

LBNL-61472

Conference Paper
Partnerships for Clean Development and Climate:
Business and Technology Cooperation Benefits

Jayant A. Sathaye, Lynn Price, Satish Kumar, and Stephane de la Rue du Can
Lawrence Berkeley National Laboratory
Berkeley, CA 94720

Corina Warfield
US Department of Energy,
Washington DC

S. Padmanabhan
US Agency for International Development
Delhi, India

22 August 2006

This work was supported by the US Agency for International Development, Office of Environment, Energy and Enterprise, New Delhi, India through the US Department of Energy under Contract Number -AC02-05CH11231.

Table of Contents

Preface.....	iii
1. What's at Stake: Clean development and Climate	1
2. Progress in Securing Energy in APP Countries	2
3. The Government of India's Energy Vision Indian Public and Private Sector Energy Institutions	6
4. Current State of Technologies and Services.....	8
5. Partnerships for the Promotion of Energy Efficiency and Renewable Energy: A Review.....	15
6. APP – Business and Technology Cooperation Benefits	25

Table of Tables

1. Electricity Generation Capacity, India (2004-05).....	4
2. Electricity from Renewable Options, Costs and Capacity.....	5
3. Cost-effective Energy Efficiency Improvement Potential, India.....	9
4. Key Activities of Industrial Sector Partnerships Related to Energy Efficiency and GHG Emissions Mitigation.....	16
5. Key Activities of Buildings Sector Partnerships Related to Energy Efficiency and GHG Emissions Mitigation.....	17
6. Key Activities of Renewables Energy Partnerships	20

Table of Figures

1. Primary energy supply fuel shares in APP countries
2. Energy efficiency is competitive with generation technologies
3. Primary Energy Supply
4. Primary Energy Supply per Capita
5. Primary Energy Supply per GDP
6. Electricity Generation per GDP
7. Primary Energy Supply Shares, APP Countries
8. Annual Production of Cement, Steel, and Aluminium in the Asia Pacific Partnership Countries
9. Primary Industrial Energy Consumption per Value Added
10. Residential Primary Energy Consumption per Capita
11. Decomposition of India's CO ₂ Emissions
12. Efficiency/Intensity Per Unit Floor Space in Existing Buildings

Preface

Development and poverty eradication are urgent and overriding goals internationally. The World Summit on Sustainable Development made clear the need for increased access to affordable, reliable and cleaner energy and the international community agreed in the Delhi Declaration on Climate Change and Sustainable Development on the importance of the development agenda in considering any climate change approach.

To this end, six countries (Australia, China, India, Japan, Republic of Korea and the United States) have come together to form the Asia Pacific Partnership in accordance with their respective national circumstances, to develop, deploy and transfer cleaner, more efficient technologies and to meet national pollution reduction, energy security and climate change concerns consistent with the principles of the U.N. Framework Convention on Climate Change (UNFCCC). The APP builds on the foundation of existing bilateral and multilateral initiatives complements.

APP has established eight public-private sector Task Forces covering: (1) cleaner fossil energy; (2) renewable energy and distributed generation; (3) power generation and transmission; (4) steel; (5) aluminium; (6) cement; (7) coal mining; and (8) buildings and appliances. As a priority, each Task Force will formulate detailed action plans outlining both immediate and medium-term specific actions, including possible “flagship” projects and relevant indicators of progress by 31 August 2006. The partnership will help the partners build human and institutional capacity to strengthen cooperative efforts, and will seek opportunities to engage the private sector.

The APP organized An Outreach Workshop: Business & Technology Cooperation Opportunities for Industry on August 26, 2006, New Delhi. This paper was prepared to provide background information for participants of the Conference. It highlights energy efficiency, renewable energy, and climate technologies, barriers, and partnerships that are being implemented in the US, India and other selected countries. The paper discusses the lessons to be learned from these partnerships, and ways by which the APP could foster cooperation between India and the other member countries. It highlights the types of technologies that Indian public sector and private industry could access from US national laboratories and also be able to leverage current and planned USAID/India activities. The paper builds on an earlier background paper that was prepared for the US-India Energy Dialogue Working Group on Energy Efficiency.¹

¹ Sathaye J., de la Rue du Can S., Kumar S., Iyer M., Galitsky C., Phadke A., McNeill M., Price L., and Bharvirkar R. 2006. *Implementing end-use efficiency improvements in India: Drawing from experience in the US and other countries*. LBNL – 60035

1. What's at stake: Clean development and climate

The Indian economy has grown rapidly over the past decade. The rapid economic growth has been accompanied by commensurate growth in the demand for energy services that is increasing the country's vulnerability to energy supply disruptions. This vulnerability is not unlike that observed in the US, China, Japan, S. Korea, and other countries² that import an increasing share of their oil and gas needs.

India relies on biomass, indigenous coal, and to a lesser extent oil, to meet its energy demand (Figure 1). While the country has large reserves of coal, it relies on imported oil for almost two-thirds of its oil needs, possesses limited natural gas reserves, and faces chronic electricity shortages. The inability of the electricity grid to supply reliable power, particularly to business consumers, has prompted increased use of captive power generation that often uses diesel fuel. The rising demand for petroleum products and natural gas is expected to be met through imports. Coupled with deteriorating coal quality, India's energy situation is likely to worsen its vulnerability to volatile fuel prices in a tightening world oil and gas market.

These vulnerabilities are being addressed through diversification of energy imports, the development of indigenous fossil and renewable energy sources, and, last but not least, reduction of the intensity of energy use of the Indian economy. In this report, we focus on ways to stretch India's existing energy supply capacity by making energy use more efficient and the development of renewable and other indigenous fuel supplies.³ The increased efficiency will permit energy companies to meet their demand obligations, and energy-short businesses to increase production that will result in higher tax payments to governments at all levels. More efficient use, and increased development of renewable energy and clean fossil fuel technologies thus have the potential to reduce the nation's vulnerability in both the imported fuels and electricity markets.

Improving energy efficiency on the demand- and supply-side forms a core component of the work plans for most of the eight APP Task Forces (TFs). A key question often posed in earlier studies of energy efficiency is if the technologies are cost effective (Figure 2) should their market penetration be higher than commonly observed in developed and developing countries? Likewise, given the strong environmental and potential rural welfare benefits of renewable energy technologies should their penetration be encouraged despite the higher cost of some technologies? If their market penetration should be higher, then what is the role for international partnerships?

² While bulk of this report is about US and India, we highlight examples from other APP countries that have made substantial gains in pursuing clean development and climate programs. .

³ There are two ways of increasing the efficiency of electricity use - 1) using energy efficient technologies to permanently reduce peak demand; and 2) creating mechanisms that allow electricity customers to occasionally reduce electricity usage for short time periods in response to signals from system operators either for economic purposes or grid safety purposes

Goal of the Report:

This report accepts the premise that many clean energy technologies are cost effective, and that their implementation is hampered by institutional, procedural, and process barriers. This is not unique to India. There are lessons to be learnt from other developed and developing countries, including the APP participants, in understanding ways that energy efficiency, renewable energy, and other APP Task Force (TF) technologies could be transferred in the Indian market environment. The main goal of the report is to explore partnership activities that ensure that public policy and programs work with market forces and businesses for implementation of energy efficiency, renewable energy and other APP technologies and practices⁴. The paper provides a review of the activities covered by selected successful partnerships in industry, buildings, and renewable energy sectors, and draws lessons about the role that APP could play in fostering cooperation among the participating countries in these and other task forces.

What the Report Covers:

The next section of the report illustrates the progress that APP countries are making in securing energy and improving energy productivity since 1971. Section 3 discusses the Indian government's vision and the institutions the country has established to design and implement its energy efficiency and renewable energy mandates. Section 4 provides examples of technology, barriers to market penetration, and the importance of identifying the institutions that could benefit from the implementation of APP technology programs and projects. Section 5 focuses on the partnerships that are being implemented in the APP countries including those in India in the buildings, industrial, renewable energy, and other sectors. Section 6 concludes by noting the lessons learned and the key activities that could become part of the APP partnership. Wherever appropriate, we note the best practices that could be implemented in India to promote APP goals.

2. Progress in securing energy in APP countries

India currently ranks sixth in the world in terms of primary energy demand. In order to achieve its goal of 8-10% of GDP growth per annum through 2030, its primary energy supply, at a conservative estimate, will need to grow by 3 to 4 times and electricity supply by 5 to 7 times. Its power generation would increase to 780,000 MW from a current level of 120,000 MW and annual coal demand would be in excess of 2000 million tons from a current level of 350 million tons⁵. At this rate, its demand for energy will continue to soar and by 2030 it could emerge as the fourth largest consumer of energy after the US, China and Japan. This extraordinary growth in demand will place great stress on the financial, managerial and physical resources of the country, creating capital and energy shortages as well as environmental problems.

India's primary energy supply, excluding the supply of about 6.8 exajoules (EJ) of biomass, was about 14.5 EJ in 2003 (Figure 3), making it the fourth ranked among APP countries after US, China and Japan. The smaller size of the Indian economy is a factor in its lower energy use, but higher space heating demand is a significant factor in the larger energy use in the US and China. India's energy use per capita (excluding traditional biomass) is the lowest among the APP

⁴ APP technologies and practices are those that are being considered by the TF action plans as being suitable for partnership consideration. The TF action plans are currently being formulated.

⁵ Planning Commission, Government of India, (2005) *Draft Report of the Expert Committee on Integrated Energy Policy*, December

countries. It increased at the same rate as that of China since 1971 despite India's much higher population growth rate (Figure 4). The Indian population increased from 560 million in 1971 to 1,064 million in 2003 while China's increased from 841 million to 1,288 million over the same period.

While the share of natural gas has increased over the past three decades, coal and oil supply dominate India's energy sector (excluding biomass) (Figure 1). Coal is used extensively for power generation and in heavy industry and to a minor extent for rail transportation and cooking. Gasoline and diesel is used predominantly for transportation, and kerosene is used for lighting and, along with LPG, for cooking in the residential sector. Natural gas is used mostly for electricity generation and as a raw material for the chemicals and fertilizer industry.

The intensity of energy and electricity use is a measure of the energy required to produce a unit of economic activity, i.e., it is a measure of the energy productivity of an economy. This energy intensity has declined steadily in the US and other industrialized countries since the late 1970s, and more steeply in China since 1980 (Figure 5). Chinese energy supply increased at half the rate of economic growth until 2001 when it began to increase rather sharply raising concerns about the country's ability to maintain a high level of energy productivity in an era of increasing market liberalization. On the other hand, electricity generation intensity in China, Japan and the US has hovered around the same level as it was in 1971 (Figure 6). Electrification of the economy is evident here as it has increasingly substituted for other energy carriers and expanded its reach into newer end uses.

In contrast to the trends observed for the US and China, India and Korea's intensity of primary energy supply increased from 1971 to the 1990s, and then declined steadily. India and Australia's electricity generation intensity too increased until the 1990s, and stabilized after that, but that in Korea continued to increase.

Installed electricity generation capacity in India was 124 GW in 2004-05 (Table 1), including 13 GW in the private sector. Over half of the capacity was coal fired, and hydro and gas constituted much of the remaining share. Due to continued shortages of electricity supply, captive power generation continues to play an important role in providing electricity, albeit expensive, for industrial and commercial, and increasingly for urban residential consumers.

Electricity shortages amounted to 8.0% of energy demand, and power shortages to 11.6% of peak demand between April, 2005 and January, 2006. Energy efficiency, particularly in lighting where the stock turnover is rapid, can provide a short-term solution for the peak power shortage.

A growing amount of diesel fuel is used for captive and/or backup electricity generation. The total installed capacity of diesel based captive power plants with a capacity more than 1 MW was 7,195 MW in 2003-2004.⁶ Manufacturers report that the capacity of plants that were sold from 1990 to 2004 is of the order of 23,000 MW. Since the life of diesel generators is generally more than 15 years, most of these plants are likely to be operational today. Hence, the total installed capacity of diesel based back-up generation in India may be estimated to be about 30,000 MW.

⁶ Central Electricity Authority (2005) *Report on Tapping of Surplus Power from Captive Power Plants*. New Delhi: CEA, Ministry of Power, Govt. of India.

Table 1: Electricity Generation Capacity, India (2004-05)

	Generation Capacity	
	(MW)	(%)
Coal	68,434	55.5
Natural Gas	12,430	10.0
Oil	1,201	0.9
Hydro	32,135	26.0
Nuclear	3,310	2.7
Other	6,158	4.9
Total	123,668	100
Captive (>1 MW)	7,195	23.8
Captive (< 1 MW)	23,000	76.2
Total Captive	30,195	100

Source: Economic Survey, Govt. of India (2006) and CEA (2005)

Information on the average plant load factor (PLF) of diesel-based back-up generation plants is not available. Shukla et al. (2004) indicate the PLF of diesel-based back-up generation plants in Gujarat ranged from 15 to 40 %.⁷ Since the price of diesel has increased substantially since the time of this study, and the shortage percentage has remained the same, the PLF of diesel based generators may be lower than indicated in this study. The average cost of supply from diesel based back up generators ranges from Rs. 8 to 12 per unit (CII, 2005) compared to between Rs. 3 to 4.5 for grid based electricity.⁸ Depending on the PLF, diesel consumption for captive electricity generation is estimated to be between 3-8% of the country's total diesel consumption of 39.7 million tonnes in 2004-05

Table 2 shows the costs and capacity of electricity from renewable options in India. The cost ranges from about Rs. 1.5 for small hydro power to as much as Rs. 20 for a photovoltaic unit. The total installed capacity of these units is about 4800 MW.

The primary energy share of industry, services and agriculture sector is shown in Figure 7. The share of industrial energy use is larger in China, India, and South Korea compared to the other three countries. India's share of agricultural energy use is about 10%, relatively higher than in the other countries. In part this is due to higher value added derived from this sector in India, about 22%, but this is also due to the use of low and subsidized tariffs that encourage inefficient use of electricity for ground water pumping.

⁷ Shukla P. R., D. Biswas, T. Nag, A. Yajnik, T. C. Heller, and D. G. Victor (2004) "Captive Power Plants: Case Study of Gujarat India." *Program for Sustainable Energy Development (PESD) Working Paper 4* Stanford: PESD. Available online at <http://pesd.stanford.edu/publications/>

⁸ Confederation of Indian Industries (CII) (2005) *Use of Captive Power Plants to Mitigate Load Shedding in Pune Urban Area*. CII's Proposal Submitted to MERC. Mumbai: CII. Available online at http://mercindia.org.in/orders_2006.htm.

Table 2: Electricity from Renewable Options, Costs and Capacity, India

Sl. No.	Source	Capital Cost (Crores of Rs/MW)	Estimated Cost of Generation Per Unit (Rs./kWh)	Total Installed Capacity (MW)
1.	Small Hydro-Power	5.00-6.00	1.50-2.50	1601.62
2.	Wind Power	4.00-5.00	2.00-3.00	2483.00
3.	Bio-mass Power	4.00	2.50-3.50	234.43
4.	Bagasse Cogeneration	3.5	2.50-3.00	379.00
5.	Bio-mass Gasifier	1.94	2.50-3.50	60.20
6.	Solar Photovoltaic	26.5	15.00-20.00	2.54
7.	Energy from Waste	2.50-10.0	2.50-7.50	41.43

Source: Ministry of Non-Conventional Energy Sources (MNES)

Steel, cement, and aluminium are all energy-intensive industrial commodities that require significant amounts of energy to produce. All six Asia Pacific Partnership countries produce each of these commodities in varying amounts (see Figure 8).

The trend in industrial energy intensity (industrial energy use per unit of value added) parallels the overall trend in energy intensity in India. It increased until the mid-1980s and continually declined after that (Figure 9). The trend is also similar to that in the US and China although the decline in India was not as steep as that in China where concerted policies and programs in the industrial sector led to a dramatic decline in energy intensity beginning in the 1980s. Much of the decline is attributed to gains in firm-level energy productivity; shifts in sectoral composition were less important at the SIC 2 digit level.

In contrast, there has been little or no change in the industrial energy intensity in Australia since 1971, and after a decline until the early 1990s, the intensity in Japan and Korea has increased slightly.

Residential energy consumption (excluding biomass) per capita increased in all APP countries, except the US, and the increase was the fastest in India followed by Korea (Figure 10). The switching from traditional biomass to modern fuel, and the increasing use of modern fuels by an expanding urban population are the driving factors behind the increase in India.

