Implementing End-use Efficiency Improvements in India:
Drawing from Experience in the US and Other Countries

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Preface

Growing concerns about energy security have prompted the U.S. and India to launch a new Energy Dialogue that reflects the transformed strategic relationship between the world's two largest democracies. The United States and India recognize their mutual interests are best served by working together in a collaborative fashion to ensure stability in global energy markets. Helping India reach its potential for energy savings is in the U.S. interest for environmental and energy security reasons. These are being addressed through the U.S.-India Energy Dialogue, which was launched on May 31, 2005. The Dialogue established five Working Groups along with a Steering Committee to provide oversight. The goals of the Dialogue are to promote increased trade and investment in the energy sector by working with the public and private sectors to further identify areas of cooperation and collaboration.

The Power and Energy Efficiency Working Group has organized the US-India Energy Efficiency Conference, which will be held on May 2-3 in New Delhi, India. This Working Group promotes the exchange of information on technology and regulatory policies and will develop cooperative programs and promote technologies to enhance electricity end-use efficiency. It is recognized by the Working Group that most energy efficiency technologies are cost effective, but implementation is hampered by institutional, procedural, and process barriers. This is not unique to India. There are lessons to be learnt from other countries in understanding ways that energy efficiency could be promoted in the Indian market environment. The main aim of the Conference is to explore the barriers to implementation of energy efficiency in India, illustrate ways in which such barriers are overcome, and delineate approaches of how energy efficiency markets could be triggered in India in the buildings and industrial sectors.

This paper was prepared to provide background information for participants of the US-India Energy Efficiency Conference. It highlights energy efficiency technologies, barriers, and policies and programs that are being implemented in the US, India and other selected countries. The paper discusses the lessons to be learned from these experiences, conditions that would facilitate energy efficiency penetration in India, and ways by which the Working Group could foster cooperation between the two countries.

1. What's at stake: The critical role of energy efficiency

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 and China[1], which too import an increasing share of their oil and gas requirement.

India relies on indigenous coal, and to a lesser extent oil, to meet its energy demand. 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.[2] 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 of energy thus has the potential to reduce the nation's vulnerability in both the imported fuels and electricity markets.

Efficiency improvement also has the potential to boost economic growth that can result in higher tax revenue for the government. An analysis of the electricity efficiency potential for India shows that efficiency improvement in combination with new supply can eliminate electricity shortages at the same investment level as for a business-as-usual electricity supply scenario.[3] A similar analysis of macroeconomic benefits for India's

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[1] While bulk of this report is about US and India, we highlight examples from China since that country has made substantial gains in reducing its energy intensity over the past two decades.

2 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

3 Sathaye J., J. Roy, R. Khaddaria and S. Das, (2005) *Reducing Electricity Deficit through Energy Efficiency in India: An Evaluation of Macroeconomic Benefits* Accepted for presentation at the Fifteenth International Input-Output Conference held from June 27 to July 1, 2005 at Renmin University, Beijing, China.

state of Maharashtra illustrates that redirecting electricity saved through efficiency improvements to electricity-short businesses has the potential to increase economic output and tax revenue, which could reduce the state government's fiscal deficit by 15-30% depending on the size of backup power generation.[4]

Economic analyses of energy efficiency, including demand response (DR), technologies often portray these as being cost-effective when compared with supply alternatives (Figure 1). Since they reduce energy use and/or shift peak energy use to off-peak hours they also eliminate deleterious environmental consequences and vulnerability to supply disruptions. A key question often posed in earlier studies of energy efficiency is if the technologies are cost effective should their market penetration be higher than commonly observed in developed and developing countries. If the market penetration should be higher then what is the role for government programs and policies?

Goal of the Report:

This report accepts the premise that most energy efficiency 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, such as the US and China, in understanding ways that energy efficiency could be promoted in the Indian market environment. The main goal of this report is to explore approaches that ensure that public policy and programs work with market forces and businesses for implementation of energy efficiency. The paper does not attempt to provide a comprehensive review, but it highlights selected ongoing policies and programs that are overcoming barriers in India, US, and other countries in the buildings and industrial sectors, and notes key issues that need to be addressed for their replication in India.

