors' uncertainty and the projects' costs. The knowledge and information about renewable resources in most developing countries is rather inadequate due to the fact that these have not been thoroughly quantified (Huacuz-Villamar, 2013; Xin-gang, Tian-tian, Lu, Pingkuo, & Yisheng, 2011). Lastly, as Barbier (2011) argues, high transaction costs are one of the most common and significant challenges that renewable energy investors face and that often affect the viability of projects. These costs are associated with missing or unclear information about applicable regulations, requirements, and permits; long, costly, and tedious bureaucratic and administrative procedures; and lack of certainty in relation to the approval of the project.

Market Distortions

Market distortions are created by unequal tax burdens and subsidy schemes that favour non-renewable energy options. Most countries, as Zyadin, Halder, Kahkonen, and Puhakka

(2014) indicate, have regulatory frameworks that promote the use of fossil fuels and adversely affect the competitiveness of renewable energy technologies through a series of inefficient, regressive, and perverse subsidies in the form of grants and tax breaks. According to the International Energy Agency (IEA) (2014b), fossil fuel consumption subsidies worldwide amounted to US$548 billion in 2013, with subsidies to oil products representing over half of the total. Those subsidies were over four times the value of subsidies to renewable energy, which accounted for $121 billion, and more than four times the amount invested globally in improving energy efficiency (IEA, 2014b). In some cases, renewable energy technologies are further disadvantaged in the market due to trade barriers such as tariffs and import quotas (Lewis & Wiser, 2007).

Additional market distortions are created in the process of determining the price of different energy technologies. Generally, as Owen (2006) explains, market prices do not reflect the economic, social, environmental, and public health costs and damage associated with conventional energy sources. By the same token, the same author argues, prices fail to recognize and incorporate, by assigning a monetary value, the multiple co-benefits of renewable energy generation (see Chapter 2). As a result, neither conventional nor renewable forms for electricity generation are priced appropriately. Therefore, it is imperative to promote the widespread implementation of methodologies designed to assess and internalize the short, mid, and long-term externalities, both positive and negative, of each energy generation system. In this manner, the market prices of conventional energy technologies would increase while the prices of renewables would decrease, hence making the latter more competitive, attractive, and affordable energy solutions.

Economic and Financial

One of the most often cited barriers blocking the implementation of renewable energy solutions in the majority of countries is the high upfront capital costs for investors. Despite the fact that the cost-effectiveness of all renewable energy power generation technologies has reached historic levels, initial costs tend to be high and in some places uncompetitive, which prohibit consumers from adopting them (Rao & Kishore, 2010). Many consumers prefer to keep the initial costs low rather than minimizing the operating and maintenance costs (Reddy & Painuly, 2004). This is particularly true in developing countries, where the low income population generally lack access to cash and/or credit (Luthra, Kumar, Garg, & Haleem, 2015). Achieving substantial price reductions and increasing the penetration of renewable energy technologies in some of these countries, as Negro, Alkemade, and Hekkert (2012) indicate, have been slow and difficult tasks due to the lack of a market base strong enough, sufficient private sector engagement and investments, and economies of scale.

High upfront capital costs, however, are not the only economic/financial barrier that renewable energy investors face. In many developing countries, there is a lack of sufficient government schemes or financing mechanisms to promote the adoption of these technologies by citizens, businesses, and industries (Dulal, Shah, Sapkota, Uma, & Kandel, 2013). The poor availability of competitive, low interest, and affordable credit and other financial alternatives not only is a major obstacle but also a complex issue. As Mirza et al. (2009) and Luthra et al. (2015) point out, it is a consequence of the lack of familiarity and awareness of renewable energy technologies and their benefits, concerns about the reliability of the equipment, high risk perception, uncertainties with regards to the profitability of projects, high discount rates, and long-payback periods.

Institutional and Regulatory

The progress of renewable energy deployment and commercialization requires of institutions, both public and private, committed to the advancement of these technologies. Most developing countries, however, lack of a strong institutional framework to support that objective. As Uddin, Taplin, and Yu (2006) explain, there is an absence in those places of institutions and mechanisms to disseminate information about renewable energy sources, costs, developments, and opportunities among producers, consumers, energy regulators, decision-makers, and other stakeholders. Similarly, there is a lack of professional institutions, research centres, and university or college programs designed to increase the knowledge-base, improve the human capital, and/or develop strategies to integrate and adapt renewable technologies to the local context (Pansera, 2012). In addition, there is little or no coordination and cooperation whatsoever within and between relevant ministries, agencies, institutes, and other stakeholders on those same issues (Mirza et al., 2009). All these factors, in consequence, delay and restrict the growth of the renewable energy sector.

The existence of weak legal and regulatory frameworks is another key factor hindering the development of domestic renewable energy markets. In many countries, particularly developing ones, there is an absence of appropriate, well-defined laws, regulations, and policies to stimulate the adoption of renewable energy technologies by citizens, businesses, and industries (Reddy & Painuly, 2004). Under these circumstances, there is little or no clarity with regards to renewable energy targets, incentives and instruments to achieve those goals, or about the roles and responsibilities of each stakeholder. This lack of clarity, as Etcheverry (2013) argues, is a serious obstacle because it constrains investment decisions and the development of manufacturing facilities. Furthermore, he claims, it raises major concerns about the ability of the

renewable energy market to provide long-term stability and grow in a sustained an organized manner. A weak legal and regulatory framework reflects, above all, a weak political commitment which, as discussed in Chapter 1, is essential to advance renewable energy and climate change mitigation efforts.

Technical

Many renewable energy technologies have existed for a long time and have proven to be cost-effective, reliable, and safe (Rutter & Keirstead, 2012). In spite of that, most countries lack minimum standards or codes that can be used to certify the durability, reliability, performance, and safety of individual systems, thus undermining consumers' confidence on renewable energy products and their commercialization (Dulal et al., 2013). The deployment and expansion of some renewable energy technologies, particularly solar and wind, has also been adversely affected due to their variability. In this regard, there are concerns about the ability of these technologies to supply uninterrupted power in periods when the sun does not shine and the wind does not blow without the use of back-up power supply sources or storage devises, which increase the overall cost of the projects. The issue of intermittency, however, is over-stated as it has been successfully overcome through innovative regulatory and technical solutions such as smart grids (Boston, 2013; Luthra, Kumar, Kharb, Ansari, & Shimmi, 2014), energy banks[3]

[3] The solution to the variability of renewable energy sources was developed in Mexico with the creation and implementation of the Energy Bank in 2001 by *Comisión Reguladora de Energía* (Energy Regulatory Commission. The Energy Bank is a mechanism for energy exchange and compensation that allows self-suppliers to deposit and accumulate excess generation in a virtual account (i.e. the bank) at any time, in a way that it can be returned upon request within a period of 12 months. This instrument, in consequence, proves that the electricity generated from renewable energies can be reliable and constant. This debunks the myth that it requires a backed source or storage devises.

(Davis, Houdashelt, & Helme, 2012), and hybrid electricity generation systems[4] (Bueno & Carta, 2006). This demonstrates that societies can afford to discontinue the use of centralized energy systems, such as nuclear power plants or coal-fired generation facilities, and to expand their renewable energy sources to the fullest potential.

The lack of robust infrastructure is arguably a greater barrier to the development and growth of the renewable energy sector. As Puga and Lesser (2009) point out, renewable energy sources tend to be located in remote, dispersed, and inaccessible areas where the grid is not available. However, building transmission lines to wheel the electric power generated in those areas requires, under most circumstances, high investments. In addition, it may not be cost-effective and, furthermore, cause severe environmental degradation (Davis, 2014). Taking that into account, it could be argued that the renewable energy potential in certain countries will not, in fact cannot, be fully realised.

The greatest technical obstacle to development and growth of the renewable energy sector is the lack of skilled personnel. In this regard, it is widely recognized that developing countries, and some developed countries to a lesser extent, have limited human resources and insufficient technical expertise for planning, building, operating, maintaining, and decommissioning renewable energy projects and for training experts in the field (Gamula, Hui, & Peng, 2013; Kandpal & Broman, 2014; Negro et al., 2012). The lack of local know-how and awareness of renewable energy options such as wind and solar systems, electronic controls, and

[4] The smallest and most southerly of the Canary Islands, El Hierro, off the west coast of Africa, is aiming to become the first energy self-sufficient island in the world. Today, between 70 percent and 80 percent of the island's electricity demand is met through a hybrid hydro-wind generation system. Five wind turbines, with a combined installed capacity of 11.5 MW, supply electricity to three desalination plants and the island's population of close to 12,000 residents. Meanwhile, surplus power is used o pump power more than 700 metres up into the crater of a sealed-off, long extinct volcano. When the wind stops blowing or electricity demand is high, water from the 500,000 cubic metre reservoir will be released into turbines to create up to 11.3 MW of hydro-electric power. The water is collected in an artificial lower reservoir before being pumped up again to the higher basin.

system administration, as Etcheverry (2013) points out, presents key challenges for the implementation of renewable energy initiatives. This is particularly true in rural areas and remote communities without access to the grid and where outside experts or technicians may not be available at all times.

Social, Cultural, and Behavioural

The growth of the renewable energy sector is also undermined by the lack of social acceptance towards some technologies. In this regard, it is widely recognized that community discontent and opposition to large scale energy projects (e.g. wind farms, hydroelectric dams, and nuclear plants) is triggered by the spatial and aesthetic impacts that the infrastructure has on the landscape (Krogh, 2011; Sijmons & van Dorst, 2012; Warren, Lumsden, O'Dowd, & Birnie, 2005; Wolsink, 2007). In some countries, solar power faces opposition due to potential environmental impacts such as land use and habitat loss, biodiversity loss, water consumption, and pollution from the use of hazardous and toxic material in manufacturing (Hernandez et al., 2014; Tsoutsos, Frantzeskaki, & Gekas, 2005). In Ontario, Canada, anti-wind activists oppose wind turbines by accusing them of causing adverse health impacts. They claim that people who live in proximity to wind farms are prone to develop 'Wind Turbine Syndrome' from exposure to high levels of noise and vibrations emitted by the turbines. This syndrome is associated with intense headaches, dizziness, anxiety, annoyance, depression, frustration, sleep disturbance, hearing impairment, amongst other symptoms (Pierpont, 2009). Objections to wind farms are also brought forward because of other alleged adverse impacts such as decline in property values, increase in bird and bat mortality, land use conflicts, and public safety concerns (Hill & Knott, 2010). The scientific evidence available to date does not demonstrate a direct causal link between wind turbines and adverse health or environmental impacts (Health Canada, 2014;

Mulvihill, Winfield, & Etcheverry, 2013). However, in order to prevent conflicts and tensions, delays, increased costs, and other unexpected problems, renewable energy project developers must address social and environmental concerns in the planning phase and throughout the life of the project (Wustenhagen, Wolsink, & Burer, 2007). .

The penetration and commercialization of renewable energy technologies has also been affected by a number of myths and misconceptions about these sources of energy. In a provocative book, Scheer (2007) identifies, discusses, and debunks some of the most popular assumptions and ideas that are embedded in the public's mind and that are used to create polemic and devalue renewable energy solutions. The task of dismantling these hurdles is a difficult one since consumers and other stakeholders in many countries lack easy access to reliable information about the latest technologies, costs, benefits, and available government incentives (Luthra et al., 1015). The lack of awareness, combined with poor information dissemination, as Mirza et al. (2009) indicate, result in uncertainty about the quality of the renewable energy products and systems, discourage potential users from adopting them, and promote the use of conventional generation technologies.