Changes in population, GDP, energy intensity, and carbon intensity of energy supply (excl. traditional biomass) may be considered key factors that contribute to changes in carbon dioxide emissions (Figure 11). The Kaya identity forms the basis for the approach used in such models. Using the identity, carbon emissions at an aggregate economy-wide level may be expressed as:

$$CO_2 = P * GDP/P * E/GDP * CO_2/E$$

where

P = Population,

GDP = Gross domestic product,

E = Primary energy use

CO₂ = Carbon dioxide emissions

India's carbon emissions from fossil fuel combustion amounted to 1,050 Gt CO₂ in 2003, or about 19% of comparable US emissions. Both population and GDP increases contributed to the increasing trend observed since 1971 despite the improvement in carbon dioxide-GDP intensity over this period. The carbon content of India's fuel mix remained relatively unchanged, and hence the carbon dioxide-GDP intensity declined due to the decline in energy intensity after 1991.

Best Practices:

The above analysis highlights the important perspective provided by comparing energy intensities across countries, and the need for careful decomposition of historical trends to estimate the relative contribution of factors to changes in energy use and carbon emissions. Such an analysis needs to be done at the individual sector level, so that the role of changes in structure and composition can be separated from that of energy efficiency. To conduct such an analysis requires long-term and systematic process of data collection, matching of energy and economic data, and continual analysis to spot unusual variances in reported data. This type of effort is not being conducted on a regular basis in India, and would be of benefit to all APP member countries.

3. The Government of India's Energy Vision and Indian Public and Private Sector Energy Institutions

In its recent draft report on an integrated energy policy, the Indian Planning Commission laid out a vision of providing energy security to all citizens of India⁹. Energy security broadly defined includes not only reducing vulnerability to supply disruptions but also ensuring that minimum energy needs of vulnerable households are met and that energy is used and supplied in an environmentally sustainable way. The three pillars of sustainable development – economic, social and environmental, all need to be addressed in the provision of adequate energy supplies. The vision also recognizes that fuel flexibility is important since energy carriers can substitute one another and, hence, an integrated policy can pay rich dividends. Articulating such a vision and making it implementable in the field of energy efficiency is a challenge faced not only by India but also by other major countries.

Energy Efficiency

In recognition of the importance of energy conservation, the Indian government created the Petroleum Conservation Research Association (PCRA) in 1978¹⁰. PCRA continues to play an active role in the promotion of petroleum fuel saving strategies and functions as a think tank to the government for proposing policies and strategies on petroleum conservation and environmental protection aimed at reducing excessive dependence on oil.

In 2001, the Indian parliament passed the Energy Conservation Act 2001, which established the Bureau of Energy Efficiency (BEE) which became operational on 1 March 2002 under the Ministry of Power¹¹. BEE's mission is to develop programs and strategies based on self-

⁹ Planning Commission, Govt. of India (2005) *Draft Report of the Expert Committee on Integrated Energy Policy*. December <http://planningcommission.nic.in/reports/genrep/intengpol.pdf>

¹⁰ <http://www.pcr.org/>

¹¹ <http://www.bee-india.nic.in/index1.php>

regulation and market principles with its primary objective to reduce the energy intensity of the Indian economy. BEE is developing regulatory and voluntary programs and strategies with primary objective to reduce the energy intensity of the Indian economy. Some key activities that BEE is pursuing include: the development of energy performance standards and labels for refrigerators; motors, air conditioners, and other mass produced equipment; certification of energy managers and auditors; assisting industry in the benchmarking of their energy use; and energy audits of prominent government buildings. BEE is also working closely with energy development agencies at the state level in order to deliver energy efficiency services including through public-private partnership.

Renewable Energy

The Ministry of Non-Conventional Energy Sources (MNES) is the nodal ministry of the Government of India for all matters relating to new and renewable energy.¹² It seeks to develop MNES into a scientific institution in the area of new and renewable energy. Towards this end, it supports the development of new and renewable energy technologies, processes, materials, components, sub-systems, products & services on par with international norms. Its role is to conduct research, design, develop, demonstrate, commercialize and deploy new and renewable energy systems / devices for transportation, portable and stationary applications in rural, urban, industrial and commercial sectors through. The Ministry has nine Regional Offices which are required to monitor and liaise with the concerned State Governments and their agencies for effective implementation of its programmes.

Electric Power

The Indian Parliament also passed the Electricity Act in 2003¹³. The Act consolidated laws related to generation, transmission, distribution, trade and use of electricity. Among other things, the Act called for the rationalization of electricity tariffs, creation of a competitive environment, and open access in transmission and distribution of electricity. The Act also mandated the creation of regulatory commissions at the central, regional and state levels. As a consequence, the electric utility system is being unbundled, tariffs are being rationalized, and regulatory commissions are playing an active role in enforcement of bill collection and the promotion of DSM programs in some of the larger states. Under orders from the Maharashtra Electricity Regulatory Commission, for instance, utility companies in Maharashtra have initiated a lighting efficiency program in the residential sector¹⁴, and the Bangalore Electricity Supply Company has initiated a similar program in Karnataka state¹⁵.

Industry Associations

Indian industry associations have played an important role in promoting energy efficiency. The Confederation of Indian Industry (CII) and Federation of Indian Chambers of Commerce and Industry (FICCI) are engaged in capacity building through the organization of training programs, workshops, conferences, exhibitions, poster displays, awards, and field visits. The Indian Green Business Centre is an example of an institution created by an industry association; CII, jointly with the Andhra Pradesh government and with technical support from USAID, established the

¹² <http://mnes.nic.in/frame.htm?majorprog.htm>

¹³ http://powermin.nic.in/acts_notification/electricity_act2003/preliminary.htm

¹⁴ http://mercindia.org.in/Orders_2005.htm

¹⁵ <http://www.bescom.org/en/news/belp.asp>.

Centre as a public-private partnership¹⁶. Its building has acquired the LEED platinum rating, and one of its five working groups is engaged in facilitating energy efficiency improvement across industry through improved capacity utilization, fine tuning, and technology upgradation. Private ESCOs have mobilized and recently set up the Indian Council for Energy Efficiency Business (ICPEEB) to network, provide input to policy makers, support business development, and disseminate information on energy efficiency¹⁷.

4. Current state of technologies and services

The eight APP Task Forces address a wide array of technologies, processes, and services that range from coal mining, cleaner fossil energy and renewable energy on the supply side to industrial and buildings and appliance efficiency on the demand-side. A primary component of these activities is the improvement of energy efficiency in various technologies that are utilized in these sectors. In this section, we focus on some of the key technologies and processes that are relevant to India in the power, renewable energy, and industrial and buildings and appliances sectors.

Technologies

Energy using technologies may be categorized into two types. One category is of technologies that are mass produced such as lamps, refrigerators, motors, air conditioners, transformers, drives, etc. The second category is of technologies that form part of larger processes such as in the production of steel, aluminum, or cement, which are more likely to be one-of-a-kind. While many of the distributed and renewable energy technologies are mass produced others that are of larger size, hydro and geothermal plants for instance, may be one of a kind.

The costs of renewable energy technologies in India is shown in Table 2. For many technologies this cost is higher than that for conventional electricity generation. The cost effectiveness of an energy efficient technology may be estimated by calculating its cost of conserved energy (CCE). The CCE provides a measure that is directly comparable to the cost or price of energy supply (Appendix A). Numerous studies worldwide have shown that the cost of conserved energy is lower than the cost of supply for a majority of the energy efficient technologies.^{18,19,20,21} Table 3 shows an example of the cost-effective energy efficiency potential for four products in India. It shows that among these products refrigerators and distribution transformers exhibit the highest potential for improving energy efficiency. In the industrial sector, in addition to efficient motors, lighting and air conditioning systems, and variable speed drives are increasingly being utilized. These are cost effective in many applications.²²

¹⁶ <http://greenbusinesscentre.com/energyeffic.asp>

¹⁷ <http://www.shrishakti.com/alternativeenergy/index.html>

¹⁸ Interlaboratory Working Group. 2000. *Scenarios for a Clean Energy Future* (Oak Ridge, TN; Oak Ridge National Laboratory and Berkeley, CA; Lawrence Berkeley National Laboratory), ORNL/CON-476 and LBNL-44029, November.

¹⁹ Energy Research Institute, China and Lawrence Berkeley National Laboratory (2003) *China's Sustainable Energy Future: Scenarios of Energy and Carbon Emissions*.

²⁰ UNDP (2000) *World Energy Assessment: Energy and the Challenge of Sustainability*. New York.

²¹ Planning Commission, Govt. of India (2005) *Draft Report of the Expert Committee on Integrated Energy Policy*. December <http://planningcommission.nic.in/reports/genrep/intengpol.pdf>

²² Phadke, Sathaye and Padmanabhan (2005) report a CCE of Rs. 0.73 per kWh for variable speed drives compared to an average industrial electricity tariff of Rs. 3/kWh in Maharashtra.

Table 3: Cost Effective Energy Efficiency Improvement Potential*, India

Product	Base Case (kWh/year)	Efficiency Case (kWh/year)	Percentage Improvement
Refrigerator			
Direct-cool	381	208	45%
Frost-free	930	508	45%
Room air conditioner			
Window ⁴	1191	1056	11%
Motors			
Agricultural – 5 HP	992 ²	875	12%
Industrial – 15 HP	4079	3264	20%
Industrial – 20 HP	5562	3387	39%
Distribution transformers			
25 kVA	1036	441	57%
63 kVA	1834	797	57%
100 kVA	2619	1068	59%
160 kVA	3757	1653	56%
200 kVA	4989	1880	62%

Source: McNeil M., M. Iyer, S. Meyers, V. Letschert, J. McMahon, 2005, Potential Benefits from Improved Energy Efficiency of Key Electrical Products: The Case of India. [LBNL-58254](#)

1. Cost effectiveness of savings potential for distribution transformers is based on cost-efficiency data submitted by the manufacturers.
2. Cost effectiveness of small motors for agricultural use assumes a small increase in the marginal electricity tariff from the current 3.2 c/kWh to 3.8 c/kWh
3. For comparison with other products, energy consumption and percentage improvement for motors is given in terms of losses, thus excluding the useful mechanical output energy produced by the motor.
4. Consumption patterns and engineering parameters for window air conditioners are assumed to hold for split systems for the purposes of this study

Mass produced energy-efficient technologies are available for most products in US markets. This is not necessarily the case in India, where consumers may often be compelled to adopt standard technologies that are more robust in order to deal with factors outside their control. Factors such as low and fluctuating line voltages, and poor and unreliable road infrastructure, building construction practices and fuel quality make it imperative to harden efficient technologies and make them as robust as standard technologies. Hardening has a drawback in that it can increase energy consumption which would reduce its energy efficiency, but its higher energy consumption may still be lower than that of the standard technology.

A more attractive alternative is to improve supply efficiency while simultaneously improving supply quality. Improving the efficiency of wind mills, PV panels, and reducing power plant own electricity use can have substantial benefits. Distribution transformers and reducing the instances of overloading can contribute to a higher quality power supply. Overloading of distribution transformers is not common in the US, although US transformers are generally oversized, which, while contributing to the losses, does not affect the overall power quality.

Other factors affecting power quality in India include increased load from inductive motors. Inductive motors are typically used for pumping water in residential and agricultural sectors and for other industrial applications. Installing capacitors close to load centers improves the power factor significantly, and has been implemented in several cases in India. Certain load factor

improvement measures have included demand- side management techniques through staggering of loads on outgoing feeders at grid substations. Automatic scheduling of rural agricultural loads has been one such measure. However, this measure has in many cases resulted in the shortening of the lifetime of the equipment as the pumps run for extended periods of time while there is power supply. Hardening measures thus may need to be coordinated to avoid direct or indirect additional costs.

Industrial Sector:

Opportunities to improve industrial energy efficiency are found throughout the steel, cement, and aluminum sectors.^{23,24,25} Efficiency improvements in cross-cutting technologies that are found in almost all industries, such as motor and pumping systems, typically range between 15% and 20% of annual facility energy consumption, often with simple payback periods of around two years and internal rates of return around 45%.^{26,27} It has been estimated that use of high-efficiency motor-driven systems, combined with improvements to existing systems, could reduce electricity use by motor-driven systems in the European Union by 30%.²⁸ The optimization of compressed air systems can result in improvement of 20% to 50%.²⁹

Assessments of cost-effective efficiency improvement opportunities in energy-intensive industries in the United States, such as steel and cement manufacturing, found cost-effective savings of 16% to 18%.^{30,31} An estimate of the 2010 global technical potential for energy efficiency improvement in the steel industry with existing technologies identified savings of 24% in 2010 and 29% in 2020 using advanced technologies such as smelt reduction and near net

²³ de Beer, J., Phylipsen, D., and Bates, J., 2001. *Economic Evaluation of Carbon Dioxide and Nitrous Oxide Emission Reductions in Industry in the EU*. Brussels: European Commission, DG Environment.

²⁴ European Climate Change Programme (ECCP), 2001. *Long Report*. Brussels: European Commission, DG Environment. http://europa.eu.int/comm/environment/climat/pdf/eccp_longreport_0106.pdf

²⁵ Intergovernmental Panel on Climate Change 2001. "Technological and Economic Potential of Greenhouse Gas Emissions Reduction" Chapter 3 in *Climate Change 2001: Mitigation*. Authored by Moomaw, W. R., J. R. Moreira, K. Blok, D. Greene, K. Gregory, T. Jaszay, T. Kashiwagi, M. Levine, M. MacFarland, N. S. Prasad, L. Price, H. Rogner, R. Sims, F. Zhou, E. Alsema, H. Audus, R. K. Bose, G. M. Jannuzzi, A. Kollmuss, L. Changsheng, E. Mills, K. Minato, S. Plotkin, A. Shafer, A. C. Walter, R. Ybema, J. de Beer, D. Victor, R. Pichs-Madruga, H. Ishitani. Geneva: United Nations and World Meteorological Organization.

²⁶ Lung, R.B., A. McKane, and M. Olzewski, 2003. "Industrial Motor System Optimization Projects in the U.S.: An Impact Study." *Proceedings of the 2003 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*. Washington, DC: ACEEE.

²⁷ U.S. Department of Energy, 1998. *United States Industrial Motor Systems Market Opportunities Assessment*, Washington, DC: US DOE.

²⁸ De Keulenaer, H., 2004. "Energy Efficient Motor Driven Systems" *Energy & Environment* **15** (5): 873-905.

²⁹ McKane, A. and Medaris, B., 2003. *The Compressed Air Challenge: Making a Difference for U.S. Industry*. Berkeley, CA: Lawrence Berkeley National Laboratory. <http://industrial-energy.lbl.gov/files/industrial-energy/active/0/LBNL-52771.pdf>

³⁰ Martin, N., Worrell, E., and Price, L., 1999. *Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Cement Industry*, Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-44182). <http://www.osti.gov/bridge/servlets/purl/751775-bfyH4x/webviewable/751775.pdf>

³¹ Worrell, E., Martin, N., and Price, L., 2001. "Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Industry," *Energy, The International Journal* **26**, 2001: 513-536: (LBNL-47910).

shape casting.³² Aluminium energy consumption in the U.S. is 24% higher than the theoretical minimum; achievable cost-effective savings are smaller.³³ Appendix tables B-1, B-2 and B-3 list energy-efficiency technologies and measures that can be used in these three industries.^{34, 35, 36}

Even greater savings can often be realized in developing countries where old, inefficient technologies have continued to be used to meet growing material demands.^{37, 38, 39, 40} The energy intensity of the Chinese steel industry dropped from 29 GJ/ton steel in 1990 to 23 GJ/ton steel in 2000 despite an increased share of primary steel production from 79% to 84%, indicating that the efficiency of steel production improved over this period as small, old inefficient facilities were closed or upgraded and newer facilities were constructed.⁴¹ Continued improvements will be realized through further adoption of advanced casting technologies, improved furnaces, pulverized coal injection, and increased recover of waste heat.⁴² In the Indian cement industry, energy efficiency improvements are the result of the combined effects of shifting away from inefficient wet kilns toward more efficient semi-dry and dry kilns, as well as adoption of less energy-intensive equipment and practices. Between 1992 and 2002, primary energy use per ton of cement produced in India dropped from 4.8 to 4.2 GJ/t.⁴³

In addition to existing technologies, there is a continuous stream of industrial emerging technologies being developed, demonstrated, and adopted. Emerging technologies, such as direct reduced iron, near net shape casting, inert anodes, and advanced cogeneration can bring even

³² de Beer, J.G., Harnisch, J. and Kerssemeeckers, M. 2000. *Greenhouse Gas Emissions from Iron and Steel Production*. IEA Greenhouse Gas R&D Programme, Cheltenham, UK.