What the Report Covers:

The next section of the report illustrates the progress India has made in improving its energy productivity in comparison to that in China and the United States since 1971. Section 3 discusses the Indian government's vision and the institutions the country has established to design and implement its energy efficiency mandates. Section 4 focuses on technology, barriers to market penetration, and the importance of identifying the institutions that benefit from the implementation of energy efficiency programs and projects. Section 5 focuses on the programs and policies that are being implemented in the US and India, and best practices that could be pursued to either implement new programs and/or expand those existing in India in the buildings sector. Section 6 illustrates the same topics for the industrial sector. Section 7 concludes by noting the

[4] Phadke A., Sathaye J. and Padmanabhan S. (2005) *Economic benefits of Reducing Maharashtra's electricity shortage through end-use efficiency improvement.* LBNL Report 57053

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lessons learned and the key activities that India could pursue in moving forward in implementing energy efficiency programs in the country. Wherever appropriate, we note the best practices that could be implemented in India to promote energy efficiency.

2. India's progress in improving its energy productivity

India currently ranks sixth in the world in terms of primary energy demand. If it perseveres with sustained economic growth, achieving 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 of today's consumption. 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 tons[5]. At this rate, its demand for energy will continue to soar and by 2030 it could be expected to 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 traditional biomass, was about 14.5 EJ in 2003 (Figure 2). This value was one-sixth that of the US and 28% that of China. 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 other two countries. India's energy use per capita (excluding traditional biomass) increased at the same rate as that of China since 1971 despite India's much higher population growth rate (Figure 3). 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 have continued to dominate India's energy sector. 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 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 measure has declined steadily in the US and other industrialized countries since the late 1970s, and more steeply in China since 1980 (Figure 4). 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

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

energy productivity in an era of increasing market liberalization. On the other hand, electricity generation intensity in both China and the US has hovered around the same level as it was in 1971 (Figure 5). 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's intensity of primary energy supply increased from 1971 to the early 1990s, and then declined steadily. India's electricity generation intensity too increased until the 1990s, and stabilized after that.

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. Figure 6 shows the average shortage for 2002-03 of 7,836 GWh and 1,300 MW in Maharashtra where supply met demand only during the night for about six hours. The situation has worsened since then due to lack of power from Dabhol. 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.

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

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

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

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 7). 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 2 digit level.

Residential energy consumption (excluding traditional biomass) per capita rose the fastest in India, compared to China and the US (Figure 8). Both switching from traditional biomass to modern fuels, and the increasing use of modern fuels by an expanding urban population are driving factors behind this increase.

Changes in population, GDP, energy intensity, and carbon intensity of energy supply (excl. traditional biomass) may be considered as key factors that contribute to changes in carbon dioxide emissions (Figure 9). The Kaya identity forms the basis for the approach

[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.

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
CO_2 = Carbon dioxide emissions

India's carbon emissions from fossil fuel combustion amounted to 1,050 Gt CO_2 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.

3. The Government of India's Energy Vision and Indian Energy Efficiency Institutions

The Indian Planning Commission in its recent draft report on an integrated energy policy laid out a vision of providing energy security to all citizens of India[9]. 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

[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

field of energy efficiency is a challenge faced not only by India but also by other major countries.

In recognition of the importance of energy conservation, the Indian government created the Petroleum Conservation Research Association (PCRA) in 1978[10]. 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) with effect from 1 March 2002 under the Ministry of Power[11]. BEE's mission is to develop programs and strategies on self-regulation and market principles 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 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.

The Indian Parliament also passed the Electricity Act in 2003[12]. It consolidated laws related to generation, transmission, distribution, trade and use of electricity. Among other things, it called for 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 sector[13], and the Bangalore Electricity Supply Company has initiated a similar program in Karnataka state[14].

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[10] http://www.pcra.org/
[11] http://www.bee-india.nic.in/index1.php
[12] http://powermin.nic.in/acts_notification/electricity_act2003/preliminary.htm
[13] http://mercindia.org.in/Orders_2005.htm
[14] http://www.bescom.org/en/news/belp.asp.