The lack of appropriate and reliable information about renewable energy alternatives imposes additional barriers. As Arkesteijn and Oerlemans (2005) suggest, the adoption of these technologies is generally influenced by the knowledge that potential users have about the quality and usefulness of the products and systems when compared to conventional technologies. Evidence from around the world, particularly from developing countries, seems to indicate that renewable energy products are resisted when consumers feel comfortable with the status quo (Pollitt & Shaorshadze, 2011; Samuelson & Zeckhauser, 1988). In this regard, Hobman and Frederiks (2014) and Stern (1992) argue that the resistance is magnified if they lack the means to

clearly understand and articulate the benefits of the new technology, the disadvantages or problems associated with the existing one, and to justify the sacrifices and the investments that they would have to make in terms of money, time, and confort.

Other Barriers

Evidence from around the world also suggests that path dependency is one of the most prominent challenges that the renewable energy sectors face. As discussed in Chapter 1, most societies are locked-in to centralized and unsustainable energy systems and infrastructure that block market entry and inhibit the diffusion of clean, renewable energy technologies despite their environmental, social, and economic advantages (Unruh, 2000). This is further aggravated by the fact that in many countries there is a lack of land or a lack of access to land in which to develop renewable energy projects due to factors such as poor communication and road transport infrastructure, difficult geographical and climatic conditions, socio-political instability, Indigenous ownership and control, amongst others (Finley-Brook & Thomas, 2011; Martinot, Chaurey, Lew, Moreira, & Wamukonya, 2002).

Finally, the lack of stakeholder and community participation in energy choices and renewable energy projects have been identified as important barriers to renewable energy deployment. In this regard, Mirza et al. (2009) explain, meaningful community participation and local capacity building have been generally restricted in most countries to ad-hoc demonstration projects. This, as Khan (2003) and Strachan, Lal, and Von Malmborg (2006) argue, creates tensions and conflicts between communities and renewable energy developers. The case of Ontario, Canada is a perfect example to illustrate this point. While some have argued that the backlash against wind turbines is fundamentally a classic example of *Not In My Backyard*

politics (Mulvihill et al., 2013), others have suggested that the opposition is a direct response to the lack of appropriate mechanisms to engage the public in decision-making processes, to compensate community members in a fair manner, and to give them the opportunity to obtain economic benefits from projects that are located near to their homes (Hill & Knott, 2010). Thus, since the *Wind Turbine Syndrome* has been largely discredited by the best available peer-reviewed scientific studies, it is possible to claim that the reason why some people who live in communities that host wind farms are getting sick is because they have been disempowered both politically and economically.

The Challenge in Front of Us

In spite of rapid technological advances and increased economic viability of several renewable energy technologies, renewable energy sources have been used to a small fraction of their potential. The penetration and commercialization of these technologies has been hindered, particularly in developing countries, by the existence of market-related, economic , financial, institutional, regulatory, technical, social, cultural, behavioural, and other barriers. Some of these barriers, as Painuly (2001) indicate, may be specific to a technology, while some may be specific to a country or a region. Overcoming them, however, is no easy task. In fact, due to their complexity and diversity, it has been suggested that organizing an energy transition from fossil fuel-based, non-sustainable energy systems to renewable energy-based, sustainable ones is the major challenge of the first half of the 21st century (Verbruggen et al., 2010). That said, the next chapter will discuss the importance of international cooperation as a strategy to help developing countries dismantle some of the barriers that hinder the development and grow of the renewable energy sector.

Chapter 4

International Cooperation on Renewable Energy: Benefits, Mechanisms, and Progress

The enormous potential of renewable energy sources is sufficient to meet the world's electricity and energy demand many times over. They can also enhance diversity in energy supply markets, contribute to long-term sustainable energy supplies, and reduce local, regional, and global atmospheric emissions. In addition, they minimize the environmental effects of the electricity sector, improve public health, enhance resiliency of energy systems, and advance climate change adaptation efforts. Furthermore, renewable energy sources provide cost-effective alternatives to enable marginalized and/or rural populations to access electricity services, create new employment opportunities, foster the development of a low-carbon economy, and when implemented as community initiatives help promote the democratization of energy in both developed and developing countries. Achieving these goals, however, is no easy task due to a

significant number of complex barriers that undermine the deployment of renewable energy technologies.

Addressing and overcoming the barriers identified in Chapter 3 will require an in-depth understanding of the challenges faced and the implementation of a variety of tools and mechanisms that are increasingly recognized by energy experts as effective in the facilitation of renewable energy deployment. These include, for instance, significant public and private investment towards research, technological development and innovation, as well as the development of programs and activities designed to enhance human capital in the renewable energy sector (Kruckenberg, 2015). At the same time, it is crucial, particularly for developing countries, to promote and maintain channels of cooperation with other developed and developing nations that have greater experience and that have managed to achieve a considerable penetration of renewable energy technologies. These collaborations, as Rickerson, Hanley, Laurent, and Greacen (2013) argue, are necessary to mitigate climate change, create economic opportunities, increase energy access, and move towards a more sustainable production and use of energy.

The benefits

The benefits associated with international collaboration in the renewable energy field are well known and widely recognized in the academic literature. It has been argued, for instance, that international cooperation mechanisms are effective vehicles for exchanging knowledge and experience, accessing finance to support the exploitation and utilization of these resources, importing advanced technology and equipment, accelerating research and development processes, improving the human resource development and market conditions, and enhancing the

policy framework (Pancera, 2012; Stambouli, 2011; Zhao, Zuo, Feng & Zillante). Collaborative arrangements, in addition, promote channels of dialogue and strengthen diplomatic relations among nations, which opens the doors to further science, technology, and expertise exchange while also fostering investments, trade, and economic activity. Furthermore, they can advance energy security at both the national and regional level (Xin-gang , Yi-Sheng, Tian-tian, & Yu-heng, 2013).

Some energy policy analysts doubt the importance of international collaboration and categorize it as a lower ranking climate mitigation strategy (Stokey, Smith, Schelling, Kydland, & Bhagwati, 2010). Etcheverry (2013) refutes this claim by demonstrating that cooperation among nations is indeed an essential tool to dismantle renewable energy barriers in a coherent and organized manner since it plays a key role in "developing local capacity, (...) ensuring that new technical and policy initiatives are informed by know-how accumulated in leading jurisdictions" and countries, and guaranteeing that "new renewable energy projects are of the highest quality and thereby foster public support for such projects" (p. 173). Sustained public support for renewable energy projects, as discussed in Chapter 3, is essential to prevent tensions and conflicts with the surrounding community, delays, increased costs, and other unexpected problems.

Mechanisms for International Cooperation on Renewable Energy Development

Cross-boundary cooperation on renewable energy development has existed for decades. In 1981, as Kozloff (1995) indicates, it was first recognized as an international priority at the United Nations Nairobi Conference on New and Renewable Sources of Energy. A wide variety of cooperation models have been implemented, some of which have been successful and some of

which have not been so successful in helping countries overcome renewable energy barriers and increase the penetration of these technologies in the electricity market. In the section that follows, some of the most salient mechanisms to facilitate assistance on renewable energy matters will be identified and reviewed.

Multilateral Cooperation

In international relations, multilateralism refers to multiple countries working in concert on a given issue. Multilateralism was defined by Kahler (1992) as "international governance of the 'many'" (p. 681). Today, multilateral collaborations for the development of low carbon energy technologies, as Barnsley and Ahn (2014) point out, are widely recognized as a crucial component in providing integrated solutions needed to reduce greenhouse gas (GHG) emissions while also fostering economic growth and access to secure, affordable, and sustainable energy. Since 2005, the year in which the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) entered into force, the world has seen as considerable growth in the number and variety of government-led multilateral initiatives designed to foster collaboration and innovation in renewable energy technologies. Some of the most prominent and successful cooperation initiatives include the creation of the Clean Energy Ministerial (CEM) as a high-level forum to promote policies and programmes that advance clean energy technologies, the Global Green Growth Institute (GGGI) as a new international organisation to foster green economic growth solutions, the Climate Technology Centre and Network (CTCN) under the UNFCCC to stimulate technology co-operation and to enhance the development and transfer of technologies, the Global Green Growth Forum (3GF) to facilitate public-private partnerships on a green growth economic path, and the United Nations (UN) Sustainable Energy for All (SE4All), aimed at encouraging universal access to modern energy services.

All those initiatives have made significant contributions to global efforts to address energy and climate challenges. In addition, they have directly benefited many countries by allowing them, for instance, to advance complementary technologies, policy and information exchange, and business cooperation in the renewable energy sector (Xin-gang et al., 2011). At the same time, it is important to recognize that since multilateral initiatives have varying, and at times overlapping mandates, activities, and focus, potential beneficiaries and other stakeholders may face difficulties in identifying the most appropriate one to assist with their renewable energy policy or program planning and implementation. Moreover, as Barnsley and Ahn (2014) explain, there is little information readily available in a single location in either academic or public policy literature in which the array of collaborative alternatives can be found mapped in a comprehensive manner. This is a limitation that further complicates the process of identifying and selecting existing initiatives that help promote renewables and other low-carbon energy technologies.

The lack of information regarding multilateral cooperation initiatives is a serious obstacle that needs to be addressed. These initiatives, however, are undermined to a greater extent by the lack of commitment of many governments to internalize the economic, social, environmental, and public health costs and damage associated with conventional energy sources, by the high investment requirements for the implementation and delivery of programs, and furthermore, by the free-rider problem (Florini & Savacool, 2009). The free-rider problem, as Hardin (1968) describes in his often cited "Tragedy of the Commons," is a common situation in which individuals, businesses, and even countries receive a benefit without paying for it or at least bearing some of the costs. In relation to multilateral collaboration on renewable energy, the free rider problem is often recognized as a major hurdle considering that the participation of countries

is voluntary and that developed, high income nations cannot be forced to implement or provide their support to cooperation initiatives (Florini & Savacool, 2009). This is the case, as Weiss (1998) argues, because we live in a world in which states are sovereign and independent entities and where international law is toothless and powerless to make binding rulings or to impose sanctions upon those countries that refuse or fail to fulfill their obligations or promises. Due to all these limitations, the effectiveness, fairness, replicability, and transparency of renewable energy multilateral cooperation initiatives is seriously jeopardized.

Clean Development Mechanism

The Clean Development Mechanism (CDM) is the main multilateral cooperation system that permits the financing of climate mitigation initiatives in developing countries. Established by the Kyoto Protocol, the CDM was designed to help industrialized countries advance their GHG reduction obligations and, most importantly, to assist developing countries achieve sustainable development and gain access to technologies previously not available in the host country (Zhang, 2006). Under that system, developed countries have the option of implementing emissions abatement projects in low income countries in exchange of saleable certified emissions reductions credits, each equivalent to one tonne of carbon dioxide (CO_2), which can be counted towards meeting their Kyoto targets. In order to qualify, the project must be linked to at least one of the following emissions reduction activities: the promotion and development of less polluting and harmful fossil fuels (e. g. natural gas, liquefied petroleum gas, unleaded gasoline); the promotion of energy efficiency and conservation; the rehabilitation of polluted sites; the development of renewable energies; or the development of environmental management in the energy and mining sector (Stambouli, 2011).

Schneider, Holzer, and Hoffman (2008) argue that the CDM, the strongest mechanism for the promotion of international renewable energy cooperation under the UNFCCC, does contribute to overcome renewable energy barriers and to foster technology transfer in terms of both equipment and know-how. However, they point out, its performance varies considerably along the dimensions of geography, technology, and project size. At the same time, it has been suggested that the CDM registration process is too long, costly, and uncertain, for which it is not possible to take for granted revenues from carbon credits when assessing the economic feasibility of new projects (Pueyo, 2013). Meanwhile, De Sepibus (2009), as well as Karakosta, Doukas, and Psarras (2010), have vehemently criticised the CDM system on the grounds that it primarily focuses on isolated and cheap short-term abatements, end-of pipe solutions, and fossil fuel power stations at the expense of renewable technologies and energy efficiency and conservation strategies, thus, locking the host country into a high-carbon energy future. Finally, Bazilian et al. (2009) claim that the CDM framework is weak and inadequate due to the fact that it is incapable of encouraging changes to the policy framework and to advance in the development of the institutional capacities necessary to foster innovation and the sustained, long term growth of the renewable energy sector. Based on those arguments, one could conclude that the CDM is insufficient to accomplish the needed energy transition and to avoid catastrophic climate change. In spite of that, one cannot deny that it is an important mechanism to reduce GHG emissions and facilitate the adoption of cleaner energy technologies.