³³ Choate, W.T. and Green, J.A.S., 2003. *U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*. Washington DC: USDOE.

³⁴ Worrell, E., Martin, N., Price, L., 1999. *Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector*, Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-41724). <http://ies.lbl.gov/iespubs/41724.pdf>

³⁵ Worrell, E. and Galitsky, C., 2004. *Energy Efficiency Improvement Opportunities for Cement Making: An Energy Star Guide for Energy and Plant Managers*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54036). <http://ies.lbl.gov/iespubs/54036.pdf>

³⁶ Commonwealth of Australia, 2000. *Energy Efficiency Best Practice in the Australian Aluminium Industry: Summary Report*. Industry, Science and Resources - Energy Efficiency Best Practice Program. <http://www.dist.gov.au/assets/documents/itrinternet/aluminiumsummaryreport20040206151753.pdf>

³⁷ Price, L., Worrell, E., and Phylipsen, D., 1999. "Energy Use and Carbon Dioxide Emissions in Energy-Intensive Industries in Key Developing Countries," *Proceedings of the 1999 Earth Technologies Forum*. Washington, DC: U.S. EPA.

³⁸ Price, L., Sinton, J., Worrell, E., Phylipsen, D., Hu, X., and Li, J., 2002. "Energy Use and Carbon Dioxide Emissions from Steel Production in China," *Energy, The International Journal* 27(2002): 429-446 (LBNL-47205).

³⁹ Schumacher, K. and Sathaye, J., 1999. *India's Cement Industry: Productivity, Energy Efficiency and Carbon Emissions*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-41842).

⁴⁰ World Energy Council, 2004. *Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation*. London: WEC.

⁴¹ Editorial Board, 2004. *China Steel Yearbook 2004*. Beijing.

⁴² Zhou, F., et al., 2003. *China's Sustainable Energy Scenarios in 2020*. China Environmental Publishing House, Beijing.

⁴³ Sathaye, J., Price, L., de la Rue du Can, S., and Fridley, D., 2005. *Assessment of Energy Use and Energy Savings Potential in Selected Industrial Sectors in India*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-57293). <http://ies.lbl.gov/iespubs/57293.pdf>

further savings as they are commercialized and adopted by industries.^{44, 45} A recent evaluation of over 50 such emerging technologies applicable to industries as diverse as petroleum refining, food processing, mining, glass-making and the production of chemicals, aluminium ceramics, steel, and paper found that over half of the technologies promised high energy savings, many with simple payback times of three years or less.⁴⁶ Analysis of energy efficiency improvements related to emerging technologies found potential savings compared to current average energy use of 35% for steelmaking over the long term.⁴⁷

Indian industry has made strides towards reducing its process energy intensity. This has happened through the use of modern best available technologies in new plants, upgrading and modernizing existing plants, and a shift towards less energy intensive processes. This improvement has occurred because of (1) stricter environmental regulations (as in the case of chlor-alkali production),⁴⁸ (2) economic considerations (as in the case of dry cement plants), and/or (3) government macro policy (for instance, the shifting of fertilizer production towards increased use of natural gas).⁴⁹ As a consequence of these types of changes during the last decade, Indian industry has acquired some of the best production technology. Arguably, the best steel plant (Tata Steel)⁵⁰ and the second best energy efficient cement plant⁵¹ in the world today are in India. The average Indian cement plant, however, consumes 25% more energy than the global best practice.⁵²

At the same time, however, Indian industry continues to own older plants that operate sub-par technologies with high specific energy consumption. In the case of each industry, there appears to be a potential for improvement that ranges from 15% to 35%. Tapping this potential will require the installation of new equipment, better management practices, and an integrated systemic approach to the evaluation of energy use in a plant. Many industry-specific improvements that are being made worldwide and have the potential for reducing specific energy consumption are noted for eight selected industries in two LBNL reports.⁵³

⁴⁴ Martin, N., Worrell, E., Ruth, M., Price, L., Elliott, R.N., Shipley, A.M., and Thorpe, J., 2000. *Emerging Energy-Efficient Industrial Technologies*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-46990) and Washington, DC: American Council for an Energy-Efficient Economy.

⁴⁵ Worrell, E., Price, L., and Galitsky, C., 2004. *Emerging Energy-Efficient Technologies in Industry: Case Studies of Selected Technologies*. Prepared for the National Commission on Energy Policy. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54828).

<http://ies.lbl.gov/iespubs/54828.pdf>

⁴⁶ Martin, N., Worrell, E., Ruth, M., Price, L., Elliott, R.N., Shipley, A.M., and Thorpe, J., 2000. *Emerging Energy-Efficient Industrial Technologies*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-46990) and Washington, DC: American Council for an Energy-Efficient Economy.

⁴⁷ de Beer, J.G., Worrell, E. and Blok, K. 1998. Future Technologies for Energy Efficient Iron and Steelmaking. *Annual Review of Energy and Environment* 23: 123-205.

⁴⁸ Stricter environmental controls can also work the other way; the installation of hydrodesulfurizers to produce low sulfur fuel increases the energy consumption of refineries.

⁴⁹ Sathaye J. Price L. de la Rue du Can S. and Fridley D. (2005) Energy Use and Energy Savings Potential in Selected Industrial Sectors in India. LBNL Report # 57293

⁵⁰ World Steel Dynamics Inc (WSD) – www.worldsteeldynamics.com/

⁵¹ Bhushan C. (2005) *Green Rating of Cement Industry*, Centre for Science and Environment, December http://www.cseindia.org/programme/industry/cement_rating.htm

⁵² Sathaye et al. 2005. op. cit.

⁵³ Sathaye et al. 2005 – LBNL #57293; and Sathaye, J., A. Gadgil, and M. Mukhopadhyay (1999) *Role of development banks in promoting industrial energy efficiency: India case studies*. In: 1999 ACEEE Summer Study on Energy Efficiency in Industry, 05/01/1999, Saratoga Springs, NY. [LBNL-43191](http://www.aceee.org/energy_efficiency/india_case_studies/)

Cost effectiveness of process energy use in the industrial sector needs to be evaluated in light of not only energy savings, but also savings or increased expenses for labor and material. One example is reported by Worrell et al. (2003) for the US iron and steel industry.⁵⁴ They report a cost-effective annual primary energy savings of 1.9 GJ/tonne of output for this sector due to the implementation of an array of 47 measures (Figure A1). Inclusion of labor and material cost savings during the operation of an efficient iron and steel plant, however, increases the potential to 3.8 GJ/tonne of output at the same cost. More importantly, the ranking of technologies changes dramatically; an oxy-fuel burner ranked # 41 when only energy cost savings are factored in becomes the # 1 technology to implement when cost savings of other factors are included. Inclusion of all resource benefits thus is crucial to understanding the full cost impacts of a technology. This may be particularly relevant to end-use energy efficiency technologies whose main goal often is not providing or saving energy but providing some other form of service or the production of an industrial good.

The time lag between program implementation and its realized electricity savings varies depending on the technologies targeted by a program. End-uses that have a short turnover period, such as lighting, will yield savings sooner than those with longer gestation periods. For a chronically electricity-short India, short-turnover-period technologies should be the primary candidates for implementation.⁵⁵

Barriers to market penetration

The market penetration of energy-efficient technologies is often hampered by barriers⁵⁶ that are influenced by prices, financing, international trade, market structure, institutions, the provision of information and social, cultural and behavioral factors. Many papers and reports have documented the pervasiveness of barriers to energy efficiency improvements.⁵⁷

India is moving toward the adoption of policies and regulations that promote competition and more open markets, and is thus positively influencing the adoption of energy efficiency technologies. Nonetheless, the adoption of energy efficient technologies faces numerous market impediments and failures that must be overcome. Some of the most significant market barriers and steps to address them include:

- Consumer discount rates are many times higher than societal discounts rates. In industrialized countries, this has meant that incentives have been required to get consumers to adopt new technologies, even when they are clearly already in their own financial interest to do so. Similar or possibly even stronger incentives will be required in developing countries like India.
- The relative lack of private sector energy efficiency service delivery mechanisms such as ESCOs. There is insufficient understanding and assessment of the risks and benefits that accrue to the parties in an energy efficiency transaction.

⁵⁴ Worrell, E. J.A. Laitner, M. Ruth and H. Finman (2003) Productivity Benefits of Industrial Energy Efficiency Measures *Energy* 11, 28, pp.1081-1098

⁵⁵ Phadke, Sathaye, and Padmanabhan (2005) (op. cit.)

⁵⁶ A barrier is any obstacle to reaching a potential that can be overcome by a policy, program, or measure.

⁵⁷ See Sathaye J. and Bouille D., et al. (2001). *Barriers, Opportunities, and Market Potential of Technologies and Practices*. Chapter in *Climate Change Mitigation*, Eds. B. Metz, O. Davidson, and R. Swart. Cambridge University Press for the Intergovernmental Panel on Climate Change for an overview

- No incentive to build efficient new buildings. Most new commercial buildings are not occupied by the owner -they are rented. The builder's objective is to construct the building for the lowest initial cost; the renters have no incentive to invest in efficiency improvements in a property they do not own.
- Failure by the power sector to treat energy efficiency on the same economic basis as new capacity. This market barrier is being addressed in industrialized countries by adopting integrated resources planning techniques, and by designing and implementing demand-side management (DSM) programs.

Economists recognize two categories of market failures that are relevant for implementation of energy efficiency – principal agent (PA) and lack of information problems. There are few, if any, papers, however, that quantify the extent to which such barriers reduce penetration of energy efficient technologies. A recent paper shows the effect of one barrier, the split-incentives or principal agent problem, on residential energy consumption in the US.⁵⁸ The PA problem affects about 26% of refrigerator energy consumption, 42% and 48% of the electricity consumption in water heating and space heating respectively, and 2% of lighting electricity consumption. A general conclusion from this analysis is that the energy use percentage affected by the PA problem is lower in end uses where the stock turnover is rapid such as lighting, and vice versa. The affected energy use is thus masked from energy prices, implying that non-pricing programs would be more effective in reaching these customers. On the other hand, efficient lighting, CFLs for instance, while not as affected by the PA problem, is still plagued by lack of information about its quality and its inappropriateness for particular applications.⁵⁹

Economic Gains – Who benefits?

At least two (and often many more) stakeholders benefit from the supply and use of energy and energy efficiency services and DR policies. Identifying beneficiaries in such transactions is an important step to determining the stakeholders who would have an interest in paying for energy efficiency. Low or no agricultural electricity tariffs benefit the farmer, but the utility loses net revenue in this transaction. While it is not in the farmer's financial interest to buy efficient pumps, it may still be in the utility company's interest to promote their use. A recent analysis for Maharashtra, for example, shows that the cost of installing efficient pumps would have been lower than MSEB's short-run cost of electricity generation.⁶⁰ It would thus be to MSEB's benefit to promote a program on agricultural efficiency.

The same analysis illustrated that reselling electricity saved by subsidized customers to electricity-short business customers would result in additional sales tax revenue for the state. The state loses sales tax worth Rs. 9 per kWh (\$0.20/kWh) for each kWh of electricity not supplied to businesses. The increased tax revenue would amount to 15%-30% of state revenue deficit depending on the level of backup generation. The state would thus be a net beneficiary and, hence, it would be in the state's interest to develop programs for the promotion of energy efficiency.

⁵⁸ Murtishaw S. and J. Sathaye (2006) *US Refrigerator, Water Heater, Space Heating and Residential Lighting Energy Use Affected by the Principal Agent Market Failure*. LBNL Report 59773.

⁵⁹ Sathaye J. and Murtishaw S. (2004) *Market failures, consumer preferences, and transaction costs in energy efficiency purchase decisions* Lawrence Berkeley National Laboratory for the California Energy Commission, PIER Energy-Related Environmental Research CEC-500-2005-020/LBNL-57318

⁶⁰ Phadke, Sathaye, and Padmanabhan, 2005 (op. cit.)

Best Practices:

Conducting critical techno-economic (TE) analysis is an important step in identifying technologies that are cost effective and developing programs that are targeted towards appropriate beneficiaries. TE analysis helps in characterization of the energy performance and economics of technologies, estimation of their technical, economic and market potential, identification and quantification of barriers, and valuation of economic gains to stakeholders. An analysis of this type is essential to the design and development of policies and programs, and determining ways to get them financed by the beneficiaries.

5. Partnerships for the Promotion of Energy Efficiency and Renewable Energy: A Review

Over time, there has been a shift from government to governance that has been accompanied by both a theoretical and a practical interest in how the three main arenas of actors – state, market and civil society – interact. Partnerships between public and private actors can maximize impact by taking advantage of each partners’ unique strengths and skill sets. The strategies of partnership, self-help and community empowerment have been used to encourage participation and to promote the idea that environmental problems are best addressed by government and industry working together with communities.

Globally, public-private partnerships are an increasingly popular tool governments use to develop, deploy, and transfer technologies and practices. The notion of partnerships between sectors was given particular credibility by the World Summit on Sustainable Development in Johannesburg, South Africa, in 2002 where several ‘Type II’ partnerships were launched involving various combinations of governments, business and civil society actors. Although it is too early to evaluate the impacts of these particular partnerships, they do represent a larger trend whereby the last decade has seen a far greater level of partnership activities between governments and NGOs on the one hand, between government and business on the other, and now increasingly all three in many sectors and in both industrialized and developing countries.

The partnerships perspective relies on the conscious collaboration of the partners in pursuit of commonly defined and agreed goals. The partners interact such that no single perspective or pair of perspectives is able to achieve dominance over the others. A stable, emergent solution, is one in which all of the participants participate through mutual accommodation of the others’ viewpoint in practice, but without necessarily having to agree on any single conceptualization of the problem.

A variety industrial and buildings sector and renewables partnerships have been implemented in APP countries and internationally in an effort to provide clean energy sources and to reduce GHG emissions of this sector. Tables 4, 5, and 6 provide information on the key activities of a sample of industrial, buildings, and renewables sector partnerships that address energy efficiency and GHG emissions mitigation in the relevant APP sectors (steel, cement, and aluminium for industry). The partnerships in these tables are divided into industry-only partnerships, partnerships between government and industry, and partnerships between non-governmental organizations and industry. The three renewable energy partnerships are more appropriately divided into international and domestic initiatives.