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 set it up as a public-private partnership[15]. 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 efficiency[16].

4. Current state of energy-efficient technologies and services

Technology: 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, drives, etc. The second category is of technologies that form part of larger processes such as in the production of steel or cement, which are more likely to be one-of-a-kind.

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. [17,18,19,20] Table 2 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

[15] http://greenbusinesscentre.com/energyeffic.asp
[16] http://www.shrishakti.com/alternativeenergy/index.html (Check)
[17] 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.
[18] Energy Research Institute, China and Lawrence Berkeley National Laboratory (2003) *China's Sustainable Energy Future: Scenarios of Energy and Carbon Emissions.*
[19] UNDP (2000) *World Energy Assessment: Energy and the Challenge of Sustainability*. New York.
[20] 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

motors, lighti ng and air conditioning systems, and variable speed drives are increasingly being utilized. These are cost effective in many applications.[21]

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 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 typically used for pumping water in residential and agricultural sectors and for other industrial applications, lower power factor and cause voltage drops. 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 lifetime of the equipment as the pumps run for extended periods of time while there is power supply. Hardening measures thus may need coordination to avoid direct or indirect additional costs.

[21] 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 2: 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

Indian industry has made strides towards reducing its process energy intensity across the board. This has happened through the use of modern best available technologies in new plants, upgradation and modernization of existing plants, and shift towards less energy intensive processes. This improvement has occurred because of (1) stricter environmental regulations as in the case of chlor-alkali production,[22] (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.[23] 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)[24] and the second best energy efficient cement plant[25] in the world today are in India. The average Indian cement plant, however, consumes 25% more energy than the global best practice.

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.[26]

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.[27] 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.

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[22] Stricter environmental controls can also work the other way; the installation of hydrodesulfirizers to produce low sulfur fuel increases the energy consumption of refineries.

[23] 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

[24] World Steel Dynamics Inc (WSD) – www.worldsteeldynamics.com/

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

[26] 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

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

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.[28]

Barriers to market penetration: The market penetration of energy-efficient technologies is often hampered by barriers[29] 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.[30]

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 both must work together to 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.

- Absence of financial intermediation by banks and other lending institutions to promote and develop energy efficiency lending; 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.

- 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 also have no incentive to invest in efficiency improvements in a property they do not own.

[28] Phadke, Sathaye, and Padmanabhan (2005) (op. cit.)
[29] A barrier is any obstacle to reaching a potential that can be overcome by a policy, program, or measure.
[30] 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

- 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.[31] 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.[32]

<u>Economic Gains – Who benefits?:</u> 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.[33] 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%-

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[31] 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 Draft Report 59773.
[32] 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
[33] Phadke, Sathaye, and Padmanabhan, 2005 (op. cit.)

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.

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. Policies and Programs for the Promotion of Energy Efficiency: Buildings Sector

Programs for increasing the market penetration of energy efficient products and processes may be categorized into voluntary programs, voluntary industrial agreements, building and appliance efficiency standards and labels, information programs, best-practice and benchmarking programs, state market transformation programs, financing, and procurement.[34] These programs are being designed and implemented by governments at all levels, industries and industry associations, public-private partnerships, and non-governmental organizations. In the US, the federal government, some state governments, utility companies, and regulatory commissions are key players in their design and implementation. In India, the central government and industry associations have played a stronger role in this arena; utility companies, regulatory commissions, and energy service companies (ESCOs) are only now beginning to assert their role.

We discuss programs related to building energy use first and then focus on industrial energy programs. In both sectors, we report on programs at the state and local level and those at the federal or central government level. We review programs mostly in the US and India, and illustrate ways that best practices among them could be implemented and/or replicated in India. While we have made an effort to cover the major categories of programs, given the relatively limited scope and length of this background paper, it is not possible to provide comprehensive information on all programs. We have included references to the major programs, which the reader may wish to review separately.