Bilateral Cooperation

In international relations, bilateralism refers to the establishment of dialogues and diplomatic relations between two sovereign states to advance win-win cooperation on political, economic, social, cultural, or environmental matters (Blum, 2008). In recent years, bilateral

collaborations on renewable energy have become more and more common as a result of increasing concerns about climate change, environmental degradation, and energy security. In fact, the number of countries that benefit from bilateral financial, technical, advisory, and capacity-building assistance continues to grow (Karakosta et al., 2010). It is often assumed that bilateral cooperation is a mechanism to transfer financial resources, technology, and knowledge from North to South. This assumption, as Brewer (2011) points out, is mistaken since it neglects the fact that some developing countries have climate-friendly technologies, knowledge, and practices which could be transferred from South to North and also from South to South as a means to promote climate mitigation, environmental protection, and sustainable development.

Bilateral cooperation initiatives on renewable energy have become a popular mechanism to advance the penetration of these technologies. A few decades ago, the emphasis of these programs was to promote off-grid electrification for marginalized and/or isolated populations in low-income developing countries (Kruckenberg, 2015). Today, bilateral collaboration initiatives are mainly concerned with fostering local capacity development, policy orientation, and technology and information exchange (Jacobsen, Prade, Schroder, & Kitzing, 2014) . In Europe, as Etcheverry (2013) and Jacobsen et al. (2014) explain, the promotion and development of collaborative bilateral frameworks has been essential to help achieve national and Europe-wide renewable energy targets. In China, the rapid growth of the renewable energy sector can be attributed, amongst other things, to the establishment of bilateral collaboration agreements with European leaders in the field (e.g. Germany, Denmark, Sweden, the United Kingdom, etc.), the United States, and Japan (Xin-gang et al., 2011; Zhao et al., 2011). Meanwhile in North America, the United States and Mexico have a rich and multi-faceted history of cooperation on renewable energy since the 1970s that has benefited the renewable energy sector and promoted

innovation on both sides of the border (Etcheverry, 2013; Wood, 2010). The Canadian government, interestingly enough, has not been involved in any of the cooperation initiatives undertaken by the Mexican and the United States governments.

Institutional Cooperation

Inter-governmental organizations (IGOs) are widely recognized as an institutional form of global governance and cooperation (Florini and Savacool, 2009). These organizations, which include the UN, the World Bank, the International Monetary Fund (IMF), the World Health Organization, amongst many others, are created and funded by national governments to manage and find solutions to shared problems (Owsiak & Diehl, 2012). Some IGOs are open to virtually all countries, while others serve a more limited membership. The International Energy Agency (IEA), based in Paris, France, has for several decades been the most influential IGO in the energy field. This institution, which is funded by member states of the Organization for Economic Cooperation and Development (OECD), was established in the 1970s as a means to allow member states coordinate a response to the Organization of Petroleum Exporting Countries (OPEC) oil embargo (IEA, 2015). Overtime, however, it has become active in providing assistance to developing countries in the design and implementation of renewable and sustainable energy policies (IEA, 2008). Today, the legitimacy and effectiveness of the IEA is challenged by many on the grounds that it excludes emerging markets, China and India for instance, as well as other countries that have a high energy consumption, that have not been involved in the creation of most IGOs, and that are generally underrepresented in the governance of these organizations (Van de Graaf, 2012). In view of that, it has been argued by Van de Graaf and Lesage (2009) that opening the doors of the IEA to non-OECD countries would contribute to increase energy security, enhance energy policy coordination, reduce environmental degradation

at the global scale, promote renewable energy collaboration, and accelerate the deployment of these technologies in low and middle income economies. However, that argument is now challenged by a recent addition to the organizational landscape, the IRENA.

The IRENA was founded in 2009 as a coalition of countries interested in maximizing the use of renewable energy worldwide through establishing collaborations and partnerships between member states, providing practical advice and support for all nations, and facilitating access to all necessary information such as resource potential, best practice, effective financial and policy tools, and technological expertise. Although the IRENA is not yet fully engaged in program delivery, it has an explicit focus on developing local capacity on renewable technologies through training and education in the least developed countries (IRENA, n.d. b). In contrast to the IEA, the membership of IRENA is open and not limited to OECD countries, which has led to high levels of support among low and middle income countries and renewable energy policy experts (Hirschl, 2009). As of May 2015, 140 states have signed the Statue of the IRENA while 32 states have started to process to become official members (IRENA, n.d. a).

As a newcomer in the global governance architecture, the IRENA has so far received scant attention in the academic literature. This omission is unfortunate given that despite its small budget (about US$30 million per year) and largely technical mandate, this IGO has already started to play an important role in environmental and energy governance and, most importantly, has achieved significant success in promoting cooperation and renewable energy deployment in low and middle income economies (IRENA, 2013a; Meyer, 2013). The key to success, as Upelainen and Van de Graaf (2015) explain, rests on the fact that the IRENA wisely decided to focus exclusively on advancing its defined set of goals and offering services that help countries deploy renewable energy capacity and, furthermore, to refrain from engaging in political issues

and debates that surround nuclear energy, fossil fuels, and climate change, and from presenting itself as an environmental advocacy organization. This innovative and successful approach, in consequence, may serve as a role model for future innovation in global energy governance and international cooperation frameworks.

Another major mechanism for global governance and cooperation on renewable energy is provided by IGOs known as international development banks (IDBs). These institutions specialize in the facilitation of economic and technical assistance, in the form of loans, to governments of member countries for the development of specific projects or as a means to help them overcome the barriers that obstruct the penetration of renewable energy technologies (Florini and Savacool, 2009). Some of the best known IDBs include the World Bank, the IMF, the African Development Bank, the Asian Development Bank, the Development Bank of Latin America, the European Investment Bank, the Inter-American Development Bank, the Islamic Development Bank, amongst others. The assistance provided by these banks has been intensively scrutinized and opposed by many analysts and social sectors on the grounds that they are seen as a tool to influence how beneficiary countries should run their economies and what paths they should take to promote economic development. This claim is based on the fact, as Williams and Ghanadan (2006) argue, that many developing, non-OECD countries have been forced to undertake profound reforms to their electric power sector in order to qualify for loans. These reforms, they explain, often involve the partial or complete liberalization of markets and the privatization of electricity generation, transmission, and distribution assets. For this reason, structural adjustment loans should be rejected and, in fact, abolished. Ii is important to remember that cross-boundary cooperation is supposed to be a vehicle to advance solutions to global challenges rather than an instrument with which developed countries can impose a particular

economic system and ideology, open markets for their businesses, and perpetuate their hegemony.

International Partnerships

Governments and the IGOs they create are not the only important actors in global governance and renewable energy cooperation. Increasingly, the world is witnessing the emergence of hybrid, multistakeholder partnerships between state and non-state actors with complementary competences. These partnerships, as Kruckenberg (2015) indicates, involve a diverse type of organizations that include, for instance, governmental agencies, IDBs and other financial institutions, utilities, universities, industry and professional associations, firms, consumer groups, advocacy non-governmental organizations (NGOs), amongst others. Multistakeholder partnerships have proven to be an effective mechanism to address existing regulatory, participation, resource, and learning gaps that challenge cooperation as they harness and combine the strengths, experience, and knowledge of private, public, and nonprofit actors (Pinkse & Kolk, 2012). Furthermore, they operate efficiently as they have a clear division of roles between partners with companies bringing specific knowledge and expertise, NGOs providing local embeddedness and contacts as well as supporting activities such as training and capacity building, IDBs supplying funding, and governments facilitating all activities in order to reduce risks (Kolk, Levy & Pinkse, 2008). For these reasons, hybrid partnerships have been designated as the "collaboration paradigm of the 21st century," needed to solve the "increasingly complex challenges" that "exceed the capabilities of any single sector" (Austin, 2000, p. 44). As a result, it is fair to claim that the development and implementation of multistakeholder partnerships is a necessary step to undertake an energy transition towards renewable energy-

based electricity systems, avoid catastrophic climate change, and achieve sustainability since they promote and facilitate participation and cooperation between different sectors of society.

One of the most frequently mentioned multistakeholder partnerships is the Renewable Energy and Energy Efficiency Partnership (REEEP). Created in the United Kingdom in 2002 by a collection of regulators, businesses, banks, non-governmental organizations, and governmental agencies, the REEEP has played an important role in the promotion of climate mitigation strategies particularly in large emerging economies such as China, India, and Brazil (Parthan et al., 2010). With over 250 funding partners from around the world, this initiative attempts to increase investments in renewable energy, promote energy efficiency measures, and facilitate access to sustainable energy services for the poor in developing countries by providing financial assistance for projects that have high potential for mass replicability, utilizing lawyers and technical experts to challenge governments' regulation and policies, and fostering local capacity building (Pinkse & Kolk, 2012). According to Parhan et al. (2010) and Pattberg and Stripple (2008), the REEEP, as well as other hybrid entities, has been effective and successful in achieving the goals it set itself due to its flexibility, diversity, small size, and innovative approach to funding in which resources are collected from partners on a voluntary basis. It is important to take into account, however, that due to the lack of permanent and stable funding the agency has been forced to implement and support only isolated, small-scale, and short-term projects (Florini & Savacool, 2009).

Assessing Progress on International Renewable Energy Cooperation

Cross-boundary cooperation on renewable energy development has existed for decades. In spite of that, progress has been slow and arguably unsatisfactory. This is the case, as

Holtsmark (2013) claims, due to the lack of commitment and interest of most countries to implement ambitious climate change mitigation strategies and to support and participate in programs that aim to increase the deployment of renewable energy technologies in developing nations. In addition, there is an inadequate structure in place to foster international collaboration. In this regard, Steiner, Walde, Bradbrook, and Schutyser (2006) explain that the current global landscape of actors and institutions in support of renewable energy is characterised by compartmentalization, limited systematic sharing of information, lack of coherence, and poor coordination. Addressing these issues is important to improve the effectiveness, efficiency, feasibility, sustainability, and transparency of existing cooperation mechanisms and arrangements.

The lack of political commitment and the existence of an inadequate institutional arrangement are significant barriers to international cooperation efforts. Yet, the greatest obstacle is the scarcity of mechanisms designed to promote local capacity building and provide training in careers related to the renewable energy industry (Xin-gang et al., 2011). With most collaboration mechanisms attempting to create platforms for technology transfer and opportunities to finance isolated renewable energy projects in developing countries, there is a shortage and an urgent need in those places for highly qualified specialists including, for instance, project managers, policy developers, designers, installers, maintenance personnel , inspectors, electricians, technicians, machine builders, customer service representatives, administrative support personnel, amongst many others (Savacool, 2012; Stapleton, 2009). Therefore, cooperation initiatives must strive to address this shortfall by providing opportunities of training and education to local populations, particularly to female heads of households and to members of sectors that face economic or social marginalization. In that sense, the establishment of the

IRENA and the implementation of multistakeholder partnerships, which are becoming increasingly popular, are a step in the right direction. However, due to their funding limitations, those initiatives are insufficient and must, in consequence, be strengthened with additional cooperation efforts and mechanisms.