Table 4. Key Activities of Industrial Sector Partnerships Related to Energy Efficiency and GHG Emissions Mitigation

	Industry-only		Government-Industry										NGO-Industry			
	Cement Sustainability Initiative	Aluminum for Future Generations	Australian Greenhouse Challenge Plus	Canadian Industry Program for Energy Conservation	China Top-1000 Energy-Consuming Enterprise Program*	Indian Industry Programme for Energy Conservation	Keidanren Voluntary Action Plan on the Environment	Republic of Korea – KEMCO Voluntary Agreement Program	U.S. Climate VISION**	U.S. DOE Industrial Technologies Program	U.S. EPA Energy Star for	U.S. EPA Climate Leaders	U.S. EPA Voluntary Aluminum Industry Partnership	Partnership for Climate Action	Business Environmental Leadership Council	Climate Savers
SECTOR REVIEWS																
Current status, baseline information	X	X		X			X	X		X	X	X	X	X		
Assessment to evaluate potential options	X	X		X	X	X			X			X				
Identification of barriers and policy opportunities	X						X							X		
GOAL SETTING AND PERFORMANCE INDICATORS																
Action plans***	X		X	X	X	X	X	X	X	X				X	X	X
Commitments, targets, agreements	X		X	X	X		X	X	X			X	X	X	X	X
Metrics to measure progress toward goals, annual or periodic reporting	X	X	X	X	X		X	X				X	X	X	X	X
TECHNOLOGY RDD&D AND TECHNOLOGY TRANSFER																
Technology-based research										X						
Discrete pilot projects										X						
Demonstration and deployment activities										X						
SKILLS ENHANCEMENT, COMMERCIAL AND INFO EXCHANGE																
On-site consultations, technical assistance, facility audits				X	X	X				X		X				
Workshops, training		X	X	X	X	X				X						
Meetings, conferences, stakeholder dialogues	X		X	X		X			X		X	X				X
Awards, recognition, publicity			X	X	X			X		X	X	X	X	X		X
DISSEMINATION OF BEST PRACTICE INFORMATION																
Information-sharing: reports, guidebooks, case studies, software, etc.	X	X	X	X	X	X			X	X	X	X	X	X	X	
Technical assistance and support from industry experts		X	X	X	X	X		X	X	X		X	X			X
Benchmarking - comparison to peers or best practice		X		X	X	X	X				X	X				
Energy/GHG reporting - inventories, protocols	X	X							X			X				
LEVERAGING RESOURCES																
Portfolios of investment opportunities						X								X		
Financial assistance, cost-sharing, tax rebates			X	X	X			X		X						

* planned activities

** a number of Climate VISION activities are indicated under DOE ITP, EPA ENERGY STAR for Industry, and EPA VAIP programs

*** “Action Plans” refer to company-specific plans for energy efficiency and GHG mitigation except for DOE ITP sector-specific visions and roadmaps

Table 5. Key Activities of Buildings Sector Partnerships Related to Energy Efficiency and GHG Emissions Mitigation

	Industry-only	Government-Industry	Australia: National Australian Built Environment Rating System	Australia: Housing Industry Association Greensmart Initiative	China: Efficient Lighting Initiative at China Standard Certification Center	India: BEE's Energy Manager and Energy Auditor Training Programme	South Korea – KEMCO Voluntary Agreement Program	Flex Your Power Campaign	USAID India's Energy Conservation and Commercialization (ECO) Project	U.S. DOE Building Technologies Program	U.S. DOE's Federal Energy Management Program	U.S. EPA/DOE Energy Star Program	NGO-Industry	US Green Building Council	ASHRAE Standards and Guidelines Activities	National Fenestration Rating Council's Windows Labeling/Certification Program	International Alliance for Inter-Operability (IAI)	Efficiency Valuation Organization (EVO)
SECTOR REVIEWS									X	X	X	X			X			
Current status, baseline information									X	X	X	X			X			
Assessment to evaluate potential options					X		X		X	X	X				X		X	X
Identification of barriers and policy opportunities			X	X	X	X	X		X	X	X	X		X		X	X	X
GOAL SETTING AND PERFORMANCE INDICATORS																		
Action plans			X		X			X	X	X	X	X		X			X	
Commitments, targets, agreements						X	X				X	X		X	X	X		
Metrics to measure progress toward goals					X	X		X	X	X	X	X		X			X	
TECHNOLOGY RDD&D AND TECHNOLOGY TRANSFER																		
Cooperative research											X							
Discrete pilot projects					X				X	X								
Demonstration and deployment activities												X						
SKILLS ENHANCEMENT, COMMERCIAL AND INFO EXCHANGE																		
On-site consultations, facility audits				X								X	X					
Workshops, training			X	X		X			X		X			X		X		X
Meetings, conferences, workshops, stakeholder dialogues			X	X	X	X			X		X	X		X		X	X	X
Awards, recognition, publicity			X	X	X			X			X	X		X				X
DISSEMINATION OF BEST PRACTICE INFORMATION																		
Information-sharing: reports, guidebooks, case studies, software, etc.			X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Technical assistance and support from industry experts			X	X	X	X	X	X	X	X	X	X			X	X	X	
Benchmarking - comparison to peers or best practice					X					X	X	X			X			
Energy/GHG management and reporting inventories, protocols					X		X				X	X		X	X			X
LEVERAGING RESOURCES																		
Portfolios` of investment opportunities									X		X	X						
Financial assistance, cost-sharing, tax rebates					X		X			X	X							

Table 6. Key Activities of Renewable Energy Partnerships

	International		Domestic
	Renewable Energy and Energy Efficiency Partnership (REEEP)	Methane to Markets Partnership	
			Million Solar Roofs Initiative (MSR)
SECTOR REVIEWS			
Current status, baseline information		X	X
Assessment to evaluate potential options		X	
Identification of barriers and policy opportunities		X	
GOAL SETTING AND PERFORMANCE INDICATORS			
Action plans			
Commitments, targets, agreements		X	X
Metrics to measure progress toward goals		X	X
TECHNOLOGY RDD&D AND TECHNOLOGY TRANSFER			
Technology-based research			
Discrete pilot projects		X	
Demonstration and deployment activities		X	
SKILLS ENHANCEMENT, COMMERCIAL AND INFO EXCHANGE			
On-site consultations, facility audits		X	
Workshops, training	X	X	X
Meetings, conferences, stakeholder dialogues	X	X	X
Awards, recognition, publicity			
DISSEMINATION OF BEST PRACTICE INFORMATION			
Information-sharing: reports, guidebooks, case studies, software, etc.	X	X	X
Technical assistance and support from industry experts	X	X	X
Benchmarking - comparison to peers or best practice	X	X	X
Energy/GHG reporting - inventories, protocols			
LEVERAGING RESOURCES			
Portfolios of investment opportunities		X	
Financial assistance, cost-sharing, tax rebates		X	X

Sector Reviews

The APP Action Plan Guidelines call for “a review of the current status of the relevant sector or theme with regard to clean development and climate, including where applicable, information on relevant baseline data (e.g. energy intensity and emissions data), information on the current state of the technology in terms of cost, performance, market share and barriers, as well as relevant knowledge relating to good practice.”

A number of existing industrial sector partnerships have also undertaken such sector reviews. The cement companies that make up the World Business Council on Sustainable Development’s Cement Sustainability Initiative (CSI) commissioned Battelle Memorial Institute to prepare a study to assess the current status of the cement industry with respect to sustainable development.

The report provided an independent assessment of the current status of the cement companies as well as ten recommendations for improving their sustainability, including those related to resource productivity, climate protection, and emission reduction.⁶¹ The Canadian Industry Program for Energy Conservation (CIPEC) provides an annual sector report as well as industry-specific reports that identify potential options such as the *Guide to Energy Efficiency in Aluminum Smelters*.^{62,63} The U.S. EPA's ENERGY STAR for Industry program evaluates the current status of specific sectors and provides information on energy use and intensity as well as information on the current state of technology in reports such as *Energy Efficiency Improvement Opportunities for Cement Making*.⁶⁴ The U.S. EPA also produces a report on the current status of the aluminium industry as well as perfluorocarbon (PFC) mitigation options, as well as an economic analysis of options for emissions reductions for use by members of the Voluntary Aluminum Industry Partnership (VAIP).⁶⁵

In the buildings sector, most of the partnerships engage the government and NGOs in cooperation with industry. An important focus of these partnerships is on identification of barriers and ways to exploit opportunities through policies and programs. Identification of barriers is particularly critical, because studies show that most energy efficiency options in this sector are cost effective, but their penetration is hampered by the presence of barriers. For example, building and municipal energy audits conducted in India routinely show energy savings to the tune of 20 to 40% and energy efficiency projects with simple payback of less than 3-4 years. In spite of such attractive project economics, institutional and process barriers have made it very difficult for an energy services sector to flourish in India. A successful example of overcoming the process and institutional barriers is the green building movement in India that had resulted in the design and construction of five certified LEED office buildings (three Platinum rated and two Gold rated). Twenty-one construction projects (approx. 7 million square feet) are registered with Confederation of Indian Industry's Green Business Center that teamed up with US Green Building Council to launch this market transformation initiative in India⁶⁶. This initiative is remarkable because prior to the launch of India Green Business Center a) there was no formal method or process that the Indian Architecture/Engineering/Construction (A/E/C) industry followed to design environmentally sustainable buildings; b) construction of a LEED-Platinum or a LEED-Gold building is considerably more expensive (in excess of 10 to 20%) than what would be considered a Class-A commercial office building in India.

⁶¹ Battelle Memorial Institute, 2002. *Toward A Sustainable Cement Industry*.

www.wbcsdcement.org/pdf/ir_apr5_lores.pdf

⁶² Natural Resources Canada (NRCAN), 2005. *The Measure of Success - For Thirty Years: Canadian Industry Program for Energy Conservation 2003/2004 Annual Report*.

<http://oee.nrcan.gc.ca/publications/infosource/pub/cipec/annualreport03-04/index.cfm?attr=24>

⁶³ Natural Resources Canada (NRCAN), Aluminium Association of Canada, and CIPEC, 1998. *Guide to Energy Efficiency in Aluminium Smelters*. <http://oee.nrcan.gc.ca/Publications/industrial/M27-01-1115E/M27-01-1115E.pdf>

⁶⁴ Galitsky, C. and Worrell, E., 2005. *Energy Efficiency Opportunities for Cement Making: An ENERGY STAR Guide for Energy and Plant Managers*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54036) www.energystar.gov/ia/business/industry/Cement_Energy_Guide.pdf

⁶⁵ U.S. Environmental Protection Agency, 2002. *U.S. High GWP Gas Emissions 1990–2010: Inventories, Projections, and Opportunities for Reductions*. Washington DC: U.S. EPA.

<http://www.epa.gov/highgwp/projections.html>

⁶⁶ For the latest list of certified and upcoming LEED buildings in India, please visit <http://greenbusinesscentre.com/grnbuildindia.asp>.

Sector reviews are also a feature of the Methane to Markets Partnership (Table 6). This public-private partnership advances methane recovery and use projects in four sectors: agriculture, coal mines, landfills and oil and gas systems. Its 18 member countries, including India, work in collaboration with the private sector, multilateral development banks, and other government and non-governmental organizations.

Goal-Setting and Performance Indicators

The APP Action Plan Guidelines state that the plans “should set out realistic and ambitious goals relating to the thematic area...To the extent possible, goals should be results-oriented and measurement systems should be aligned, so that progress toward achieving the goals can be gauged. For this purpose, Task Forces should consider using relevant metrics to measure progress in energy efficiency, air pollution, greenhouse gas emissions, or other relevant criteria (e.g., recycling), either in the context of specific goals or as an aggregate measure of progress within the areas under its scope.”

Goal-setting is often accompanied with the development of an action plan that outlines the measures that will be taken to reach a specific target. Almost all of the partnerships reviewed in Tables 4-6 include development of an action plan. In government-industry partnerships, action plans are typically developed by the private sector participant and submitted to the government. For example, each Greenhouse Challenge Plus member at the “Leader” or “Champion” level agrees to provide the Australian government with an action plan and to report annually on the specific achievements against the action plan. The action plans must outline measures in the following areas: energy efficiency, reducing or re-using waste, fuel switching, managing fugitive emissions, establishing greenhouse sinks, and purchasing emissions offsets. Regarding the energy efficiency elements, detailed guidance is provided regarding the steps involved in understanding baseline energy use, making an assessment of the systems already in place for managing energy, describing potential of energy saving measures including their costs and benefits, and developing a list of which actions will be implemented over the next 4 years under the action plan.^{67, 68, 69} For the Voluntary Agreement program in the Republic of Korea, companies are required to submit an action plan which specifies the business organizational management plan for conserving energy, current energy consumption and CO₂ emissions at the site, reduction goals, and a detailed five-year energy conservation and CO₂ emission reduction plan.⁷⁰ The U.S. EPA’s Climate Leaders program requires members to “set an aggressive corporate-wide GHG emissions reduction goal to be achieved over 5 to 10 years”. Examples of such goals include Baltimore Aircoil Company’s pledge to reduce U.S. GHG emissions by 15%

⁶⁷ Australian Government, Department of Industry, Tourism, and Resources, n.d. *Energy Efficiency Opportunities – Greenhouse Challenge Plus: Approaching Participation in an Integrated Way*.

<http://www.energyefficiencyopportunities.gov.au/assets/documents/energyefficiencyopps/Info%20sheet%20web20060725155311.pdf#search=%22greenhouse%20challenge%20plus%20action%20plan%22>

⁶⁸ Australian Greenhouse Office, 2005. *Greenhouse Challenge Plus: A Big Plus for Business and the Environment*. Canberra: AGO. <http://www.greenhouse.gov.au/challenge/publications/pubs/gcp-brochure.pdf>

⁶⁹ New South Wales, 2005. *Guidelines for Energy Savings Action Plans*. Sydney: NSW Dept of Energy, Utilities and Sustainability. <http://www.deus.nsw.gov.au/waterandenergysavings/Guidelines%20for%20Energy%20Savings%20Action%20Plans.pdf>

⁷⁰ MOCIE (Korea Energy Management Corporation), n.d., Guide to Voluntary Agreement System for Energy Conservation and Reduction of Greenhouse Gas Emission.

per ton of steel processed from 2004 to 2009, Holcim (US) Inc.'s pledge to reduce U.S. GHG emissions by 12% per ton of cement from 2000 to 2008, and St. Lawrence Cement's reduce global GHG emissions by 15% per ton of cementitious product from 2000 to 2010.^{71,72}

Under USAID's Energy Conservation and Commercialization (ECO, phase II) project, Maharashtra Strategic Energy Conservation Plan was developed to provide a roadmap for future energy efficiency programs that can be implemented by Maharashtra Energy Development Agency⁷³. Two more strategic energy conservation plans are proposed to be developed under the next phase of ECO project. Further, Bureau of Energy Efficiency with the support of GTZ under the Indo-German Energy Programme (IGEN) is also providing support to designated state agencies to develop action plans⁷⁴.

For nearly 10 years, the Million Solar Roofs Partnership (MSR) has worked to solarize communities with solar electric, domestic water and pool heating systems. This has been done through true public-private partnership comprised of stakeholders including utilities, the buildings and solar industries, state and local governments, non-profits, the national laboratories and research universities, labor and agriculture. MSR's objectives were to overcome barriers to market entry and support states and local communities in facilitating sustained deployment of solar energy technologies. As the title implies its original goal was to solarize a large number of homes over the partnership's lifetime.

Technology Research, Development, Dissemination, and Deployment and Technology Transfer

Guidance regarding the APP Action Plans also calls for "technology-based research, pilot projects, demonstration and deployment activities" and asks that the plans identify "opportunities to enhance the enabling environment for technology research, development, deployment, dissemination and transfer". The U.S. Department of Energy's Industrial Technologies Program is the sole industrial sector partnership identified that includes such activities. The ITP program provides cost-shared funding to risky or costly but potentially high-payoff energy and environmental research and development projects that address industry-defined priorities. ITP-supported research, development, and demonstration projects have produced more than 170 commercialized technologies which have saved U.S. industries 366 trillion Btu and over \$2 billion in energy expenditures.⁷⁵

In the buildings sector, US Department of Energy's Building Technologies Program's funding to Lawrence Berkeley National Laboratory led to the development of now "industry standard"

⁷¹ U.S. Environmental Protection Agency, 2005. *A Program Guide for Climate Leaders: Setting the Standard for Greenhouse Gas Management*. Washington DC: U.S. EPA.

http://www.epa.gov/stateply/docs/cl_programguide_508.pdf

⁷² U.S. Environmental Protection Agency, 2006. *Partner Goals*. <http://www.epa.gov/stateply/partners/ghggoals.html>

⁷³ http://www.usaid.gov/in/Pdfs/Maha%20_EC_Action_Plan.pdf

⁷⁴ http://www.energymanagertraining.com/Presentations/SDA_01Aug2006/Scheme_financial_SDA.pdf

⁷⁵ U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Industrial Technologies, 2006. *Impacts – Industrial Technologies Program: Summary of Program Results for CY 2004: Boosting the Productivity and Competitiveness of U.S. Industry*. Washington, DC: U.S. DOE.

http://www1.eere.energy.gov/industry/technologies/commercial_successes.html

technologies such as low-e windows, high-frequency (also known as electronic) ballast, DOE-2 and Energy Plus building energy modeling program. In fact, DOE's investment of \$6 million dollars in R&D of low-e windows and high-frequency ballast resulted in net project savings of \$84 billion (Rosenfeld, 1999)

Several discrete projects are part of the Methane to Markets Partnership. These include a coal mine safety and emissions reduction project in Ukraine, and demonstration projects for large methane recovery systems in China.