State and Local Energy Efficiency Programs:

Buildings and appliances are usefully divided into two categories -- new construction and existing stock. Building stock lasts for several decades and provides excellent opportunity

[34] Tax credits, accelerated R&D, and a carbon cap and trade system are not discussed in this document.

for planting seeds of energy efficiency that will continue to produce annual energy savings for future decades. Major appliances, refrigerators, air conditioners, water heaters and furnaces last between 15 to 20 years and provide a similar opportunity. Because of the significant presence of barriers discussed in Section 3 above, buildings and appliances are amenable to energy savings through regulatory standards, labels, codes, and procurement practices.

United States:

States have adopted a number of energy efficiency policies and programs that overcome key market, regulatory, and institutional barriers that hinder investment by consumers, businesses, utility companies, and public agencies. Table 3 summarizes four that have been successfully implemented by several states. In addition to these four, there are a number of other policies that states are adopting to (1) ensure that energy efficiency programs are adequately funded, (2) allow energy efficiency to compete in the energy marketplace, (3) integrate energy efficiency measures into energy and air quality planning, and (4) lead by example by implementing energy efficiency within state government operations.

One review of programs that are being implemented at the state level in the US[35] provides information on 18 public benefits state-level energy efficiency programs.[36] These states spend over $900 million per year on the programs, and annual savings in just 12 of the states reporting evaluation data were nearly 2.8 TWh/year, and power savings reported by 8 of the states were 1060 MW. The cost of conserved energy ranged from $0.023 to $0.044 per kWh. Electricity savings ranged from about 0.1 to 0.8 percent (mean 0.4 percent), i.e., this figure represents the percentage points shaved off electricity growth. The most common approach used by the states to fund such programs is a "public benefits charge" consisting of a small non-bypassable per kWh charge on the electric distribution service. Some states use a flat monthly fee or a charge that is embedded in the rates. The median value of the charge was just over $0.0011 per kWh.

About half of the 18 study states relied principally on utility administration of the programs, and the other half relied on either government agencies or an independent non-profit organization (Kushler, York and Witte, 2004). For example, in California, the energy efficiency programs are administered by utility companies with substantial direction from the California Public Utilities Commission (PUC), in New York by the New York State Energy Research and Development Administration (NYSERDA) a non-

[35] This US Department of Energy web site provides a summary description of the US state energy efficiency programs http://www.eere.energy.gov/femp/program/utility/utilityman.energymanage.cfm.

[36] Kushler M., D. York and P. Witte (2004) – *Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies* ACEEE #U042

utility entity, in Michigan by the Michigan PUC, and in Arizona by the utility company. Administration of programs has evolved with more programs now being administered by non-utility entities than before. Each type of program appears to be best suited to the needs of the state and no one program administration is better than another. Blumstein et al. (2003) provide five different models and their suitability for implementation of energy efficiency programs at the state level.[37]

Public purpose funded energy efficiency programs that are administered by investor-owned utility companies in California, for example, include the Standard Performance Contracts (SPC) program, Express Efficiency Program (EEP), and a Savings by Design Program (SDP). The SPC provides performance-based incentives for energy efficiency retrofits, including lighting, heating, ventilation, and air conditioning (HVAC), motors, variable speed drives (VSDs), controls, and custom projects. Incentives range from $0.05/kWh (lighting measures) to $0.14/kWh (most air conditioning and refrigeration measures) for electric energy efficiency projects. The EEP provides rebates to small- and medium-sized customers (500 kW or less) for specific energy-efficient products including lighting, air conditioning, refrigeration, motors, and natural gas-fired equipment, such as boilers, and provides incentives for energy efficiency measures in new construction and major renovations. The SDP offers building owners and their design teams a range of services, including design assistance, "owner incentives" to help offset the costs of new energy-efficient buildings, and "design team incentives" to reward designers who meet ambitious energy efficiency targets.

In addition to these programs, state utility companies offer programs in their own service areas. Pacific Gas and Electric (PG&E) for example, provides large customers (over 500 kW peak demand) rebates for replacing lighting, HVAC, refrigeration, and food service equipment with qualified energy-efficient models. Rebates can range as high as $300,000 per customer. The utility companies also offer a variety of demand-response programs that are geared towards reducing and levelizing peak loads.