Chapter 5

Canada's Responsibility

The progress of cross-boundary cooperation on renewable energy development, which has existed for decades, has been slow and unsatisfactory. This, as explained in Chapter 4, can be attributed to poor political commitment combined with an inadequate institutional framework and with an insufficient number of mechanisms designed to foster local capacity building and provide training opportunities in the renewable energy sector for populations in low-income countries. As a result, this research project advocates for the immediate implementation of new innovative collaboration mechanisms and efforts as a strategy to address and remedy the shortfalls of the current system. Those initiatives, for a number of reasons that will be discussed below, must be planned, financed, delivered, and monitored by high-income, industrialized nations targeting gaps in developing countries. That focus is based on the principle of 'common but differentiated responsibilities' that is part of the United Nations Framework Convention on

Climate Change (UNFCCC) and which Canada is a signatory to. That said, the scope of this chapter is to discuss why developed countries, specifically Canada, should assist in the process of advancing renewable energy deployment in countries where the penetration of those technologies in the electricity mix is low or non-existent. Similarly, this chapter examines the ways in which developed countries can benefit from providing such assistance. This is an important question to consider taking into account that cooperation agreements in which one or more participants fail to obtain tangible benefits are neither desirable nor fair.

Why Should We?

The central argument of this research project, as mentioned above, is that developed countries must take the leadership and provide technical, policy, and financial assistance to developing countries that are seeking to overcome the barriers and increase the deployment of renewable energy technologies in their territories. This argument is based on several grounds. To begin, it cannot be forgotten that climate change was created by industrialized countries, which for centuries have emitted greenhouse gases (GHGs) and overstepped nature's boundaries in order to create and accumulate wealth, to improve the quality of life, and to meet the seemingly insatiable desires of a growing population (Intergovernmental Panel on Climate Change [IPCC], 2001). In that sense, developed nations have a moral obligation with present and future generations to help other countries, particularly the most vulnerable that will experience climatic changes and significant impacts.

Canada is one of the countries with a moral responsibility to support developing nations in their efforts to reduce GHGs emissions and improve their adaptability and resiliency to climate change. Canada is among the top ten GHG emitters by any measure: per capita (1^{st}),

absolute (9th), and historical (9th) (Ge, Friedrich, & Damassa, 2014). These figures confirm that Canada is one of the world's major contributors to climate change and, furthermore, that the current federal Conservative government is fully committed to expanding the fossil fuel sector, which has become the fastest growing source of GHG emissions in the country. The current federal government has positioned the nation as an "Energy Superpower" by intensifying oil and gas extraction from Alberta's tar sands. Under those current circumstances, it is hard to believe that Canada will become, at least in the near future, a leader or an active international player in the promotion of renewable energy technologies.

The claim that Canada and other industrialized nations have an obligation to support climate mitigation and adaptation efforts in low-income countries is based on moral but also on legal grounds. That obligation is derived from the polluter pays principle and from the United UNFCCC. The former, which is strongly supported and has been recognized by the Organization for Economic Cooperation and Development (OECD) and the EU (European Union) as a legally binding principle in international environmental law, establishes that states have the obligation to bear the expense of preventing, controlling, and cleaning up pollution or any other damage done to the natural environment (Moellendorf, 2012). Meanwhile, the UNFCCC indicates under Article 3.1 that rich industrialized countries have the duty to protect the climate system for the benefit of present and future generations of humankind by reducing their emissions as well as providing technical and financial assistance to developing countries in accordance with their respective capabilities (Metz, 2000). Article 4.5, in addition, states that developed countries must take all practical steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to developing countries (Karakosta et al., 2010). The Canadian state, as a member of the UNFCCC and as a country that openly

recognizes, in fact endorses, the polluter pays principle, has the legal obligation to undertake tangible actions to remedy climate change and compensate developing nations that have been affected by it.

Most industrialized countries, in addition, have extensive experience and expertise in the renewable energy sector from which developing countries can learn and benefit. Canada, in particular, has several renewable energy centres and institutions that are active and capable of training the specialists needed to design, implement, maintain, and evaluate projects. Furthermore, Canada has well-organized and influential renewable energy trade associations, such as the Canadian Solar Industries Association (CanSIA) and the Canadian Wind Energy Association (CanWEA), which work collaboratively to develop and promote a strong, efficient, ethical, professional, and sustainable Canadian renewable energy industry with capacity to provide innovative solutions and play a major role in a global transition to a clean energy future (CanSIA, n. d.; CanWEA, n. d.). Lastly, it is important to take into account that several Canadian jurisdictions have significant experience in the development and implementation of renewable energy policies. The Province of Ontario, which in 2009 introduced a feed-in tariff program through the *Green Energy and Green Economy Act* (to support and incentivize electricity generation from renewable sources), has become a regional leader in this area and accumulated valuable know-how and lessons that would be useful for other countries and jurisdictions. The point is, in short, that Canada, as other industrialized nations, has the conditions, the capacity, and the knowledge base to help less privileged nations improve their human capital, research centres and training institutions, market conditions, and policy frameworks. The question then would be: why not do that?

How Can We Benefit?

The creation and implementation of international cooperation programs on renewable energy would likely be challenged by a number of groups and sectors in industrialized countries. Opposition should be expected especially from right wing political parties, activists, and organizations under the argument that the collaboration would only benefit developing countries and impose further pressure on public finances. This opposition, however, is mistaken and should not discourage developed countries from fulfilling their obligation. The fact is, as argued below, that the implementation of renewable energy cooperation programs and activities in the Global South has the potential to provide significant benefits to all participants. These initiatives, first and foremost, would benefit all humanity, both current and future generations, by decreasing GHG emissions associated with electricity generation, transmission, and distribution. Canada would be particularly favoured since it is a northern country in which many communities, critical infrastructure (e.g. cities, transportation systems, energy and communication grids, etc.), and ecosystems are highly vulnerable to the impacts of climate change (Lemmen, Warren, Lacroix, & Bush, 2008).

The implementation of cooperation agreements on renewable energy development offers additional advantages for industrialized nations. One of those advantages is that they would face less competition to access valuable non-renewable energy resources (e.g. oil) as developing nations would become more energy independent and less reliant on fossil fuels. This, in turn, would reduce geopolitical tensions and conflicts, thus, contributing to global peace (Karlsson-Vinkhuyzen et al., 2012). Another tangible benefit is the strengthening of dialogue and diplomatic relations among rich and poor nations. This is an important aspect taking into account that the existence of friendly relations opens the doors to collaboration in other areas (e.g.

transportation, health care, education, security, intelligence, etc.), enables opportunities for further science, technology, and expertise exchange, and fosters investments, trade, and economic activity (Desbordes & Vicard, 2006).

Undoubtedly, those are all compelling motivations to support the implementation of renewable energy cooperation initiatives. But there is another powerful reason to do so. This is related to the idea, as Cafaro (2009) observes, that citizens of countries that participate meaningfully and/or become global leaders in advancing solutions to global problems tend to develop patriotism and a sense of pride for their country. At the same time, Atteridge, Shrivastava, Pahuja, and Upadhyay (2012) point out, it improves the country's image and reputation internationally, which is a useful tool to attract tourists, investors, businesses, and foreign capital, stimulate economic activity and exports, and increase the country's political influence in the global arena.

The issue of reputation is particularly relevant for Canada. Prior to 2006, Canada was widely recognized for playing a constructive role in the global stage due to its efforts and commitment to promote peace, protect human rights, develop scientific knowledge, and fight against environmental degradation and climate change. Today, however, things are different. In the process of transforming the country into an "Energy Superpower," the current federal Conservative government has ignored the values for which Canadians stand for and has seriously damaged the country's reputation. Since then, paradoxically, Canada has gained recognition as a country that makes every possible effort to obstruct and sabotage international climate negotiations (Holmes, 2013). As the only country that failing to meet its GHG reduction obligations under the Kyoto Protocol withdrew from this Treaty in order to avoid the applicable sanctions (Glenn & Otero, 2012). As a country where the Prime Minister and members of his

Party have become fervent advocates of the fossil fuel industry and human-induced climate change deniers (Boyle, 2014). As a country where anyone who raises concerns about the rapid expansion of the tar sands and associated infrastructure is branded as a "radical," "extremist," and even "terrorist" (Climate Action Network Canada, 2012; Preston, 2013). And lastly, as a country in which state agencies, including police forces, the Royal Canadian Mountain Police, the Canadian Security Intelligence Service, Canada Revenue Agency, among others, have been deliberately, and illegally, used to control, intimidate, silence, oppress, and criminalize scientists, health professionals, politicians, environmental organizations, and First Nations who criticize and speak against the government's energy policy (Lukacs & Groves, 2012; Preston, 2013).

In that scenario, it could be argued that the implementation of a federal program focused on helping developing nations overcome renewable energy barriers and accelerate the deployment of these technologies would be a step in the right direction to start rebuilding Canada's international reputation as a leader in environmental protection. Additional steps would involve, for instance, adopting an ambitious national GHG emissions reduction target and strategy, eliminating subsidies to the fossil fuel industry, developing a national energy policy based on renewable energy, energy efficiency, and conservation, engaging and contributing to international climate negotiations, putting a price on carbon, and adopting the other recommendations proposed by over 60 Canadian scholars under the umbrella of Sustainable Canada Dialogues that could be implemented immediately to begin the necessary transition towards a low carbon and sustainable economy and society.[5]

[5] http://www.sustainablecanadadialogues.ca/en/scd

Chapter 6

Canada's Record and the Way Forward

In the previous Chapter, it was argued that Canada and the other rich industrialized countries have a legal duty, under the United Nations Framework Convention on Climate Change (UNFCCC), as well as a moral obligation with current and future generations to help poor developing countries in the development and implementation of climate change mitigation and adaptation strategies. This chapter builds upon that argument and attempts to identify the most appropriate mechanism through which the Canadian federal government, in a post-Harper era, can collaborate with low-income countries seeking to increase the penetration of renewable energy technologies in the electricity mix. That said, the discussion will start with a review of the most salient actions and initiatives implemented by the Canadian government to cooperate with and assist countries to overcome barriers and enhance renewable energy deployment. Subsequently, a number of different collaboration models and approaches will be assessed by

relying on the principles of effectiveness, efficiency, fairness, replicability, sustainability, and transparency (see Introduction) in order to identify the most promising, viable, and rational alternative.

Canada's Record on Renewable Energy Cooperation

Prior to 2006, the year in which the Conservative Party won the federal elections and formed a minority government under the leadership of Mr. Stephen Harper, Ottawa played an active role in the area of renewable energy cooperation. Between 2000 and 2005, the Canadian government created the Canada Climate Change Development Fund (CCCDF) as part of its climate change strategy. With a budget of $110 million that was administered by the Canadian International Development Agency (CIDA), this initiative provided financial assistance to low-income countries to develop projects on four key areas: emissions reductions, carbon sequestration, core capacity building, and adaptation (Government of Canada, 2014 -November 17). That program was an important tool to enhance Canada's reputation as it achieved impressive results in all geographic regions and in each of its focus areas. Yet, several issues contributed to inefficiencies in the administration of the CCCDF and reduced its overall effectiveness. One of the most pervasive problems was the lack of time to thoroughly design, implement, and evaluate projects due to short timelines and staff shortages (CIDA, 2004). Another significant shortcoming was the lack of engagement, consultation, and participation of developing country partners throughout the different phases of projects, a factor that undermined confidence and reduced local support (CIDA, 2004). The implementation of the CCCDF must, therefore, be used as a learning experience for future cooperation initiatives to ensure that they fulfill the objectives that they are meant to accomplish.

Simultaneously, the Canadian government, as most industrialized countries, strongly supported the Clean Development Mechanism (CDM) because of its potential to provide increased flexibility in achieving greenhouse gas (GHG) emissions reduction targets to which it committed under the Kyoto Protocol. Initially, even though Ottawa did not see itself as a project investor, it actively facilitated and promoted private sector involvement in the CDM system (Pape-Salmon, 2000). For this purpose, in 1998 it established the CDM & Joint Implementation Office, which received funds of $25.25 million between 2001 and 2006 (Government of Canada, 2009 - February 4). In the budget of 2000, however, the federal government allotted $100 million over four years to help developing countries reduce their GHG emissions (The Centre for Global Studies, 2001). Most of these funds were available for CDM activities through CIDA though a small portion was allocated to finance renewable energy projects (The Centre for Global Studies, 2001).