Skills Enhancement, Commercial and Information Exchange

Projects and activities that include “skills enhancement and exchange, commercial and information exchanges (workshops and dialogues)” are called for by the APP Action Plan Guidelines. Activities such as on-site consultations, facility audits, workshops and training, meetings and conferences, stakeholder dialogues along with awards, recognition, and publicity for participants are all common in the identified industrial partnerships. The U.S. Climate Leaders program, for example, provides up to 80 hours of technical assistance – including on-site consultations -- to participating companies to help them develop an initial GHG emissions inventory and up to 10 hours annually to assist with updates or adjustments to the inventory.⁷⁶ US DOE's Industrial Technologies Program provides on-site Energy Savings Assessments for the largest industrial facilities, Plant-Wide Assessments for medium to large-sized industrial facilities, and audits by the Industrial Assessment Centers for small and medium-sized industrial facilities.^{77,78} Businesses that participate in the Australian Greenhouse Challenge Plus program receive assistance with developing their agreements, measuring and monitoring their GHG emissions, and reporting annually to the government and public on their achievements.⁷⁹ Climate Savers companies agree to share non-proprietary information about reducing emissions during the annual Climate Savers meetings.⁸⁰ Annual awards, such as the U.S. ENERGY STAR Partner of the Year awards, and other forms of recognition such as plaques and publicity through newsletters, websites, and publications are also provided by most industrial partnerships.

US DOE's Federal Energy Management Program (FEMP) provides a range of design and technical assistance, training, and outreach activities⁸¹. The SAVEnergy Audit is a comprehensive examination of the energy systems in your facility or building. The auditors evaluate the operating condition of your facility, assess its energy use, and identify operation and maintenance (O&M) activities. In order for SAVEnergy Audits to lead to more than simply a list of recommendations, agencies must be prepared from the onset to commit to reviewing the

⁷⁶ U.S. Environmental Protection Agency, 2005. *A Program Guide for Climate Leaders: Setting the Standard for Greenhouse Gas Management*. Washington DC: U.S. EPA.

⁷⁷ U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Industrial Technologies, 2005. *Save Energy Now*. Washington DC: U.S. DOE.
http://www1.eere.energy.gov/industry/saveenergynow/pdfs/save_energy_now_fs39112.pdf

⁷⁸ U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Industrial Technologies, 2006. *Energy Technology Solutions: Public-Private Partnerships Transforming Industry*. Washington DC: U.S. DOE.
http://www1.eere.energy.gov/industry/bestpractices/pdfs/itp_successes.pdf

⁷⁹ Australian Greenhouse Office, 2005. *Greenhouse Challenge Plus: A Big Plus for Business and the Environment*. Canberra: AGO.
<http://www.greenhouse.gov.au/challenge/publications/pubs/gcp-brochure.pdf>

⁸⁰ World Wildlife Fund (WWF), n.d. *Climate Change >> Featured Projects: Climate Savers*.
<http://www.worldwildlife.org/climate/projects/climateSavers.cfm>

⁸¹ The full list of services offered by FEMP is available at <http://www.eere.energy.gov/femp/services/index.html>

recommendations and implementing identified improvements where appropriate and feasible. This is especially relevant in the Indian context because the problem of low conversion of energy audits to energy efficiency projects – currently plaguing the Indian energy efficiency sector – was also encountered by FEMP during the early part of the SAVEnergy Audit program. USGBC provides top quality educational offerings on green design, construction, and operations for professionals from all sectors of the building industry. Perhaps the most well-known is the LEED Professional Accreditation that distinguishes individuals with detailed knowledge of LEED project certification requirements and processes and a command of integrated design principles. Initiated in 2001, Flex Your Power is a partnership of California's utilities, residents, businesses, institutions, government agencies and nonprofit organizations working to save energy through statewide energy efficiency marketing and outreach campaign. Flex You Power partnership includes retail promotions, a comprehensive website, an electronic newsletter, educational materials and advertising.

All three surveyed renewable energy partnerships include training workshops, and organize meetings and conferences for capacity building and information exchange as part of their activities. The REEP partnership was organized by the UK before it was converted into an international NGO. It includes regional secretariats that provide local training and expertise. It focuses on policy and finance and does not fund hardware projects, and has four projects in India.

Dissemination of Best Practice Information

The APP Action Plan Guidelines call for “measures to disseminate best practices”. Such measures can include information sharing through reports, guidebooks, case studies and software programs, technical assistance and support from industry experts, benchmarking – where a facility is compared to its peers or to global best practice, and development of energy or GHG management and reporting inventories or protocols. International Aluminium Institute's Aluminium for Future Generations program has assembled a team of leading industrial technical experts to provide advice and training on good practice from around the world. This program also provides its members with PFC emissions benchmarking reports annually⁸²; the Canadian Industry Program for Energy Conservation publishes sector-specific benchmarking guides⁸³; the Keidanren Voluntary Action Plan on the Environment program conducts an international comparison of energy efficiency in participating industries⁸⁴; the U.S. EPA ENERGY STAR for Industry benchmarks facilities to sectoral average energy consumption⁸⁵; and the U.S. Climate Leaders program evaluates proposed company targets against a projected benchmark GHG emissions improvement rate for each Partner's sector.⁸⁶ The Cement Sustainability Initiative and

⁸² International Aluminium Institute (IAI), 2006. The International Aluminium Institute Report on the Aluminium Industry's Global Perfluorocarbon Gas Emissions Reduction Programme: Results of the 2004 Anode Effect Survey. London: IAI. <http://www.world-aluminium.org/iai/publications/documents/pfc2004.pdf>

⁸³ Natural Resources Canada (NRCAN), 2001. *Energy Consumption Benchmark Guide: Cement Clinker Production*. Ottawa: NRCAN. http://oee.nrcan.gc.ca/publications/industrial/BenchmCement_e.pdf

⁸⁴ Nippon Keidanren (Japan Business Federation), 2005. Results of the Fiscal 2005 Follow-up to the Keidanren Voluntary Action Plan on the Environment (Summary) – Section on Global Warming Measures - <Performance in Fiscal 2004 >. <http://www.keidanren.or.jp/english/policy/2005/086.pdf>

⁸⁵ Boyd, G.A., 2006. Development of a Performance-Based Industrial Energy Efficiency Indicator for Cement Manufacturing Plants. Argonne, IL: Argonne National Laboratory. <http://www.energystar.gov/ia/business/industry/ANL-DIS-06-3.pdf>

⁸⁶ U.S. Environmental Protection Agency, n.d. *Setting a Greenhouse Gas Emissions Reduction Goal*. Washington DC: U.S. EPA.

the International Aluminium Institute both developed sector-specific GHG emissions inventory addenda for the World Business Council for Sustainable Development/World Resources Institute's Greenhouse Gas Protocol.^{87,88} Companies that join U.S. EPA's Climate Leaders are required to complete and maintain a high-quality, corporate-wide GHG emissions inventory.⁸⁹

All three renewable energy partnerships disseminate best practices through information sharing, technical assistance, and benchmarking.

Leveraging Resources

The APP Action Plan Guidelines note that "Action Plans will be most successful where they catalyze actions by the private sector and leverage resources available..." The Indian Industry Programme for Energy Conservation requires energy managers to present financially attractive investments to reduce energy costs to management annually.⁹⁰ Energy Action Plans developed for the Australian Greenhouse Challenge Plus program are required to list energy savings measures in order of their cost effectiveness using Internal Rate of Return (IRR) to rank measures or using Net Present Value (NPV) to assess the viability of a measure. The measures should then be grouped into those energy savings measures that exceed the organization's hurdle rate of return (cost of capital), including measures which can be implemented with little or no capital cost or which are highly cost-effective and energy savings measures that are below an organization's hurdle rate of return but which may become cost-effective with financial assistance.⁹¹ Businesses that participate in the Australian Greenhouse Challenge Plus program are eligible to receive more than \$3 million in fuel tax credits in a fiscal year.⁹² The Canadian Industry Program for Energy Conservation's Industrial Energy Innovators are eligible for a Government of Canada incentive of up to \$5,000 for a facility energy audit.⁹³ Companies that sign voluntary agreements with KEMCO in the Republic of Korea will be provided with low interest loans and tax incentives to promote energy conservation and greenhouse gas reduction.⁹⁴ The U.S. DOE's Industrial Technology Program provides funding for cost-shared research and

<http://www.epa.gov/stateply/docs/CLGoalsFactSheet.pdf>

⁸⁷ International Aluminium Institute (IAI), 2003. The Aluminium Sector Greenhouse Gas Protocol (Addendum to the WBCSD/WRI Greenhouse Gas Protocol) Greenhouse Gas Emissions Monitoring and Reporting by the Aluminium Industry. London: IAI. http://www.world-aluminium.org/environment/climate/ghg_protocol.pdf

⁸⁸ Vanderborght, B. and Brodmann, U., 2001. The Cement CO2 Protocol: CO2 Emissions Monitoring and Reporting Protocol for the Cement Industry Guide to the Protocol, Version 1.6. <http://www.wbcscement.org/pdf/co2-protocol.pdf>

⁸⁹ U.S. Environmental Protection Agency, 2005. *A Program Guide for Climate Leaders: Setting the Standard for Greenhouse Gas Management*. Washington DC: U.S. EPA.

⁹⁰ Bureau of Energy Efficiency, n.d. *Energy Managers: Responsibilities*. New Delhi: Government of India, Ministry of Power. <http://www.bee-india.nic.in/Energy%20Manager/Responsibilities.html>

⁹¹ New South Wales, 2005. *Guidelines for Energy Savings Action Plans*. Sydney: NSW Dept of Energy, Utilities and Sustainability.

<http://www.deus.nsw.gov.au/waterandenergysavings/Guidelines%20for%20Energy%20Savings%20Action%20Plans.pdf>

⁹² Australian Greenhouse Office, 2005b. *Greenhouse Challenge Plus: Membership for Receipt of Fuel Excise Credits from 01 July 2006: Joining Early is a Big Plus*. Canberra: AGO.

<http://www.greenhouse.gov.au/challenge/publications/pubs/gcp-fueltaxcredits.pdf>

⁹³ Natural Resources Canada (NRCAN), 2006. *Industrial Energy Audit Incentive: Program Guide*. Ottawa: NRCAN. <http://oee.nrcan.gc.ca/cipec/ieep/iei/products/AuditGuideE.cfm?attr=24#top>

⁹⁴ Korean Energy Management Corporation (KEMCO), 2005. *Voluntary Agreement*. http://www.kemco.or.kr/english/sub03_VA.asp

development projects and financial and technical support to inventors and small businesses for promising energy-saving concepts and technologies.⁹⁵

Efficient Lighting Initiative – a partnership between International Finance Corporation and China Standard Certification Center with the goal to develop and expand the ELI certification and branding system globally. The first phase of ELI was designed to lower market barriers to efficient lighting through a set of multi-country initiatives, local and global partnerships, and interventions tailored to individual country conditions. Such a collaborative approach and leveraging of resources can greatly aid in reducing the cost of developing standards and labeling programs in a region and at the same time promote free trade by reducing barriers. Similarly, National Fenestration Rating Council develops consensus energy performance rating/labeling indicators by harmonizing testing methods for specification of energy performance of fenestration products. ASHRAE's Standards, Efficiency Valuation Organization's International Performance Measurement and Verification Protocol (IPMVP), and USGBC's LEED Rating development efforts rely on the knowledge and expertise of volunteers to develop technically rigorous documents that are adopted widely. The ability of such organizations to attract leading experts and stakeholders to come together and serve on a prestigious technical committee is an excellent example of leveraging an organization's modest resources to achieve outstanding results.

Methane to Markets partnership provides financial assistance to its member countries, including India, and funds discrete projects in addition to supporting capacity building and technology transfer activities. It places a strong emphasis on cost sharing. Likewise, the Million Solar Roofs Initiative, a domestic US initiative, provides grants to local partnerships to perform solar projects.

6. APP -- Business and Technology Cooperation Benefits

Future growth in energy demand will place considerable stress on India's ability to garner domestic and imported energy supplies. Continued energy shortages and environmental pollution, particularly in urban areas, may be exacerbated, as the country continues to be vulnerable to potential oil and gas supply disruptions, and to the volatility of petroleum crude prices. Exclusive dependence on supply sources would aggravate the energy security risk posed by such disruptions.

International public-private partnerships offer an effective approach to addressing this risk. A US-India strategic partnership to build capacity to plan and implement energy programs is already underway through the US-India Energy Dialogue. The Asia Pacific Partnership (APP) complements this activity and offers an international process that will focus on energy and clean development technologies. It will help advance India's energy security and mitigate the environmental impact of strong energy growth, particularly coal. This review of technologies and partnerships suggests the following activities that could assist the country in achieving this goal.

⁹⁵ U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Industrial Technologies, 2006c. *Financial Opportunities*. <http://www1.eere.energy.gov/industry/financial/index.html>

Improving energy efficiency, combined with an emphasis on renewable energy and clean coal development, is a core element of the APP task forces. While coal and other fossil fuels play a major role in the country's energy mix, India has made great strides in improving the energy productivity of its economy since the early 1990s, and it has devoted resources and raised the profile of renewable energy through its Ministry of Non-conventional Energy Sources. The APP offers various benefits to its partners that are illustrated in Tables 4, 5 and 6 in six major categories. The APP Task Forces are currently formulating action plans that include projects to address these categories of activities. Below, we summarize the lessons learned from the review and the role that APP TFs could play in supporting India's public and private sector enterprises through partnership activities.

Enhancing APP Participation

Entities at all levels would benefit through APP participation. The progress made in the US, China, and Japan and in some key sectors (cement for example) in India offers valuable lessons on the role of energy efficiency and renewable energy for all its partners. In the former three countries, energy efficiency is being promoted at all levels. Federal and state governments, utility companies and regulators, private industry and non-profit associations, and energy service companies, all play important roles in promoting the efficient use of energy. Efficiency improvement is being achieved through both mandatory and voluntary means, through federal and state government programs, through better business practices and vigilant non-profit associations in these. India could benefit by encouraging participation in the APP from central and state government agencies and the private sector.

States and local bodies including city governments have a strong role to play. In India, the thrust on energy efficiency has largely focused at the central government level with increasing involvement of the private sector. The engagement of the state government in these activities has been limited. The need, content and strategic thrust of a state energy conservation program may differ from state to state depending upon its size, energy resource mix, the nature and pattern of energy demand, status of power sector reforms and size and growth of the power sector. Reducing the fiscal deficit through energy efficiency measures is perhaps one of the strongest arguments for instituting a state level energy efficiency program. Efficiency offers a cost-effective near-term solution to electricity shortages, and consequently the increased and better quality of electricity supply can amplify industrial production and government tax revenue. The participation of state government agencies, state utility companies and regulatory commissions in the APP process would bring significant benefits through skills enhancement, and knowledge and technology transfer.

The REEP partnership offers a successful example of an organizational structure that seeks to maximize local input in its operations. It is run by regional secretariats that are based in several countries and thus able to provide local/regional expertise and access for enhancing local technologies and practices. The APP could benefit through a similar structure in India and perhaps other partner countries by setting up country-specific secretariats that are better able to identify, engage and deliver local business and public sector talent and expertise in its activities. .

Sector Review

The APP Action Plan Guidelines call for information on the current status, baseline information, evaluation of potential options, and identification of barriers and policy opportunities. About half the reviewed partnerships call for a sector review. Unlike the industrial sector, the buildings sector stands out in its emphasis on evaluation of barriers and programmatic activities.

The APP includes this category since it provides a valuable context for members to understand the performance of their technologies relative to that in other countries and seek ways for its improvement through partnership activities. APP sector reviews would include items such as the collation and reporting of existing data on shares of production by industry category (Figure 8), current institutional status and goals of a country's energy programs (Section 3 above), a listing of options that are available for improving industrial energy efficiency (Appendices B-1,2, and 3), and so forth. In buildings sectors a review would put more emphasis on a discussion of barriers and policy and programmatic options that are being pursued in a country for their removal. To the extent possible a quantification and appropriate classification of the barriers would help in improving the targeting of programs and policies.

A sector review is also likely to reveal the paucity of data in some countries. Figure 12 shows the lack of data on buildings energy performance in India relative to that in the industrialized countries. Regularizing data collection and analysis would help to quantify technology performance, its cost-effectiveness, role of barriers, identification of beneficiaries, and targeting of government and industry policies, programs, and measures.