Another company, Southern California Edison (SCE), offers an agricultural sector program (funded through a public goods charge) that provides services to test the water pumping system, and deliver a site specific energy efficiency and cost analysis report. SCE reports that 69% of the customers made shaft, impeller, and pump bowl improvement and that 27% of the customers were free riders. Key lessons learned from such agriculture water pumping programs in the US were that farmers value local knowledge and hence location or region-specific programs work better and packaging

[37] Blumstein C., C. Goldman and G. Barbose (2003) *Who Should Administer Energy Efficiency Programs?*. LBNL-53597

agriculture and non-agriculture programs works as well as or better than agriculture-only programs

All California investor-owned utility companies also offer a variety of DR programs that are geared towards reducing and levelizing peak loads. Examples of DR programs include critical peak pricing (CPP), demand bidding program (DBP), and interruptible rates. CPP is a version of time of use (TOU) rates where a customer is informed one day in advance about an "emergency" event. During that event the price of electricity is raised 3-5 times of the non-event-day price giving the customer an incentive to reduce usage during that period by either foregoing use or shifting it to another period. Under DBP a customer bids in a demand resource similar to a generator bidding a supply resource in wholesale market. If the customer's demand bid is accepted by the system operator the customer is then obliged to reduce load or else pay a penalty for non-performance. Similar programs are administered by the New York Independent System Operator throughout the state of New York, and PJM Interconnection, the largest system operator in the world, in their service territory.

State performance contracting programs of California, New York, Texas, Colorado, and Wisconsin are supported by public benefit charge funds. Approximately $400 million of ratepayer funds are expected to be committed for these programs. Two main characteristics of these programs are a) incentive payments that are based on documented energy savings for some periods after project installation; b) use of private sector energy efficiency service providers as the predominant mechanism for marketing and development of projects. In the New York and California program, incentive payments are made to participants over a two-year period, based on demonstrated annual savings. Standard M&V protocols are used to determine the actual savings.[38]

India:

In India, the Energy Conservation Act 2001 provides for the establishment of state energy conservation agencies to plan and execute programs. An agency of the state of Maharashtra, such as the Maharashtra Energy Development Agency (MEDA), and/or the utility company, Maharashtra State Electricity Board (MSEB), could implement public benefit programs similar to those being implemented in the United States. The Prayas Energy Group (Pune) in its report on the DSM potential in India noted that DSM programs were initiated in India by the Ahmedabad Electric Company in 1994 and several subsequent programs were initiated by utility companies in the states of

[38] Schiller S., C.A. Goldman and B. Henderson (2000): *Public Benefit Charge Funded Performance Contracting Programs - Survey and Guidelines* ACEEE 2000 Summer Study on Energy Efficiency in Buildings, Vol. 5, pp. 299-317. American Council for an Energy-Efficient Economy, Washington, DC

Maharashtra, Delhi, Madhya Pradesh, Uttar Pradesh, and Karnataka. [39] These focused on lighting, agricultural pumping, solar water heating, and reactive power management. The implementation of these schemes was always at the pilot or experimental scale, however, and no replication of the programs was attempted by the utility companies or required by the regulatory commissions until the recent experience in Maharashtra and Karnataka.

The Maharashtra Electricity Regulatory Commission (MERC) instituted a public-benefits type of electricity charge on industry, funds from which can be used to finance renewable energy and energy efficiency programs in the state. MERC ordered utility companies in the state to begin CFL programs in the residential sector in Mumbai and in the Nasik District using these resources in late 2005.[40] In another example, BESCOM in Karnataka initiated a program to promote the use of CFLs.[41]

An analysis of the MSEB agricultural electricity supply system shows that a program replacing two components, undersized pipes and high friction foot valves, can save the utility company Rs 2.1 /kWh due to reduction in fuel use and other short-run costs, even assuming a zero agricultural electricity tariff. The proportionally high savings per kWh warrants a program that includes rebates and even direct replacement of the two components.