As part of the climate change strategy, the Canadian government implemented additional international cooperation programmes in support of renewable energy technology development. One of the most prominent initiatives was the Technology Early Action Measures (TEAM). Established in 1998 with a budget of $56 million, this programme aimed to accelerate the commercial deployment of environmentally sound technologies that could deliver GHG reductions by funding demonstration projects locally and in developing countries (Liming, Haque, & Barg, 2008). During its 10-year history, TEAM brought together private and public sector partners including Natural Resources Canada, Environment Canada, Industry Canada, Enbridge, Loblaw, Toronto Hydro, and 350 additional private companies and organizations (Government of Canada, 2008). By 2008, the initiative had successfully completed 140 projects,

23 of which focused on distributed renewable energy generation, in Canada and around the world (Government of Canada, 2008).

Thus far, Canada's main contribution to promote the deployment of renewable energy both locally and abroad is RETScreen, a pragmatic and innovative collaboration initiative that has gained global recognition. Since 1999, Natural Resources Canada and several strategic partners, including the U.S. National Aeronautics and Space Administration (NASA), the United Nations Environment Programme (UNEP), the Global Environmental Facility (GEF), the Renewable Energy and Energy Efficiency Partnership (REEEP), the International Renewable Energy Agency (IRENA), amongst others, have been involved in the development and improvement of RETScreen. RETScreen is a sophisticated clean energy software that is offered in 35 different languages , free of charge, and that is used around the world as a tool to predict, monitor, and evaluate the energy production, financial and technical viability, life-cycle costs, and GHG emissions reductions from various types of proposed energy efficiency and renewable energy technologies and projects (Government of Canada, 2005). As of March 2015, RETScreen had over 442,000 users in 222 countries (Government of Canada, 2015 - March 31). A new, improved version of the software, called RETScreen Expert, will be released to the public by the second quarter of 2016. With that upgrade, its creators expect to exceed one million users worldwide over the next decade and to reinforce RETScreen's position as the gold global standard for clean energy project analysis (Government of Canada, 2015 - January 23).

RETScreen has proven to be a valuable tool for many people and organizations. Being based in Microsoft Excel, as Roth et al. (2011) explain, makes it a convenient and easy to use application as most individuals and companies have access to that program and previous experience using it. In addition, the fact that RETScreen offers the option of choosing between

multiple energy systems and that each technology comes with a comprehensive manual, as well as with a wide range of supporting material on how to perform the calculations and understand the results, is a factor that enhances the friendliness and facilitates the use of the software (Roth et al., 2011). The high popularity of RETScreen, Etcheverry (2013) points out, can also be attributed to the work of a small, talented, and interdisciplinary team of experts that focuses its efforts "and limited resources for widespread development of local capacity in areas of strategic importance thorough innovative and sophisticated learning tools" (p.55).This approach and model, interestingly, has demonstrated that it is possible to make meaningful and transformative contributions to climate change mitigation and environmental sustainability without enormous amounts of money (Etcheverry, 2011). For all these reasons, one could argue that that these type of initiatives must inform future renewable energy collaboration arrangements.

Paradoxically, as mentioned above, the commitment of the federal government to promote and advance climate change mitigation efforts both locally and abroad was greater 10 years ago than what it is today. The reality is that since 2006, when the country was globally recognized as a leader in environmental protection, Ottawa has gradually reduced its support for renewable energy cooperation initiatives. This argument is based on the fact that Canada lacks federal policies or incentives to accelerate the deployment of renewable energy technologies (Climate Action Network Canada, 2012), that it has decreased the funds for renewable energy CDM projects, and that the current government eliminated CIDA and merged it with the Department of Foreign Affairs, Trade, and Development, an organization that is increasingly aligned with the government's foreign policy and trade objectives and not particularly interested in environmental, social, and humanitarian issues. Those facts are rooted in the reality that Ottawa has been opposed to the implementation of legally binding emission reduction targets

under a new framework, reluctant to join IRENA and, furthermore, that it has cancelled significant cooperation initiatives such as the CCCDF and TEAM.

It is important to recognize, however, that the Canadian federal government has maintained some cooperation programmes, such as RETScreen, and that it has implemented new ones. One of the most recent and significant collaboration initiatives is the Asia-Pacific Partnership on Clean Development and Climate. Launched in 2005 and terminated in 2011, the APP was a public-private partnership comprised of 7 countries (Canada, Australia, China, India, Japan, South Korea, and the United States) designed to accelerate the deployment and diffusion of clean energy technologies within Asia-Pacific countries as a strategy to address climate change, energy security, and air pollution challenges (International Energy Agency [IEA], 2012 - July 18). Canada joined the APP in October 2007 and was an active member in the partnership. Between 2008 and 2011, the Canadian government invested $13 million in 35 APP projects (Government of Canada, 2012 - May 9). In the field of renewable energy and distributed power generation, Ottawa helped to fund 7 projects, with an estimate investment of $3 million (Government of Canada, 2012 - May 9).

In other regions, Canada's engagement in renewable energy cooperation has also been focused on financing ad hoc, specific projects and initiatives. According to the Canadian government, between 2011 and 2013 Ottawa provided over $1.2 billion to support climate change actions in over 50 African, Asian, European, Latin American, and Caribbean countries (Government of Canada, 2013b). These resources have been used, primarily, to fund adaptation initiatives, clean energy projects, and reforestation campaigns in some of the world's poorest and most vulnerable countries (Government of Canada, 2013b). The problem with this model of collaboration, which is based on handing out money without appropriate scrutiny and

monitoring, is that it does little to promote the exchange of knowledge, experience, and technology, to accelerate research and development processes, to address the lack of a skilled labour force, to improve the market conditions for renewable energy technologies, and to enhance the policy framework. In other words, it is an insufficient and inadequate response to the needs of developing countries since it only helps to address the lack of financial resources, one of the many barriers that undermine the deployment and penetration of renewable energy technologies. With that said, it is clear, as Brown (2012) argues, that Canada's poor performance on international renewable collaboration is the direct result of the government's lack of ambition and commitment and, most importantly, of the lack of support to initiatives that do not offer opportunities or gains to Canadian businesses and that have little potential to advance Canadian interests.

The Way Forward

In recent years, Canada's international cooperation efforts in the renewable energy field have overwhelmingly been focused on financing isolated projects and initiatives in developing countries. This form of collaboration, even though useful to increase the offer and availability of financial resources in regions where the penetration of renewables is low or non-existent, is insufficient to address the broader issues that undermine the adoption of these technologies and the sustained growth of the sector. The main point of this research, therefore, is that Canada needs to redefine its current assistance programs and prioritize the expansion or development of new mechanisms designed to build or improve local know-how, to transfer experience and technology, to foster research and knowledge mobilization, to make renewables more cost-effective and competitive in the energy market, and/or to help beneficiary countries improve their policy and regulatory frameworks. The experiences of many countries and jurisdictions

from around the world suggest that in order to attract significant private sector investment, to make the renewable energy sector expand in a sustainable, organized, and fair manner, and to achieve economies of scale it is imperative to offer a qualified labour force, an appealing investment climate and incentives, transparent and accountable energy governance systems, and a culture of innovation and entrepreneurialism (Jacobsson & Lauber, 2006).

The post-Harper Canada must play an active role in assisting developing countries achieve GHG emissions and renewable energy targets. Canada's contribution would be particularly significant and useful in promoting and enhancing local capacity development and in improving renewable energy policy framework taking into account that it has experience and expertise in those areas. The key questions then become 1) how should Ottawa proceed or, in other words, what cooperation mechanism(s) or model(s) must be adopted to coordinate and provide the proposed assistance?; and 2) how could the Canadian government fund collaborative initiatives without imposing additional burdens on federal or provincial budgets?

In regards to the latter question, it can be expected that the large majority of Canadians will be opposed to the implementation of a international cooperation program, particularly during times of budgetary constraints, if it is to be funded with public money. In that sense, this research considers that the most viable alternative to advance international collaborations on environmental and humanitarian issues, finance climate change mitigation and adaptation initiatives, both locally and abroad, and foster sustainability education and actions is through the reduction or preferably elimination of federal subsidies to the fossil fuel industry. According to a 2014 report by the Pembina Institute, the annual federal subsidies to the oil and gas sectors amount to $2.8 billion (Dobson & Asadollahi, 2014). With those resources, Canada could make significant contributions towards solving complex transboundary problems, such as climate

change, and rebuild the reputation that it once had in the global sphere as an environmental and capacity development leader.

The question that remains to be addressed is what cooperation mechanism(s) or model(s) must be adopted to coordinate and provide international collaboration in the areas of renewable energy, local capacity development, and policy advising. In the area of capacity development, this research advocates for the expansion and strengthening of RETScreen. Over the years, that tool has proven to be an effective and comprehensive capacity development mechanism for specialists and professionals who are responsible for designing, implementing, maintaining, monitoring, and evaluating renewable energy and energy efficiency projects anywhere in the world. In addition, RETScreen has demonstrated to be an efficient and fair instrument taking into account that it has been around for over 15 years, that it is improved in a continuous basis, that can be downloaded by users in any country free of charge, that it is available in 35 different languages, and that it is a user-friendly software based on Microsoft Excel. Most importantly, as pointed out above, RETScreen has proven that it is possible to make meaningful and transformative contributions to climate change mitigation and environmental sustainability without having to invest astronomical amounts of money.

The proposal to the Canadian government could focus, most specifically, on offering comprehensive RETScreen training and certification free of charge for individuals who are involved or interested in pursuing a career in the renewable energy field as project designers, architects, engineers, developers, contractors, analysts, consultants, etc. The second component of the proposal consist in offering training and certification programs at no cost for members of marginalized and rural populations, prioritizing females heads of household, whom would be interested in becoming installers and/or operators of renewable energy systems. To take

advantage of these opportunities, beneficiaries must be citizens or permanent residents of those developing countries that are interested in creating a bilateral collaboration agreement with Canada. Whenever possible, the training should take place overseas. This would reduce the costs of the programs and provide a familiar learning environment in which participants feel comfortable and secure. However, if participants have the means to pay for most of their travel and accommodation expenses, Ottawa could provide the training in Canada and facilitate their movement by processing their temporary visa application free of charge. This focus could take advantage of the vast network of public institutions that the federal government already funds.

Currently, the RETScreen Training Institute already offers on-site training anywhere in the world. Under this program, RETScreen International sends two trainers from the RETScreen development team to conduct one or more of the RETScreen Training Institute courses. These courses, which are conducted on a full-cost recovery basis, have been offered in several countries, including Chile, Saudi Arabia, and China. In Chile, the staff of the Renewable Energy Centre, a division of the Chilean Ministry of Energy, received a comprehensive training through this modality in August 2012. Since then, they have developed the capacity to train others on RETscreen and have delivered numerous RETScreen workshops across the country (Government of Canada, 2013 - August 28).

The proposed mechanism of collaboration offers additional advantages. On the one hand, it could be argued that it is a feasible and pragmatic model taking into account that its design, implementation, administration, and evaluation can be carried out by a small number of people and uses existing supporting infrastructure such as universities and colleges. Similarly, it has a high potential for replicability since the proposed training and certification programs could be delivered at any time and place and could involve people from many different nationalities.

Lastly, it cannot be forgotten that the suggested cooperation initiative would be a step in the right direction towards advancing social and environmental sustainability as it would equip people and communities in developing countries with the technical tools that they require to build and maintain clean energy generation systems and, furthermore, with the knowledge to improve the livelihoods and standards of living for current and for future generations without destroying or irreversibly changing their natural environment.