Goal Setting and Performance Indicators

The APP Action Plan Guidelines include the development of action plans, setting commitments, targets, and/or agreements, and common metrics in order to measure progress towards a goal. The partners may be private companies that commit to adhere to a voluntary or mandatory target of energy efficiency improvement, reduction of CO₂ emissions, etc. The target may be an intensity or absolute energy or emissions target. About two-thirds of the reviewed partnerships included goals and metrics so that participants could measure their own progress and seek or provide assistance to other members as needed. Renewable and energy performance standards, harmonization of test procedures and stand-by power standards for household electronic products, land rehabilitation and worker safety goals in coal mining activities, energy intensity targets in cement production are some examples of the types of goals that participants could agree on. Obviously, these goals would have to be consistent with each country's own laws and regulations.

Skills Enhancement, Commercial and Information Exchange

The APP Action Plan Guidelines include activities such as on-site consultations, facility audits, training, meetings, conferences; and stakeholder dialogues along with awards, recognition, and publicity for participants. Coverage of these activities varies among the 34 reviewed partnerships. A majority include conferences, workshops and stakeholder dialogues, but only a few offer on-site consultations and facility audits to their participants.⁹⁶ APP action plans under preparation include workshops and regular consultations both at the Task Force and APP overall levels. Awards, recognitions and publicity are yet to be widely recognized within the APP framework

⁹⁶ Free audits have been derided in the past since they raise long-term customer expectations of free services.

but could play an important role in the partnership context. India's BEE program's industrial partnership includes this activity as an element of its approach to promoting energy efficiency in industry that could be shared with other countries. The APP Buildings and Appliances Task Force plans to develop building energy modeling capacity through professional training to promote energy efficiency in new construction in India. Similarly the Renewables TF proposes to conduct training on the assessment of renewable energy resources in India.

Dissemination of Best Practice Information

The APP Action Plan Guidelines call for "measures to disseminate best practices". Such measures can include information sharing through reports, guidebooks, case studies and software programs, technical assistance and support from industry experts, benchmarking – where a facility is compared to its peers or to global best practice, and development of energy or GHG management and reporting inventories or protocols. Coverage of these activities varies among the 34 reviewed partnerships varies with a majority pursuing information sharing and providing technical assistance with support from industry experts, about half focusing on the reporting of GHG inventories using common protocols, but relatively few, about one-third, pursuing benchmarking.

Sharing of tools for benchmarking including metrics to measure energy intensities of specific processes in each APP task force activity would enhance the partnerships value to its private sector partners. The APP Cement Sector Task Force is considering such an activity. Other APP task forces are considering information sharing between private sector partners as an important mechanism for fostering future exchange of knowledge and technologies. The Power Generation Task Force has scheduled a site visit to a US power plant to share experiences about its modern technologies and operating practices as a means for transparent transfer of technology. The site visit will focus on ways to improve heat rates and on two IGCC units that are under construction and a planned ultrasupercritical pulverized coal unit at American Electric Power sites in the US. Sharing building certification practices, ways to design and implement building codes, conduct monitoring and evaluation of energy efficiency and energy generation, design and implement product procurement, trigger market transformation to increase penetration of energy efficient products are ways that APP could provide useful inputs to their implementation in India. The Aluminium TF proposes to PFC management and measurement workshops that from experience in the US and Japan indicates would result in significant CO₂ equivalent reductions. The Coal Mining TF proposes to pursue a coal beneficiation, economic modeling, analysis and case studies to highlight problems with Indian coal supply and ways to resolve them. These will be disseminated to Indian coal industry. The Steel TF has proposed the development of a handbook of best available technologies for steel production and utilization.

Leveraging Resources

The APP Action Plan Guidelines note that "Action Plans will be most successful where they catalyze actions by the private sector and leverage resources available..." The development of a portfolio of investment opportunities and provision of financial assistance through cost sharing, tax rebates, etc. are ways that permit the leveraging of resources. Few of the reviewed partnerships include these types of activities. But partnerships in APP countries cited in Tables 4 and 5 in India, Australia, US, China and South Korea pursue one or both activities. The APP could provide support for public and private sector partner companies that wish to prepare a

portfolio of investment opportunities in the relevant product lines and/or sectors, such as those illustrated by the cost curve in Appendix A. The Buildings and Appliance APP task force plans to identify and share successful models of innovative approaches for overcoming barriers to financing of and contracting for energy efficiency programs, including performance contracting for energy service companies (ESCOs). The Renewable Energy and Distributed Generation Task Force proposes to assist in the prioritization of hydropower projects and conduct industry outreach in India.

As mentioned above and discussed in Section 5.1 on leveraging resources, partnerships provide financial assistance to domestic industry in several APP countries. Extending these resources to other countries occurs usually through foreign aid programs. There are several ongoing activities funded and managed by USAID in India that APP could build on in a partnership format. Examples of these extensions include the introduction of advanced monitoring technologies aimed at improving coal-fired station heat rates, detailed design engineering and project implementation of an IGCC demonstration plant, setting up of regional energy efficiency centers, and supporting risk mitigation of renewable energy investments in distributed generation (DG) technologies in rural areas (see Appendix C for more information on these activities). In each case APP public and private partners would engage with their respective counterparts to define the need and share resources as appropriate.

Technology Research, Development, Dissemination, and Deployment and Technology Transfer

Guidance regarding the APP Action Plans also calls for “technology-based research, pilot projects, demonstration, and deployment activities” and asks that the plans identify “opportunities to enhance the enabling environment for technology research, development, deployment, dissemination and transfer”. The U.S. Department of Energy’s Industrial Technologies Program and Building Technologies Program are the sole industrial and buildings sector partnerships identified in our review that include such activities and so does the Methane to Markets renewable energy partnership. The latter does not address technology-based research, however, and the former two cater to US entities.

The US national laboratories are an example of an important source of APP-relevant technologies that APP private and public partners can access. The United States has over 700 federal laboratories, most of them are government-owned and government-operated (GOGO), and the rest are government-owned and contractors-operated (GOCO). The overall US federal funding for R&D amounted to \$23.2 billion, which resulted in about 3000 active licenses in FY 2001. Federal agencies collected about \$60 million of income from these licenses.

The US Department of Energy (USDOE) owns 24 laboratories and facilities and 22 of them are GOCOs, e.g., the Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory, National Renewable Energy Laboratory, and Oakridge National Laboratory. National Energy Technology Laboratory is an example of a GOGO. The DOE annual R&D budget was \$4.9 billion in 2001, and it employs about 14,500 Federal and 100,000 contractor employees.

The Lawrence Berkeley National Laboratory (LBNL) is one example of a GOCO that is managed by the University of California for the US Department of Energy. There are two basic ways that industry can access technologies funded by the US government at the laboratory.⁹⁷ One approach is to seek licenses to technologies that were developed at LBNL, and another is to conduct research jointly with laboratory scientists in a public private partnership. Two Indian and two Chinese companies have a non-exclusive license to LBNL technologies at present. In the second approach, DOE and industry jointly sponsor a research project. Costs, personnel, facilities, equipment, or research capabilities may be shared for mutual benefit. This provides industry with a way to leverage their research activities. IBM and Intel (lithography) are two multinational companies that have cooperative agreements with LBNL.

LBNL will only license to companies that are able to marshal the financial, manufacturing, marketing, and managerial requisites. Once a company is found to possess the necessary capabilities, the licensing staff negotiates a licensing agreement. Different inventions require different licensing strategies. For example, a common strategy for a new scientific tool likely to be widely used is to license it on a non-exclusive basis (i.e., to more than one company or user). In contrast, an invention that requires a significant investment to bring it to market is typically exclusively licensed to a single company. Licenses may also be exclusive or non-exclusive for a particular field of use or geographic region. When an agreement grants an exclusive license for the U.S. market, the licensee must substantially manufacture the technology in the U.S. The U.S. government is granted a fully paid-up, nontransferable, non-exclusive license to use the invention for government purposes only, as is the case with other federally funded inventions.

Both exclusive and non-exclusive licenses may be accessed by US and foreign companies. The Lab does not discriminate between US and non-US entities in its selection of companies that will be permitted an exclusive or non-exclusive license. All other things being equal, however, US small businesses gets a preference, and exclusive licenses to non-US entities are referred to the Department of Energy, which in turn may consult with the office of the US Trade Representative to ensure compliance with the export control regime.

A private industry can access technologies and tailor these further to suit its needs. Further development may be done by sponsoring research for this purpose at LBNL. The resulting new patents may then be shared between private industry and LBNL on a mutually agreed basis.

A partial list of the types of APP-relevant technologies that can be licensed from national laboratories is shown in Appendix D. These include technologies related to new materials, batteries and fuel cells, building ventilation, windows, lighting, new windmills, PV systems and so forth. APP participants can also participate in visits to learn about results of new research at the laboratories on these and other technologies and at private entities such as the aforementioned IGCC plants under construction that are being demonstrated in the US. Currently there are 850 participating foreign guest researchers at LBNL alone with 51 from India and 175 from China.

While the above discussion highlights the role of US national laboratories, the mechanism for accessing technologies from other national laboratories and universities in the US and other APP

⁹⁷ <http://www.lbl.gov/Tech-Transfer/index.html>

countries is very similar. APP could investigate this further in putting together a viable mechanism for providing technology information and ways to access these technologies in a coordinated manner.

Technology cooperation between APP countries requires that entities with common clean development and climate goals and activities exist in the participating countries, which is not the case today. At the federal level, in the US, the DOE and EPA has several hundred staff members, and combined with the expertise at the national laboratories, thousands of staff are engaged in various facets of energy and global environment research, demonstration, development and transfer of technology. The US state governments, utility companies and commissions have similar magnitude of expertise for promotion of energy efficiency. Cooperating with other APP countries, including India, would require that entities with similar functions (not necessarily the same structure) exist in the country. Energy efficiency and fossil energy centers are an example of effective counterparts for cooperative research and as recipients of technologies that are being developed at the national laboratories in the US and other APP countries (Appendix C).

Acknowledgements: The lead author (Jayant Sathaye) would like to thank S. Padmanabhan and Archana Walia, USAID, Delhi, for their gracious and unwavering support for the project and substantial inputs to the draft, Stephanie Smith Kinney and Satish Kulkarni, State Department and Graham Pugh, Jarad Daniels, US DOE for fruitful discussions, and for providing inputs on the Renewables and Power Sector TFs respectively and Corina Warfield, USDOE for her work on renewable energy partnerships, Stephane de la Rue du Can for obtaining historical data from the International Energy Agency (IEA) on energy and from the World Bank on country economics and demographics, and preparing the energy indicators, Lynn Price for data and information on US and other industrial energy programs, Maithili Iyer and Michael McNeill for contributing data and information on energy use in four products in India, Satish Kumar and Jeff Harris for the information on US and Indian buildings energy efficiency programs, Amol Phadke for his analysis of India's captive power needs and its diesel fuel implications, Cheryl Fragiadakis for information on LBNL technology transfer program, Tom Wilbanks, Oakridge National Laboratory and Ravi Upadhye, LLNL, for sharing a list of technologies available for licensing, and Scott Smouse, NETL for assistance on power sector technologies. This work was a collaborative effort among all the above contributors and would not have been possible without their critical inputs. Any errors or omissions in the document are the responsibility of the lead author (Jayant Sathaye) and should not to be attributed to the contributors.

Appendix A
Supply curves for energy efficiency and GHG emissions reductions
(Conservation Supply Curves)

Conservation Supply Curves (CSCs) have been a primary analytic tool for evaluating the economic benefits of energy efficiency for over two decades now. These have been constructed for the major energy demand sectors, and the energy savings have been translated into corresponding GHG emissions reductions in many countries. A CSC plots the marginal cost of conserved energy by a mitigation option against the total amount of energy conserved. Equation 1 shows the parameters used in estimating the marginal cost of conserved energy. CSCs apply to a mitigation option taken on top of some standard base case, and after the next most energy efficient package.

$$CCE = \frac{I \cdot q}{ES} \text{-----(1)}$$

$$q = \frac{d}{(1 - (1 + d)^{-n})}$$

Where:

CCE = Cost of conserved energy for a mitigation option, in \$/kWh

I = Capital cost (\$)

q = Capital recovery factor (yr⁻¹)

ES = Annual energy savings (kWh/yr)

d = discount rate

n = lifetime of the option (years)

Earlier analyses of energy efficiency options typically ignored other effects of their implementation. These effects include changes in labor, material, and other resource requirements that are often monetizable, and others such as reduced pollution due to decreased use of electricity and other fuels that may be more difficult to quantify, and in particular more difficult to attribute to a mitigation measure. Adding monetizable effects that are attributable to an energy efficiency option can increase or decrease the cost of conserved energy. These may be expressed as shown in Equation 2.

$$CCE = \frac{I \cdot q + M}{ES} \text{-----(2)}$$

Where

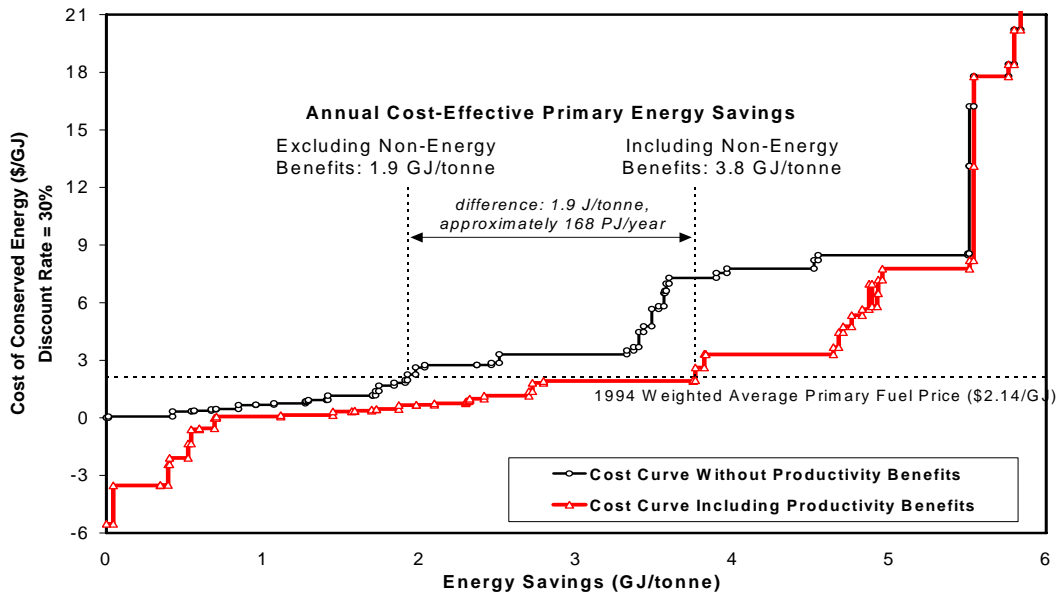
M = Annual change in labor, material and other costs, and monetizable benefits (\$/yr)

Accounting for such “hidden benefits” requires that bottom-up models look beyond the energy markets and examine the cost considerations in light of their impact on other resource markets. One example is reported by Worrell et al. (2003) for the US iron and steel industry.⁹⁸ They report

⁹⁸ Worrell, E. J.A. Laitner, M. Ruth and H. Finman. 2003. “Productivity Benefits of Industrial Energy Efficiency Measures” *Energy* 11, 28, pp.1081-1098 (2003).

a cost effective annual primary energy savings of 1.9 GJ/tonne of output for this sector due to the implementation of an array of 47 measures (Figure A1). Inclusion of labor and material cost savings during the operation of an efficient iron and steel plant, however, increases the potential to 3.8 GJ/tonne of output at the same cost. More importantly, the ranking of technologies changes dramatically; an oxy-fuel burner ranked # 41 when only energy cost savings are included becomes the # 1 technology to implement. Inclusion of all resource benefits thus is crucial to understanding the full cost impacts of a technology. This may be particularly relevant to end-use energy efficiency technologies whose main goal often is not providing or saving energy but providing some other form of service or the production of an industrial product.