In parallel to the efforts to enhance renewable energy local know-how in partner developing countries, the Canadian federal government could and should also provide its assistance to improve the policy framework in partner countries. This is a critical issue taking into account that the existence of renewable energy legislation, targets, and of a qualified labour force is not sufficient to develop a strong market. Achieving high penetration of renewable technologies requires, first and foremost, strong political commitment and a comprehensive package of policy instruments and incentives designed to and capable of enhancing the market competitiveness of renewable energy sources of electricity (Sawin, 2006). Several Canadian jurisdictions, as pointed out in Chapter 5, have accumulated valuable experience in the development and implementation of renewable energy policies. That practical experience could be useful for other countries and jurisdictions.

An example of this type of collaboration is the International Feed-In Cooperation. This is a joint project between the governments of Germany, Spain, and Slovenia that intends to foster the exchange of experience concerning feed-in tariff systems and help other countries in their endeavours to improve their existing, or introduce new feed-in tariff systems. With those purposes, since 2005 the Cooperation organizes two international workshops per year in which policy-makers, researchers, industry representatives, and other key stakeholders from different

nationalities have an opportunity to share experiences with the various design options of feed-in tariffs and discuss innovative approaches. With the support of this initiative, several countries and jurisdictions have successfully improved their existing framework or implemented new feed-in tariff schemes. Those schemes, interestingly enough, have proven to be the most suitable mechanisms to effectively and efficiently promote the development and deployment of renewable energy technologies (International Feed-In Cooperation, 2013).

In that context, this research recommends the federal government of Canada to consider the possibility of organizing and financing the implementation of a Renewable Energy Policy Expert Group (REPEG). This group, which would be bring together the country's leading experts and practitioners in the field, would be responsible for providing objective advice and recommendations to developing countries that seek assistance or guidance in the design, implementation, and/ or evaluation of renewable energy policies. Most of the initiatives that have attempted to establish mechanisms for policy exchange, coordination, and learning have achieved positive results as they often promote the adoption of the best available practices and policies and, most importantly, prevent making the same mistakes others have made in the past (Jacobs, 2012).

The chances of achieving the desired outcomes are higher if the Canadian government decides to pursue bilateral cooperation. This means that Ottawa should establish individual agreements with each country with which it plans to engage in collaboration. Taking this path would increase the effectiveness, efficiency, fairness, and transparency of the renewable energy partnership as it would be possible to customize it so that the specific needs of each country can be addressed and, furthermore, to ensure that beneficiary nations fulfill their obligations, if any, with Canada. Unfortunately, history has shown that multilateral cooperation frameworks, which

are the other alternative, are often ineffective, since there is no mechanism in international law to force compliance, inefficient, since negotiations are often complex and highly contentious, and unfair, as free-riders enjoy the same benefits without making any effort or sacrifice than those parties that fulfill their obligations.

To conclude this part of the discussion, it is important to reiterate that the Canadian government should start by redefining its role in renewable energy cooperation. As argued below, Canada's assistance would be more useful and meaningful if it dedicates its efforts and resources, both human and financial, to provide education and training opportunities for marginalized populations and to help developing countries enhance their policy frameworks, rather than limiting itself to finance isolated renewable energy projects, which is what it currently does. For this reason, it is imperative to strengthen and develop new channels for cooperation with the IRENA, the Clean Energy Ministerial (CEM), the Global Green Growth Institute (GGGI), the Climate Technology Centre and Network (CTCN), the United Nations (UN) Sustainable Energy for All (SE4All), the Renewable Energy and Energy Efficiency Partnership (REEEP), the Feed-in Tariff Cooperation, and any other Inter-governmental organizations (IGOs) and multistakeholder partnerships that work towards finding solutions to overcome non-financial barriers to renewable energy deployment. At the same time, it would be smart to work closely with international development cooperation agencies from other industrialized countries that are interested in advancing climate change mitigation initiatives in developing nations.

Chapter 7

Exploring Opportunities for Renewable Energy Collaboration between Canada and Colombia

Over the last decade, Canada's efforts in the field of international cooperation on renewable energy have been primarily focused on financing small scale, isolated projects in developing countries. Due to the sole focus on fossil fuel development, there has been a complete lack of interest in implementing initiatives that can help those nations overcome non-financial barriers to renewable energy development and diffusion. This research aims at filling that gap and suggest new ways for the Canadian government to redefine its role in the international stage and to begin a new chapter of cooperation in which Canadians can share their knowledge, expertise, and experience with those who need it the most. With that said, the purpose of this chapter is to demonstrate that implementing collaboration initiatives focused on building human resources in the renewable energy industry and in providing policy advice and support would benefit developing countries in terms of greenhouse gas (GHG) emissions

reduction, energy security, and environmental and social sustainability. Seeking to enhance the quality of the discussion, the analysis will focus on Colombia, and, more specifically, on how this South American nation could see tangible benefits if it decides to partner with Canada to advance collaboration on GHG mitigation focused on renewable energy.

The first question to consider is whether the Colombian government would be interested in entering into an eventual collaboration with its Canadian counterpart. As argued below, there are strong reasons to assume that Colombia would in fact be open to explore that possibility. The second section of the chapter will provide a brief overview of Colombia's electricity sector, a description of the main challenges and obstacles that hinder the growth of the renewable energy industry, and a short summary of the existing policy instruments and incentives through which the Colombian government attempts to foster the adoption of these technologies. Then, the chapter will conclude with a discussion of the potential benefits that Colombia's renewable energy industry, and society at large, could see if the country works closely with Canada towards building a strong renewable energy labour market and a comprehensive renewable energy policy framework.

Colombia: One of Canada's Potential Partners in Renewable Energy Cooperation

Colombia is a country that may potentially be interested in collaborating with Canada seeking to increase the penetration of renewable energy technologies, reduce GHG emissions, and advance energy security and sustainability. This assumption is based on the fact that both nations established full bilateral diplomatic relations in 1953 and that Colombia is one of Canada's closest partners, both politically and economically, in Latin America. As a matter of fact, the relationship between the two countries is multifaceted and it includes: closer economic

ties as a result of a bilateral free trade agreement that entered into force in 2011; a frank dialogue on human rights; development cooperation; support for Colombia's justice, security and peace-building efforts; exchange of people and culture; and, close cooperation on multilateral issues (Government of Canada, 2014 -March). From 2011, in addition, Canada has invested over $7 million towards the implementation of climate change mitigation and adaptation initiatives in Colombia. None of those initiatives, however, has yet focused on promoting renewable energy solutions.

The second reason to believe that Colombia would welcome Canada's cooperation is that the current Colombian government has expressed interest in promoting sustainable practices across all economic sectors. In his inauguration speech, President Juan Manuel Santos stated the following: "In this new dawn our country will be recognized for its leadership in addressing the most important issues for humanity, such as the sustainable use of biodiversity, clean energy, food security, technological development, and innovative industries" (2010, August 7). In support of those words, that year the country signed the International Renewable Energy Agency (IRENA) Statue (IRENA, 2013b). In 2014, in addition, the national Congress passed Law 1715 aiming to promote the development and use of non-conventional sources of energy, particularly those that are renewable and that do not pose unacceptable risks to global climate through emissions of carbon dioxide. Simultaneously, several Colombian universities and organizations (both governmental and non-governmental) have organized and held important conferences and events that have brought leading local, regional, and international academics, experts, and advocates, such as Al Gore, to discuss issues and strategies for advancing sustainable development, environmental protection, and social justice. In December 2015, similarly, the eyes of many will be on the City of Cali since it will host, with the support of the Colombian

government, the first version of The Solar Decathlon Latin America and the Caribbean, a prestigious competition that challenges participating teams to design, build, and operate houses that are run by solar power (Solar Decathlon 2015, 2015). All these events are indication that the Colombian government and society are starting to think differently and to embrace a culture of innovation and sustainability.

The third and arguably most important reason for welcoming international collaboration on renewable energy development is related to the fact that these technologies, as argued in Chapter 2, are key tools for advancing climate mitigation and adaptation since they reduce GHG emissions and diversify the energy matrix. In Colombia, these arguments are paramount taking into account that the country and its electricity system are highly vulnerable to the impacts of climate change. As of 2014, according to the Unidad de Planeación Minero Energética (UPME or Mining and Energy Planning Unit) (2015), the National Electricity System (NES) had 14,423 MW of installed capacity with large (>20 MW) hydroelectric generation systems accounting for 64.88 percent, small (<20 MW) hydroelectric systems for 2.88 percent, natural gas-fired stations for 27.79 percent, coal-fired units for 4.94 percent, cogeneration plants for 0.14 percent, and wind projects for 0.13 percent. Due to the dominance of hydroelectricity, Colombia's electricity generation sector has a lower carbon footprint in comparison to most developing countries. However, climatic changes and phenomena, such as El Niño, threaten to affect the availability of hydric resources, to raise energy demand and costs, and to increase energy production from fossil fuel-fired generation plants, which would boost GHG emissions, air pollution, and environmental degradation (Garcia, Corredor, Calderón, & Gómez, 2013; Mantilla-González, Duque-Daza, & Galeano-Ureña, 2008). As a result, it could be argued that promoting the diversification of its electricity mix by increasing the penetration of clean, renewable energy technologies is the most

sensible decision that the Colombian government could make. Failing to do so will increase the vulnerability of the sector, jeopardize energy security and reliability, and deprive Colombians from enjoying the benefits and opportunities that these sources of energy offer.

Colombia's Electricity Sector

During the second half of the 20th century, the Colombian state decided to make the expansion of the electricity network one of its main priorities. With the establishment of Interconexión Eléctrica SA (ISA) as the state-owned electricity grid operator in 1967, the creation of the Ministry of Mines and Energy in 1974, and the foundation of the Colombian Energy Institute (ICEL) in 1975, the integral development of the energy sector started (Briceño, 2006). During that period, Colombia's public debt increased dramatically as a result of investments in electricity generation, transmission, and distribution infrastructure (Briceño, 2006). In addition to the high debt, there was a crisis in the sector due to many inefficiencies in planning, structuring, and coordination between and within entities, which led to considerable delays and overruns in the development of projects, to inadequate allowance schemes, to the politicization of state enterprises, and to a low rate of electrification (Larsen, Dyner, Bedoya, & Franco, 2004). Meanwhile, influenced by neoliberal ideas and beliefs, governments in many countries moved ahead to allow private sector participation in electricity generation, transmission, distribution, and/or commercialization activities under competitive free-market conditions. These changes were in response to inefficiencies in the operation and management of state monopolies, to the desire to privatize state-owned companies and infrastructure, and to allow the injection of private capital in order to continue the expansion of a sector that requires huge investments with long payback periods (Batlle, Barroso, Pérez-Arriaga, 2010; Goldemberg & Mielnik, 1996).

In 1991, Colombia enacted a new Constitution which, among other things, substantially transformed the schemes for the provision of electricity and other public services. As in other countries, the state ceased to be the exclusive provider. The ratification of the new Constitution coincided with an intense drought, attributed to El Niño, that hit the country and caused a significant decrease in the levels of rivers and reservoirs and, furthermore, with a period in which most thermoelectric power plants were out of service due to lack of maintenance (Arango, Dyner, & Larsen, 2006). As a result, from March 1992 until April 1993 Colombia went through a period of electricity rationing that affected the majority of the population (Garcia & Dyner, 2000). In the context of that crisis and with the framework provided by the Political Constitution, in 1994 the National Congress promulgated Law 143 (the Electricity Law). This legislation profoundly reformed the electricity sector with the purpose of avoiding at all cost a future energy crisis (Larsen et al., 2004). Some of the major reforms included, for instance, a provision to allow the participation of public, private, and hybrid actors throughout the electricity supply chain, the creation of a wholesale electricity market, and the establishment of the UPME as the planning authority for the sector, the Energy Regulatory Commission as the market regulator authority, and the Superintendency of Residential Public Services as the state agency in charge of regulating and overseeing public utility service providers (Republic of Colombia, 1994 - July, 11). The reforms resulted in a change in the historical institutional structure, assigning the state the responsibility for defining policies, managing and regulating the wholesale electricity market, planning the development of the sector, and for supervising and monitoring electricity providers.

The reform to Colombia's electricity sector that took place during the 1990s did not intend to promote the development and implementation of renewable energy sources. In fact, the

Electricity Law did not even mention them. In consequence, it is clear that legislators at that time did not consider that climate change was a threat to the country's energy security. Perhaps they thought that the severe drought that led to prolonged nation-wide electricity rationing was an isolated, one-time even or that the country would have unlimited fossil fuel resources to compensate for a reduction in hydroelectric power generation and to meet the increasing demand for energy (Isaac, Biechl, & Gonzalez, 2008). However, in view of the impacts of climate change and of the fossil fuel industry, today it is clear that Colombia needs to start the transition towards a clean, low-carbon, reliable, resilient, affordable, and sustainable energy system right away by increasing the deployment of renewable energy technologies (other than large hydro), accelerating the uptake of energy efficiency, and promoting a culture of energy conservation.

Fortunately, Colombia has an enormous abundance of renewable resources. Based on information provided by the UPME (2010), the country's solar energy potential is estimated at 48,000 MW with radiation averages that vary from region to region between 4 kWh/day/m^2 and 6 kWh/day/m^2. Meanwhile, the wind potential, which is concentrated in the northern Department of La Guajira, is calculated at 99,000 MW. With regards to biomass, the UPME (2010) indicates that the potential is 19,000 MW, approximately, taking into account that there are huge coffee and banana plantation fields in several regions such as the coffee growing axis and the Gulf of Uraba, respectively. Similarly, it is important to consider the potential of small hydro (25,000 MW) as well as the potential of oceans (30,000 MW), which can generate renewable electricity from tidal streams, waves, or differences in salinity. The potential of geothermal energy, on the other hand, is unknown. However, preliminary studies suggest that it is high particularly in Los Nevados National Natural Park and in the border with Ecuador. The data presented here

represents information from possible and probable reserves. Therefore, it is imperative to develop studies aimed at evaluating, determining, and testing which resources are financially, technically, environmentally, and socially feasible to exploit and which are not. In relation to the last point, it is important to point out that Canada has experience and expertise mapping renewable energy resources.

Renewable Energy Targets, Policies, and Incentives in Colombia

In the last decade or so, there has been growing interest in developing renewable energy in various Latin American countries as a strategy to address energy challenges, advance climate mitigation and adaptation, and create economic opportunities. In 2010, Colombia committed itself to meeting 3.5 percent of electricity generation to the grid from renewables (excluding large hydro) by 2015 and 6.5 percent by 2020 (Republic of Colombia, 2010 - June 2). Furthermore, it was established that at least 20 percent of the electricity generated in non-interconnected (off-grid) zones must come from renewable sources (excluding large hydro) by 2015 and at least 30 percent by 2020 (Republic of Colombia, 2010 - June 2). These targets lack ambition and are a complete disappointment (given the gravity of the challenges faced and the abundance of renewable energy resources with which the country was endowed). However, it is imperative to understand that the Colombian renewable energy sector cannot grow without the existence of a strong legal, regulatory, and institutional framework, without innovative policy instruments and incentives, and without creating the conditions under which renewables can become cost-effective alternatives and compete with conventional energy technologies.

In Colombia, until very recently, there was no explicit legislation or regulation to promote the implementation of renewable energy solutions. The efforts have been emphasized

on energy efficiency and conservation programs, in which renewable energy sources have been introduced as an annexed theme (Republic of Colombia, 2001 - October 3). In 2000, the Colombian government established a tax support system to sustain financially the electrification of isolated and/or marginalized communities located in regions outside of the interconnected system. The Fund for the Electrification of Non-interconnected Zones (FAZNI), which receives a contribution of US$0.04457[6] per each dispatched kilowatt-hour (kWh) in the wholesale electricity market, finances the implementation of the most feasible (both financially and technically) electrification solutions (Republic of Colombia, 2000 - December 29). Thus, given that enabling interconnection to the national electric system in many cases is not a cost effective or even a possible alternative (due to factors such as distance, lack of infrastructure, geographic conditions, among others) the FANZI has become, unintentionally, the country's most effective tool to promote the deployment of distributed generation renewable energy technologies (Rodriguez-Patarroyo, 2014).

Over the last 15 years, as a result of this initiative hundreds of communities throughout the nation have been benefited with clean, sustainable energy systems that harness available renewable energy resources to generate electricity (Morales et al., 2015). This has translated into improved quality of life, reduced poverty and marginalization levels, and enhance education, health, security, and equality. Today, according to the World Bank (n. d.), there are over 1.4 million Colombians (3 percent of the total population) who continue lacking access to this essential service. Therefore, a key question is how to ensure that those 1.4 million individuals can have access to clean, renewable electricity so that they can be empowered and have the tools to overcome economic and social marginalization? Although answering that question is beyond

[6] Col.$1 was equivalent to US$0.04457 in February 2001 when the fund began receiving such money.

the scope of this paper, it must be noted that bilateral collaboration with Canada can help to advance a solution.

In 2002, some direct and indirect incentives for renewable energy promotion were established through the 788 tax reform. The Article 18 of such Law exempts from income tax to generators that sell wind and biomass electricity for a minimum of 15 years, as long as they fulfill two requirements: (1) to trade, to obtain, and to sale emission certificates of carbon dioxide according to the Kyoto Protocol, and (2) to invest at least 50% of the incomes obtained from the sale of such certificate in social infrastructure projects in the region where the generator operates (Republic of Colombia, 2002 - December 27). The Article, however, does not specify from when such tributary exemption goes into force and, most troublesome, it does not include other renewable energy sources and technologies that are abundant in Colombia (e.g. solar, small hydroelectric stations, and geothermal energy). In spite of these limitations, for many years the state naively expected that this incentive would be sufficient to encourage private sector investments in the renewable energy industry. As we know today, that expectation was not fulfilled since investors did not perceive renewables as profitable alternatives.

In view of that, in 2014 the Colombian government passed Law 1715. The legislation attempts to promote the integration of renewable electricity into the NES by establishing a legal framework and the instruments for the promotion of those technologies. It mandates, specifically, for the implementation of new taxation and financial incentives to facilitate the import of technology, for establishing a scheme to encourage small-scale electricity generation for self-supply purposes (net metering or net billing), and for replacing diesel power generation systems by cleaner and more efficient technologies in non-interconnected zones (Republic of Colombia, 2014 -May 14). At the time of writing this paper, the regulations of Law 1715 had not

yet been released. Despite that, there is great optimism within government circles about the ability of the legislation to accomplish its goals. In this regard, Dr. Táutiva (personal communication, March 30, 2015) indicated that the proposed instruments will provide certainty to all players in the sector, reduce the costs of renewable energy technologies, foster private sector investments, and empower common citizens through the democratization of energy generation. Dr. Zapata-Lesmes (personal communication, April 13, 2015) further suggested that the new law will help advance climate change mitigation and adaptation efforts in a sustained and organized manner and without jeopardizing energy security, reliability, or the stability of the wholesale electricity market.

Obstacles to Renewable Energy in Colombia

Colombia, as discussed above, has an enormous abundance of renewable energy resources. Yet, the share of these technologies (except large-hydro) in the country's energy portfolio is extremely low. This situation should not come as a surprise given that Colombia lacks appropriate incentives and policies, it has been governed by individuals who have different agendas and priorities, and that, until very recently, it did not have a legal and regulatory framework designed to dictate the deployment of renewable energy technologies and to provide certainty to investors. In addition, it cannot be forgotten that Colombia lacks detailed renewable energy studies as well as reliable information about the characteristics, distribution, and potentials of renewable energy reserves. Without that information it is impossible to start the transformation of the energy sector.

The growth of the renewable energy industry in Colombia is further undermined by the high costs of the technologies in relation to other energy sources. In this regard, it cannot be

denied that renewable energy solutions generally require greater upfront capital investments per MW installed. However, the main reason for that situation, as Garcia et al. (2013) point out, is that the methodologies used in Colombia to determine electricity generation costs neither take into account the negative social and environmental externalities of conventional technologies throughout their life-cycle nor the numerous social, economic, and environmental benefits that renewable technologies have (see Chapter 2). These methodologies, in consequence, unfairly disadvantage renewables.

In addition, the current electricity regulatory system promotes the construction of large hydroelectric dams and thermoelectric stations by offering a subsidy for every kWh of electricity generated. The rationale for this subsidy, which is known as the Reliability Charge, is that hydroelectric, gas, and coal power plants can produce and deliver energy uninterruptedly. This rationale ignores the fact that renewable energy sources, such as wind and solar, are also reliable due to rapid advances and increased affordability of energy storage technologies and solutions. For that reason, one could argue that the Reliability Charge, which was introduced in 2006 to guarantee supply reliability during periods of drought (Energy Regulatory Commission, n. d.), discourages investments in variable renewable energy technologies, thus, perpetuating the dominance of conventional energy sources, undermining the diversification of Colombia's electricity mix, and making the country's energy system increasingly dependent on fossil fuels and vulnerable to the impacts of climate change.

Another barrier to the development of renewable energy technologies in Colombia is given by the lack of financial mechanisms directed specifically to the implementation of projects. There are some government funds that can help finance research, development, and innovation projects (e.g. Bancoldex - Colciencias Fund) as well as projects for environmental improvement

and sustainability (e.g. Bancoldex "aProgresar" Fund) (Rodriguez, 2011). There are also credit lines available through commercial banks, though the interest rates are extremely high (Benavides, 2011). Lastly, there are also a few funds provided by some of the most recognized multilateral banks and organizations, including the Inter-American Development Bank, the World Bank, the United Nations Environment Programme (UNEP), the United Nations Development Program, and the Global Environment Facility, which are specifically designed to finance renewable energy projects in developing countries. These mechanisms, however, are insufficient to meet the demand for finance to develop renewable energy sources to their full potential.

In addition, the Clean Development Mechanism (CDM) has not been an effective vehicle for promoting renewable energy deployment in Colombia. Given that the electricity mix is dominated by hydro generation and that it has lower contribution of GHG compared to the electricity mixes of other countries, such as Mexico and China, which are highly dependent on fossil fuels, it has been regarded as clean and environmentally friendly (Lokey, 2009). As a result, renewable energy project developers have faced enormous challenges when seeking to obtain CDM credits. In fact, as of 2015, only 25 projects have been partially or completely financed through this system (United Nations Framework Convention on Climate Change [UNFCCC], 2015). For this reason, it is imperative to understand that for the energy transition to happen in Colombia it is absolutely necessary to create attractive financial mechanisms to which small and medium-size companies, communities, and individuals interested in developing renewable energy projects can easily access favourable finance and know-how.

Another obstacle to consider is that most renewable energy resources in Colombia, as in other countries, are located in remote, inaccessible areas where the grid is not available. These

areas, incidentally, tend to be property of either Indigenous or Afro-Colombian populations or have been designated as natural reserves or parks. In addition to the lack of transmission lines, there is a lack of clarity in the legislation with regard to processes of consultation with communities and to environmental impact assessments. As a result, renewable energy developers usually find themselves in a situation in which not only they lack the infrastructure that they need to wheel the electricity generated but also clear directions on how to engage local populations and on how go about fulfilling environmental protection requirements, thus, making the process difficult, time-consuming, and expensive. The development of thermoelectric power plants, in contrast, does not face these challenges as they have been given the advantage to be installed anywhere without as much red tape.

It is also important to point out that the political and social conditions in Colombia are not the most favourable for renewable energy investments and deployment. Over the last 60 years, this South American country has faced a civil armed conflict between the state, left-wing guerrilla groups, and right-wing paramilitary organizations in which millions of Colombians have been murdered, disappeared, kidnapped, and/or displaced from their homes and territories. Although the perception of security has improved during the last few years, there are still instances when illegal armed groups commit terrorist acts on energy and oil/gas infrastructure (e.g. transmission towers and pipelines), kidnappings of workers and executives in isolated areas of the country, and attacks on rural civilian populations. This unrest creates unstable environments for local and international businesses and investors that may be interested on harnessing the vast untapped renewable energy potential available in the country.