Figure A1: Conservation supply curves with and without including non-energy benefits, US steel industry (Worrell et al. 2003)



**Appendix Table B-1.
Energy-Efficient Technologies and Measures for Steel Production.**

Overall Measures (measures apply to both integrated and secondary plants)	
Preventative maintenance	
Energy monitoring and management systems	
Variable speed drives for flue gas control, pumps, and fans	
Cogeneration	
Integrated Steel Making Measures	Secondary Steel Making Measures
<i>Iron Ore Preparation (Sintermaking)</i>	<i>Electric Arc Furnace</i>
Sinter plant heat recovery	Improved process control (neural networks)
Use of waste fuels in the sinter plant	Flue gas monitoring and control
Reduction of air leakage	Transformer efficiency measures
Increasing bed depth	Bottom stirring/gas injection
Improved process control	Foamy slag practices
<i>Coke Making</i>	Oxy-fuel burners/lancing
Coal moisture control	Post-combustion
Programmed heating	Eccentric bottom tapping (EBT)
Variable speed drive on coke oven gas compressors	Direct current (DC) arc furnaces
Coke dry quenching	Scrap preheating
<i>Iron Making - Blast Furnace</i>	Consteel process
Pulverized coal injection (medium and high levels)	Fuchs shaft furnace
Injection of natural gas	Twin shell DC arc furnace
Top pressure recovery turbines (wet type)	
Recovery of blast furnace gas	
Hot blast stove automation	
Recuperator on the hot blast stove	
Improved blast furnace control	
<i>Steel Making - Basic Oxygen Furnace</i>	
BOF gas & sensible heat recovery (suppressed combustion)	
Variable speed drive on ventilation fans	
CASTING AND ROLLING (measures apply to integrated and secondary plants unless otherwise specified)	
<i>Casting</i>	
Adopt continuous casting	
Efficient ladle preheating	
Thin slab casting	
<i>Rolling</i>	
Hot charging	
Recuperative burners in the reheating furnace	
Controlling oxygen levels and variable speed drives on combustion air fans	
Process control in the hot strip mill	
Insulation of furnaces	
Energy efficient drives in the hot rolling mill	
Waste heat recovery from cooling water	
Heat recovery on the annealing line (integrated only)	
Automated monitoring & targeting system	
Reduced steam use in the pickling line	

Source: Worrell et al., 1999.

Appendix Table B-2.
Energy-Efficient Technologies and Measures for Cement Production.

Raw Materials Preparation

Efficient transport systems (dry process)
 Slurry blending and homogenization (wet process)
 Raw meal blending systems (dry process)
 Conversion to closed circuit wash mill (wet process)
 High-efficiency roller mills (dry process)
 High-efficiency classifiers (dry process)
 Fuel Preparation: Roller mills

Clinker Production (Wet)	Clinker Production (Dry)
Energy management and process control	Energy management and process control
Seal replacement	Seal replacement
Kiln combustion system improvements	Kiln combustion system improvements
Kiln shell heat loss reduction	Kiln shell heat loss reduction
Use of waste fuels	Use of waste fuels
Conversion to modern grate cooler	Conversion to modern grate cooler
Refractories	Refractories
Optimize grate coolers	Heat recovery for power generation
Conversion to pre-heater, pre-calciner kilns	Low pressure drop cyclones for suspension pre-heaters
Conversion to semi-dry kiln (slurry drier)	Optimize grate coolers
Conversion to semi-wet kiln	Addition of pre-calciner to pre-heater kiln
Efficient kiln drives	Long dry kiln conversion to multi-stage pre-heater kiln
Oxygen enrichment	Long dry kiln conversion to multi-stage pre-heater, pre-calciner kiln
	Efficient kiln drives
	Oxygen enrichment

Finish Grinding

Energy management and process control
 Improved grinding media (ball mills)
 High-pressure roller press
 High efficiency classifiers

General Measures

Preventative maintenance (insulation, compressed air system, maintenance)
 High efficiency motors
 Efficient fans with variable speed drives
 Optimization of compressed air systems
 Efficient lighting

Product & Feedstock Changes

Blended Cements
 Limestone cement
 Low Alkali cement
 Use of steel slag in kiln (CemStar®)
 Reducing fineness of cement for selected uses

Source: Worrell and Galitsky, 2004.

Appendix Table B-3.
Energy-Efficient Technologies and Measures for Aluminium Production.

Bauxite Mining

Design and gradients of haul routes
 Logistical planning of mine face activity to minimize haul distances
 Optimization of blasting and ripping techniques from the perspective of reducing milling requirement
 Increased use of cost-effective solar applications
 Fuel recording and maintenance practices to optimize fuel efficiency of haul trucks
 Research and development support to haul truck manufacturers to develop more fuel-efficient vehicles

Alumina Refining

Improved thermal efficiency for heat exchange into slurries, alumina calcinations, and evaporation
 Improved co-generation energy efficiency
 Improved compressed air systems

Aluminium Smelting

Improved smelter fume systems
 Improved compressed air systems
 Improved anode plant operations
 Improved casthouse operations
 Optimized burner positioning to enhance heat transfer in reverberatory furnaces
 Improved air tightness in furnaces
 Heat recovery devices on exhaust stacks of aluminium melting furnaces
 Heat recover systems: heat exchangers and heat regenerators
 Melting of secondary aluminium using oxy-fuel
 Circulating pump in melting furnaces
 Real-time controls for cooling aluminium ingots

Semi-Fabrication

Die oven management (extrusion only)
 Improvements in heat recovery and process optimization
 Automated process control
 Variable speed drives for presses and in rolling mills
 Improved compressed air and lighting systems
 Ingot heating

General Measures

Use of high-performance motors
 Installing variable speed drives on electrical motors
 Optimizing operation of ventilation systems
 Installation of insulating material

Sources: Baillargeon, et al., 1998; Commonwealth of Australia, 2000.

Appendix C

USAID India Activities That Could be Leveraged for the APP Program

- a. Power Generation & Transmission TF: Introduction of a variety of advanced condition-monitoring technologies aimed at improving coal-fired station heat rates. These on-line technologies will be networked through a centralized monitoring system that provides real time solutions. A typical system will cover coal-fired power plants of select SEBs through a master controller arrangement executed through a series of "expert systems" that form an advanced intelligent heat rate improvement algorithm and network. Under a phased program, all SEB coal fired stations in the country could be similarly networked. CENPEEP, NTPC established in partnership with NETL/DoE under AID's GEP project could be engaged in this task.
- b. In support of the above, APP could promote partnerships between US private sector power plant "service providers" and their counterpart entrepreneurs in India. The Clean Coal Business Development Council of CII-GBC could be entrusted with the task of developing these business partnerships.
- c. Clean Fossil Energy TF: Detailed design engineering and project implementation of a 100 MW commercial demonstration IGCC plant operating on run-of-mine high ash Indian coals. As per a current USAID/I supported study, the capital requirements for such a demo plant is around \$ 1600/Kw and that of a future commercial plant in India could be well within the competitive range of \$ 600-750/kW. Over 60% of the 100,000 MW power demand required in the next ten years in India are to be provided by coal. So, IGCC plants could potentially have a very large market size in India. Capturing CO₂ from syngas is substantially easier and less costly than that from coal fired boiler flue gas because of the smaller gas volume, higher pressure and higher CO₂ concentration of the syngas all facilitate the CO₂ capture. If CO₂ capture for climate change becomes a pressing issue in India and for APP, the IGCC technology can become even more competitive.
- d. Buildings & Appliances TF: APP could support the development of Energy Efficiency Regional Centers in India aimed at building public education and awareness, business development and market transformation. Currently two of five such centers are being developed under a public-private partnership in the areas of efficient illumination (at Bangalore) and efficient electrical motors and motor drives (Hyderabad). Both these centers are a outcome of previous work done by USAID under the ECO and GDA programs respectively. Additional centers have been informally discussed with the MoP, GoI on efficient home appliances (Kolkata), agricultural pumpsets (Chandigarh), eco-housing/green buildings (Pune) and HVAC (Delhi).
- e. Renewable Energy and Distributed Generation (DG) TF: APP could support risk mitigation of renewable energy investments in DG technologies through technology and business partnerships that advance access of electricity supply to rural areas in India. This can build on the current efforts of US private sector groups such as GE who are working in partnership with Indian private and public groups to establish off-grid RE systems in select Indian states. Also build on the efforts of USDA's RUS program with India's REC supported under USAID/T's DRUM Project.

Appendix D

A. Examples of APP Relevant LBNL Technologies Available for Licensing

(<http://www.lbl.gov/Tech-Transfer/techs/index.html>)

- [Zinc-Nickel Oxide Battery](#)
- [Cost Effective Method for Removing Arsenic from Water](#)
- [Gas Filled Insulating Panels](#)
- Aerosol Sealing:
 - [Aerosol Remote Sealing System](#)
 - [Clog-free Atomizing and Spray Drying Nozzle](#)
- [Aerogels](#)
- [Electrochromic Device Controlled by Sunlight](#)
- [Energy Efficient Laboratory Fume Hood](#)
- Energy Efficient Lighting:
 - [High Performance, Energy Efficient Table Lamp](#)
 - [Lighting Control System - Phase Cut Carrier](#)
- [EnergyPlus:Energy Simulation Software for Buildings](#)
- [Gas Filled Insulating Panels](#)
- [Lean Flame Stabilization Ring Converts Natural Gas Burners to Burn Lean](#)
- Low Cost, Stable Switchable Mirrors
 - [Lithium Ion Mirrors with Improved Stability](#)
 - [Transition Metal Switchable Mirrors](#)
- [Solid Oxide Fuel Cells](#)

B. Examples of APP Relevant ORNL Technologies Available for Licensing

- Remote Monitoring of Building Operations:
http://www.ornl.gov/sci/engineering_science_technology/sms/Hardy%20Fact%20Sheets/Remote%20Monitoring.pdf
- Refrigerant Charge Indicator:
http://www.ornl.gov/sci/engineering_science_technology/sms/Hardy%20Fact%20Sheets/Refrigerant%20Charge%20Indicator.pdf
- Cost Effective Smart Materials for Diesel Engines:
http://www.ornl.gov/sci/engineering_science_technology/sms/Hardy%20Fact%20Sheets/Cost-Effective%20Smart.pdf
- Technologies for the Assessment of Heat Damage to Composite Materials and Structures:
http://www.ornl.gov/sci/engineering_science_technology/sms/Hardy%20Fact%20Sheets/Technologies.pdf
- Fluorescent Coatings for Turbine Engine and Thermal Barrier Coating Diagnostics:
http://www.ornl.gov/sci/engineering_science_technology/sms/Hardy%20Fact%20Sheets/Fluorescent%20Coatings.pdf
- High-Temperature Superconductivity:
<http://www.ornl.gov/sci/htsc/documents/archives/factsheet.htm>
- Triple-Voltage DC/DC Converter:
http://www.ornl.gov/adm/tted/available_technologies/new/172.shtml

- Thin Film Lithium Batteries:
<http://www.ornl.gov/sci/cmsd/main/Programs/BatteryWeb/Applications.html>;
http://www.ornl.gov/adm/tted/available_technologies/ps/thin_film_lithium.shtml
- Substrates for Photovoltaic Cells:
http://www.ornl.gov/adm/tted/available_technologies/ps/photovoltaic_cells.shtml

C. Examples of APP Relevant LLNL Technologies Available for Licensing
(<http://www.llnl.gov/IPandC/technology/portfoliopprofile.php>)

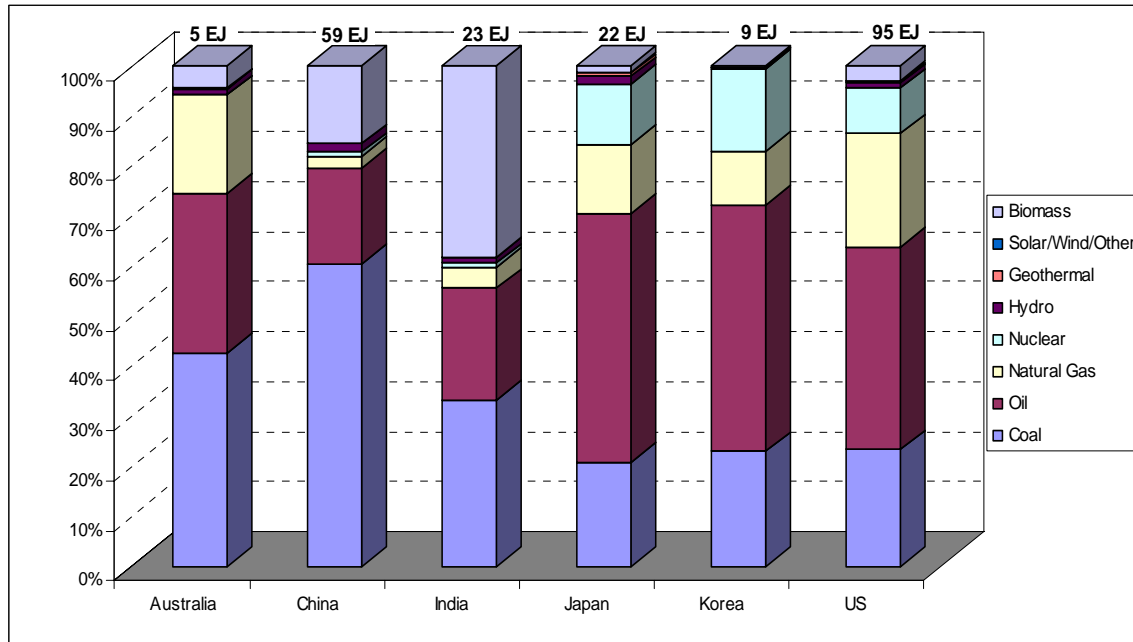
Sensors, Electronics, and Instrumentation

Integrated Emissivity and Temperature Measurement of a Surface
Harvesting Energy from Abundant, Low Quality Sources of Heat
Smart Borehole Casings

Energy

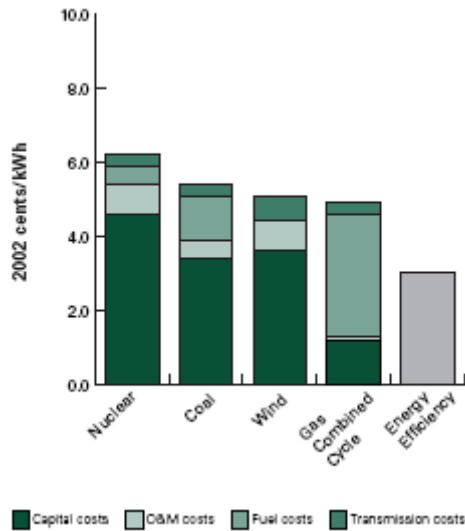
Gradient Porous Composite Membrane for Fuel Cell Applications
Gradient Porous Composite Membrane for Fuel Cell Applications
Modular Electromechanical Batteries for Cost-Effective Bulk Storage of Electrical
Energy
Harvesting Energy from Abundant, Low Quality Sources of Heat
Smart Borehole Casings

Figure 1: Primary energy supply fuel shares in APP countries



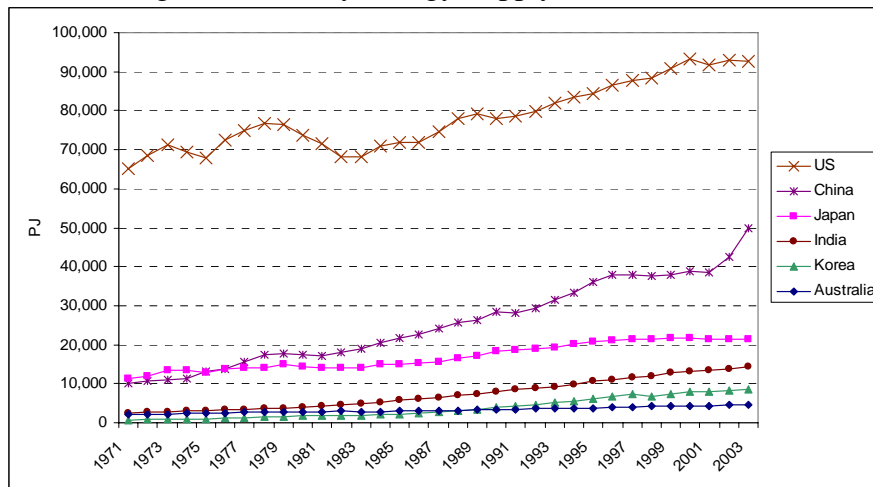
Source: International Energy Agency, Paris

Figure 2: Energy efficiency is competitive with generation technologies



Source: US EPA (2006). *Clean Energy-Environment Guide to Action*. Pre-publication draft.