Finally, it must be said that the lack of local know-how is a major obstacle to the penetration of renewable energy technologies in the Colombian electricity sector. In this regard,

Dr. Zapata-Lesmes (personal communication, April 13, 2015) claims that the country has a serious shortage of institutions, universities, and colleges dedicated or at least interested on promoting research, technological development and innovation, and the formation of human capital in the renewable energy field. He further argues that the limited number of programs on renewable energy system installation and project planning and implementation, which are offered by educational institutions such as the University of Los Andes, the National University of Colombia, and the National Service of Learning, only accept few people in the country's largest urban centres, thus, leaving rural and small-city populations excluded and deprived from educational opportunities. This fact is just a the reflection of a broader and more complex issue, namely, the state's abandonment of its responsibility to guarantee economic development opportunities in all regions and to promote social justice.

What Role Can Canada Play?

The central argument of this research is that the Canadian federal government should become more involved in assisting low-income, developing countries to promote the use of renewable energy technologies. That type of collaboration, as argued in Chapter 6, can be bilateral and focused on enhancing the partner country's policy and regulatory framework and on fostering local capacity development. The example of Colombia provides an illustration of the areas where help is needed and the type of barriers to renewable energy development that need to be addressed. A well designed bilateral collaboration with Canada can result in increased penetration of renewables particularly if the selected cooperation mechanisms are well-funded and sustained over a long period of time.

The areas of collaboration for the government of Canada have two main components. First and foremost, it is recommended to take the necessary steps to implement the Renewable Energy Policy Expert Group (REPEG) as a tool to work closely with beneficiary countries towards improving policy and regulatory frameworks. Considering that Colombia recently passed Law 1715 to legislate the integration of renewable electricity into the NES, the assistance and expertise of such a group would be highly valuable particularly during the drafting of regulations and the design of the policy instruments that are needed to achieve the goals of the legislation (Dr. Táutiva, personal communication, March 30, 2015). Without that assistance, Colombia is exposed, due to the lack of experience, to repeat some of the mistakes made in other countries and jurisdictions. It will also risk developing inadequate or obsolete regulations and/or selecting the policy tools that may not necessarily be the most effective, efficient, fair, feasible, replicable, sustainable. From that perspective, one could argue that the implementation of the REPEG would be a step in the right direction towards ensuring that Colombia and other developing countries develop policies and regulations capable of making the renewable energy sector grow in a sustained and organized manner.

The second component of bilateral collaboration analysed consists of two recommendations aimed at building local know-how and skills on renewable energy systems and technologies. The first recommendation is to offer comprehensive RETScreen training and certification free of charge for trainers who are involved or interested in pursuing a career in the renewable energy field. The second recommendation is to provide high-quality training and certification programs at no cost for members of marginalized and rural communities, prioritizing females heads of household that can become installers and/or operators of renewable energy systems. Thus, given that Colombia lags behind in terms of renewable energy capacity

development and that an overwhelming majority of its population lacks access to training programs, it is clear that the implementation of these recommendations would help to address the shortage of skilled personnel and the insufficient technical expertise for planning, building, operating, maintaining, and decommissioning projects and for training experts in the field (Dr. Táutiva, personal communication, March 30, 2015).

Overcoming renewable energy obstacles is a priority considering that Law 1715 will likely increase investments in the renewable energy sector as well as the demand for qualified workers. In addition, since the Colombian government is currently engaged in negotiations with illegal armed groups to put an end to the civil war, there is an urgent need to develop strategies to help hundreds of thousands of soldiers and rebels reintegrate into society and to improve the livelihoods of victims and their families once the conflict is resolved. In that context, the proposed collaboration between Colombia and Canada in the area of renewable energy capacity development can be seen as an opportunity to promote reconciliation and healing and as a chance to change and improve the lives of individuals who were immersed and/or who suffered the consequences of war. Similarly, it can be seen as a vehicle to empower them economically and to give them the tools to transform their communities into more sustainable, resilient, and prosperous places.

To summarize, this paper presents and explores a few suggestions so the Canadian federal government can play a more active and meaningful role in assisting other countries, such as Colombia, in promoting the implementation of renewable energy solutions. The proposed system of collaboration does not necessarily have to be limited to provide financial assistance for the construction of isolated projects. In fact, as Dr. Táutiva (personal communication, March 30, 2015) and Dr. Zapata-Lesmes (personal communication, April 13, 2015) argue, Canada's

cooperation would be much more useful and valuable if it focuses on transferring accumulated experience and knowledge and in devoting resources, both human and financial, aimed at creating an attractive renewable energy market, regulatory and social conditions for private investments, local community participation in renewable energy projects, and opportunities to empower local trainers and entrepreneurs. In that sense, it is worth to reiterate that the next federal government has the challenge, and opportunity, to redefine the country's role in the international stage and to decide whether Canada can be again a well-respected international leader.

Conclusion

The scientific evidence available today overwhelmingly indicates that the warming of the climate system, as a result of human interference, is unequivocal and unprecedented. Avoiding catastrophic climate change requires immediate attention and collective efforts. One of the main priorities is to reduce greenhouse gas (GHG) emissions across all countries and economic sectors by promoting the use of clean, low-carbon technologies. This tasks entails, more specially, the use of instruments and incentives designed to start a transition towards energy systems based on renewable energy sources. The good news is that the deployment of these technologies not only advances climate mitigation efforts but also promotes environmental and resource conservation, energy security, employment creation, economic development, social *justice, and resilience against a changing climate and extreme* weather events. The bad news, on the other hand, is that despite rapid technological advances and increased economic viability, the widespread

implementation of renewable energy solutions has been hindered, particularly in developing countries, by the existence of market-related, economic, financial, institutional, regulatory, technical, social, cultural, behavioural, and other barriers.

Dismantling those barriers will require an in-depth understanding of the challenges faced and the implementation of a variety of instruments and mechanisms that are increasingly recognized by energy experts as effective in the facilitation of renewable energy deployment. International cooperation is one of those tools. Collaboration among countries can play a constructive role in the development, diffusion and transfer of knowledge and environmentally sound technologies as well as in fostering local capacity, accessing finance and funding to develop new projects, ensuring that new technical and policy initiatives are informed by know-how accumulated in leading countries and jurisdictions, and guaranteeing that new renewable energy projects are of the highest quality and reliability. A wide variety of cooperation models have been implemented through multilateral initiatives, such as the Clean Development Mechanism (CDM), bilateral efforts, Inter-governmental organizations (IGOs), such as the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), and International Partnerships, such as the Renewable Energy and Energy Efficiency Partnership (REEP). Some mechanisms have been more successful than others in helping countries overcome renewable energy barriers and increase the penetration of renewable energy technologies. However, the overall progress in the field has been slow and unsatisfactory due to the lack of commitment of most developed countries to implement, support, and/or become engaged in cooperation initiatives and to the fact that the current landscape of actors and institutions in support of renewable energy is characterised by compartmentalization, limited systematic sharing of information, limited funding, and poor local coordination.

In addition to that, it must be noted that there are insufficient mechanisms designed to promote local capacity building and provide training in careers related to the renewable energy industry. Most collaboration initiatives, as a matter of fact, focus on creating platforms for technology transfer and opportunities to finance isolated renewable energy projects in developing countries. As a result, there is a shortage and an urgent need at the local and national levels for individuals and specialists capable of planning, building, operating, evaluating, and decommissioning renewable energy systems. For that reason, this report recommends that the Government of Canada creates new collaboration initiatives aimed at addressing those shortcomings. The proposal, more specifically, advocates for implementing a program in which individuals who meet a number of conditions would qualify to receive a comprehensive training and certification free of charge either on RETScreen and/or on renewable energy system installation and maintenance.

This report also recommends that the Canadian federal government takes steps to help partner developing countries enhance their policy framework for renewables. This is a critical issue taking into account that achieving a high penetration of renewable energy technologies requires the existence of a comprehensive package of policy instruments and incentives designed to and capable of enhancing market competitiveness and community participation. Therefore, it is desirable to create a Renewable Energy Policy Expert Group (REPEG). This group would bring together Canada's leading experts and practitioners in the renewable energy field and would be responsible for providing objective advice and recommendations to low-income countries that seek assistance or guidance in the design, implementation, and/ or evaluation of renewable energy policies, strategies, or programs.

The proposed initiatives should ideally be funded with public money. This alternative, however, is not politically or economically feasible if the programs put increasing pressure on the federal budget. Therefore, it is imperative to find alternative funding sources. In that sense, this research concludes that the most viable solution is to reduce, or preferably eliminate, federal subsidies to the fossil fuel industry and to use those resources to advance environmental, sustainability, social, and humanitarian initiatives both locally and abroad. At the end of the day, it must not be forgotten that Canada has a moral and legal responsibility to help developing nations in the implementation of climate change mitigation and adaptation strategies. This argument is based on the facts that our country is among the top ten emitters of GHG and has formally endorsed the United Nations Framework Convention on Climate Change (UNFCCC) as well as the polluter pays principle, and that over the years it has accumulated valuable experience and know-how on renewable energy development from which low-income, developing countries, including Colombia, could learn and benefit.

The concluding message that this report aims to convey is that Canada is a privileged country that has the necessary tools, capacity, knowledge base, and talent to become an international leader in the promotion of renewable energy development and deployment. Other developed countries, such as Germany, have managed to achieve a higher penetration of these sources of electricity in relatively short periods of time and play a very active international role facilitating renewable energy development worldwide. Several Canadian provinces have successfully developed, without any support from the federal government, their own renewable energy industry, policy framework and incentives, trade associations, as well as centres and institutions that are capable of training the specialists needed to design, implement, maintain, evaluate, and decommission projects. This suggests that if Ottawa decided to promote the

renewable energy sector to the same extent that it promotes tar sands development, Canada could accomplish what Germany is doing. At the same time, it could improve, increase, and expand renewable energy collaboration programs in developing countries where the penetration of these technologies is insignificant. With that in mind, it is worth to reiterate that our country urgently needs new leadership at the federal level and a government that recognizes the importance of transitioning towards a low-carbon, sustainable economy and society and that represents the interests of the people and not the interests of the fossil fuel industry.

In the meantime, it is imperative to conduct further research that can help Canadians understand the importance and benefits of implementing the proposed initiatives. It would also be useful to start identifying countries that are seeking to reduce their GHG emissions, advance on issues such as energy security, and that would be interested in entering into a long-term bilateral agreement with the Canadian government to expand renewable energy collaboration. As part of this process, researchers must analyse whether cooperation between the two nations is in fact feasible. Furthermore, they ought to gain an in depth understanding of the electricity sector, of the regulatory and policy framework for renewable energy development, and of the barriers that hinder the penetration of these technologies and their ability to enter and compete in the market. Simultaneously, and most importantly, they should assess whether political commitment exists and whether Canada's collaboration, which would primarily focus on capacity building and policy advising, could help the country in question overcome the barriers and enhance the implementation and commercialization of renewable energy solutions in an effective, efficient, fair, and transparent manner.

Lastly, it is important to research and analyse alternative courses of action. One of the paths that Canada could follow is to join the IRENA, contribute to its funding, and provide

scholarships to train renewable energy policy developers, project managers, designers, technicians, installers, inspectors, electricians, machine builders, etc. Taking that direction may possibly be a more effective, efficient, fair, feasible, replicable, and sustainable collaboration strategy to facilitate renewable energy development in low-income countries than the one proposed in this paper. The point is, therefore, that in order to make an informed and rational decision Canadian legislators need to be provided with evidence that conclusively demonstrates that a particular collaboration model, mechanism, or strategy is more appropriate, suitable, and desirable than others.

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