Figure 3: Primary Energy Supply (Excl. biomass)



Source: International Energy Agency, Paris, France.

Figure 4: Primary Energy Supply (Excl. biomass) per capita (Indexed to 1971=100)

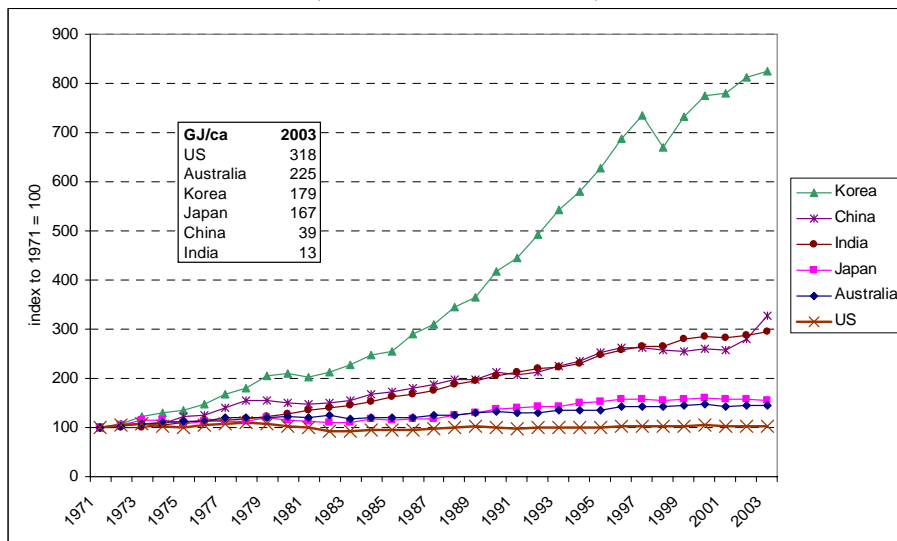
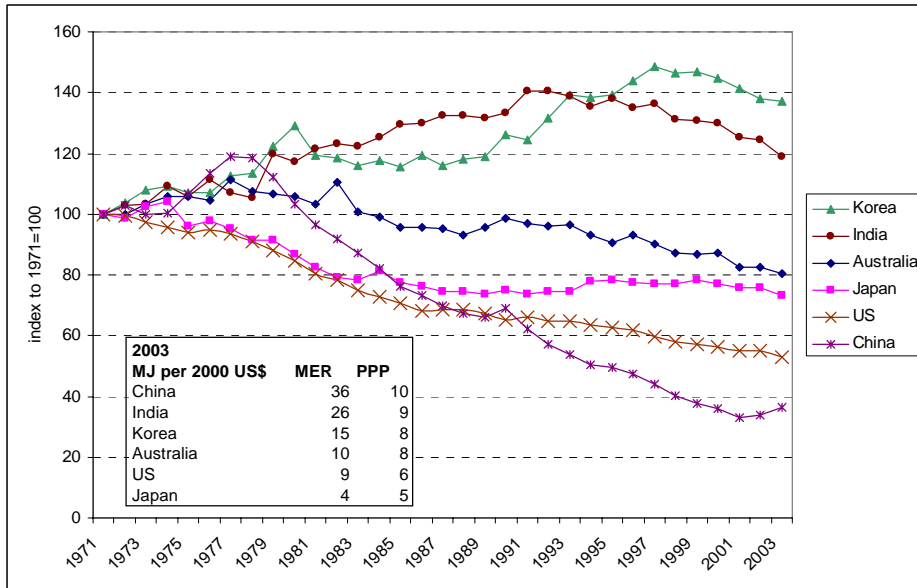
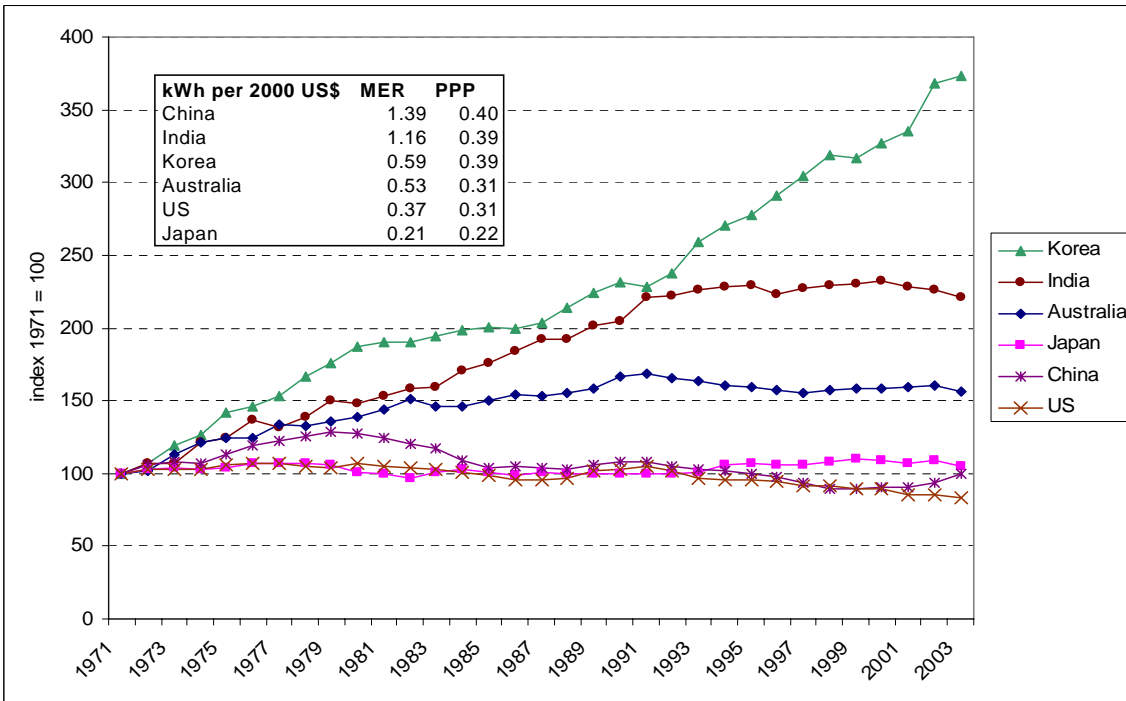


Figure 5: Primary Energy Supply /GDP
(PJ/2000 US \$ MER; Excl. traditional biomass, Indexed to 1971=100)



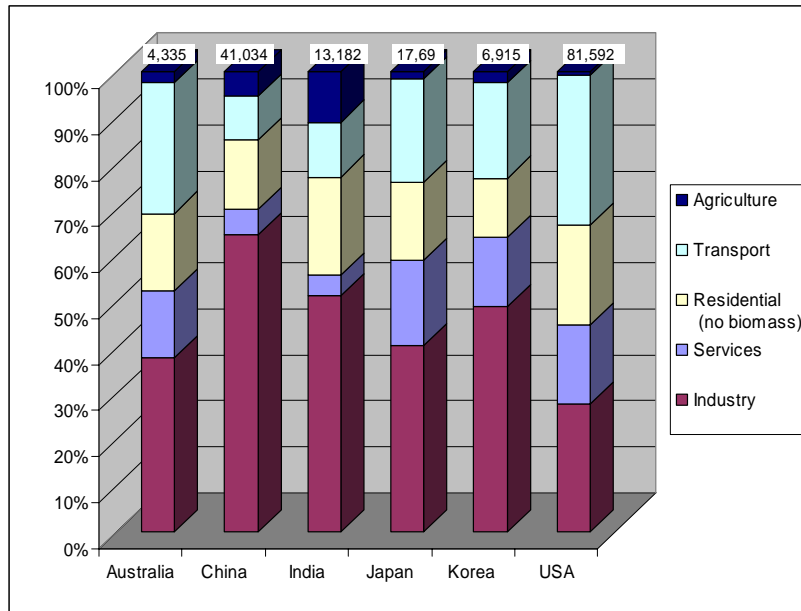
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 6: Electricity Generation/GDP
(kWh / 2000 US \$ Market Exchange Rate (MER), Indexed 1971=100)



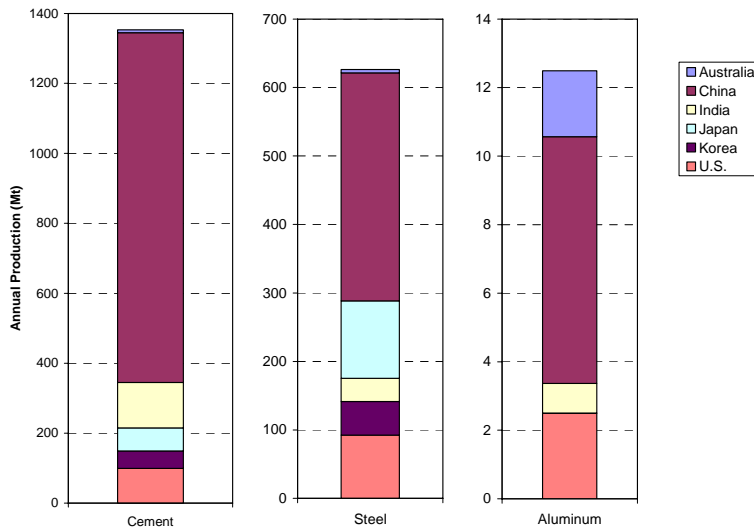
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 7: Primary Energy Supply Shares, APP Countries



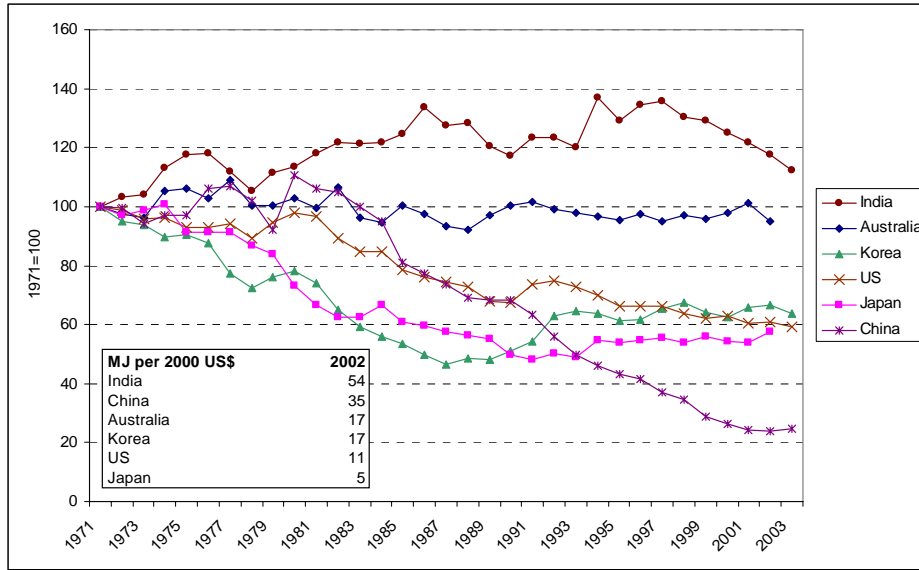
Sources: International Energy Agency, Paris, France

Figure 8. Annual Production of Cement, Steel, and Aluminium in the Asia Pacific Partnership Countries. *Note different scales.*



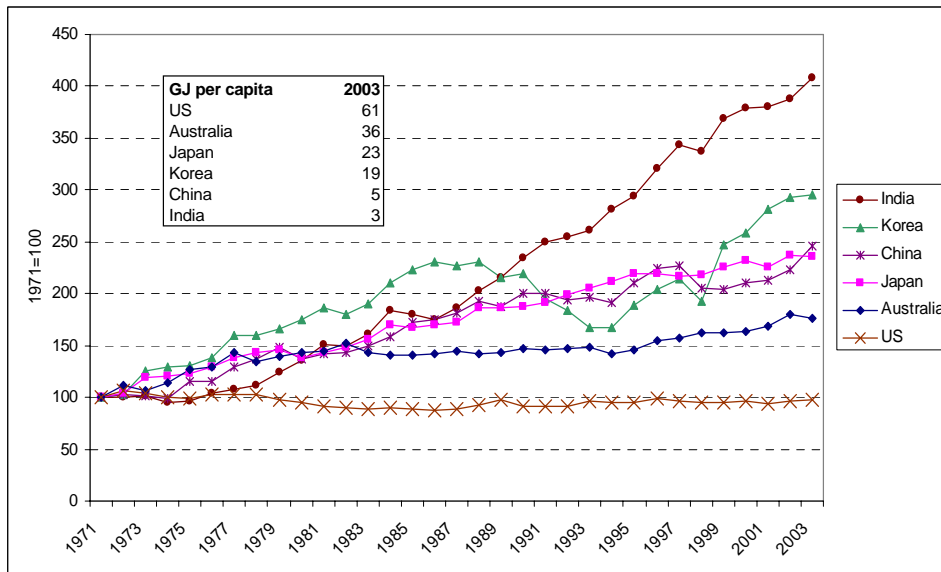
Sources: CIF, 2005; USGS, 2006a; USGS 2006b; USGS 2006c; USGS 2004a; USGS 2004b.

Figure 9: Primary Industrial Energy Consumption /Value Added
(PJ/2000 US \$ MER; Indexed to 1971=100)



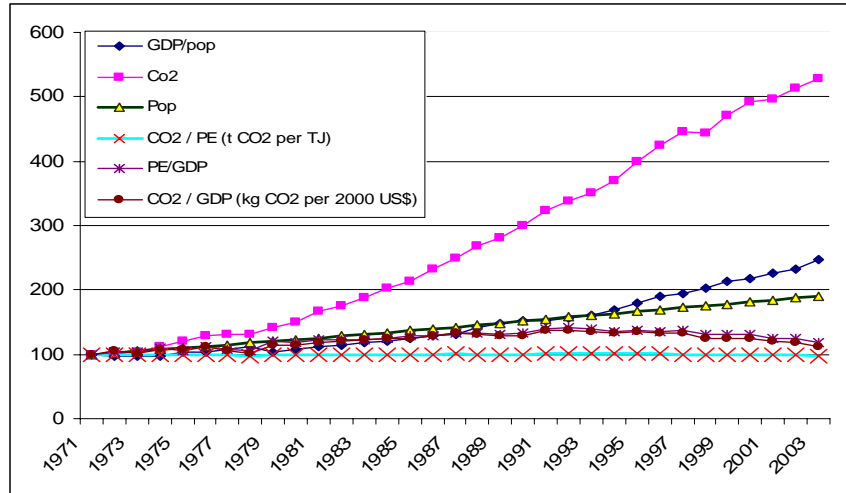
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 10: Residential Primary Energy Consumption per Capita
(Excl. biomass; 1971=100)



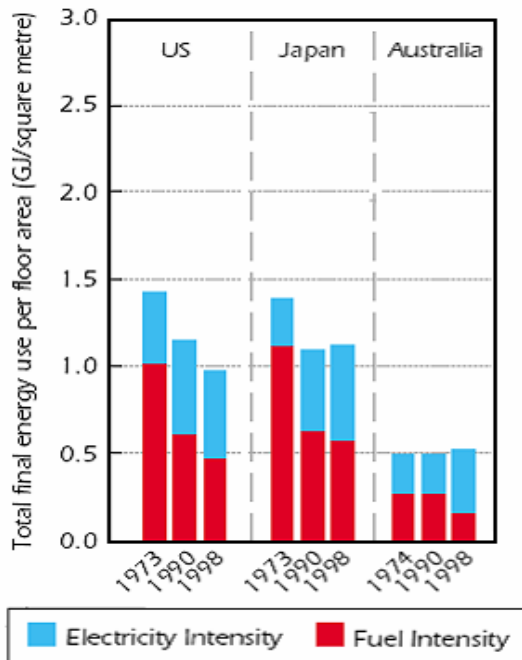
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 11: Decomposition of India's CO₂ Emissions
(Primary energy excludes traditional biomass)



Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 12: Efficiency/Intensity Per Unit Floor Space in Existing Buildings
Electricity and Fuel Use per Unit of Floor Area



Source: Oil Crises & Climate Challenges- 30 Years of Energy Use in IEA Countries
<<http://www.iea.org/textbase/nppdf/free/2004/30years.pdf>>.