With support from US EPA and US AID, LBNL is assisting the Maharashtra government in identifying opportunities to reduce electricity consumption in the public sector[42]. It is working with Maharashtra Public Works Department (MPWD) to help identify energy savings opportunities in government buildings. Two cost-effective pilot projects were implemented by MPWD at Mantralaya (project investment: Rs. 4 million with an estimated simple payback of 2.3 years) and Vidhan Bhavan (project investment: Rs. 7.9 million with an estimated simple payback of 2.2 years) using government funds. [43] Encouraged by the success of these two projects, MPWD estimates that approx. 29 GWh can be saved through an investment of Rs. 270 million with a simple payback of about 2.3 years by implementing just two lighting energy efficiency measures.[44]

Utility-run energy efficiency programs can reduce the price of energy efficiency measures through bulk procurement. Such programs reduce transaction costs (search, information, installation costs etc.) incurred by individual consumers. Bulk purchase has

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[39] Prayas Energy Group (Pune) 2005. *Demand-side Management (DSM) in the Electricity Sector: Urgent Need for Regulatory Action and Utility-Driven Programs*. Report by Prayas Group for WWF, India, Feb
[40] MERC (op. cit.)
[41] BESCOM (op. cit.)
[42] More information on the "Promoting an Energy Efficient Public Sector" can be found at http://www.pepsonline.org/
[43] MPWD presentation at PEPS-India Workshop in Mumbai, September 2005
[44] Ibid

the potential to reduce the purchase cost by 30 – 40 % compared to the retail price. Since utilities are in regular contact with consumers for metering, billing, and repairs, and can collate information about their consumption patterns, they could implement programs at a lower cost compared to the acquisition of such devices by individual entities. Under the same Maharashtra project, technical specifications for an energy efficient procurement strategy for fluorescent tube lights and electronic ballasts are being developed. Both are mature and reliable technologies that are ideally suited for implementation by ESCOs.

Table 3: State-level US Energy Efficiency Policies and Programs

Type of Policy and/or Program	Description	State Examples
Energy Efficiency Portfolio Standards (EEPS)	Similar to renewable portfolio standards (RPS) already in place in 21 states and Washington, D.C., EEPS require that energy providers meet a specific portion of their electricity demand through energy efficiency. EEPS designs vary by state and include targets that range from the equivalent of a 10% to a 50% reduction in energy demand growth. California's targets, set in terms of kilowatt-hours (kWh) and therms saved based on percentages of total sales, are expected to reduce demand growth by more than 50% for electricity and more than 40% for natural gas. Texas is the one state in which standards have been in place long enough to measure results from an EEPS approach. Its 10% reduction in load growth goal was exceeded in 2004 and, in that year, Texas saved more than 400 million kWh at a cost of $82 million, for a net benefit of $76 million to date.	CA, IL, NJ, NV, PA, TX,
Public Benefits Funds (PBFs) for Energy Efficiency	PBFs for energy efficiency are a pool of resources used by states to invest in energy efficiency programs and projects and are typically created by levying a small charge on customers' electricity bills. Seventeen states have established PBFs for energy efficiency. PBFs are being used to finance the design, implementation, and evaluation of various energy efficiency programs, including the three listed in this table.	CA, NY, OR, WI
Building Codes for Energy Efficiency	Building energy codes establish energy standards for residential and commercial buildings, thereby setting a minimum level of energy efficiency and locking in future energy savings at the time of new construction or renovation. More than 40 states have implemented some level of building codes for residential buildings and/or commercial buildings. If all states adopted the most recent commercial and residential model energy codes, improved compliance levels, and applied model energy codes to manufactured housing, the United States would reduce energy use by about 0.85 quads annually, with cumulative savings through 2020 of about five quads. In 2020, annual consumer energy bill savings would be almost $7 billion, and the construction of 32 new 400 megawatt (MW) power plants could be avoided (Prindle et al. 2003). Lack of enforcement of building codes is a key issue, and only the largest states effectively enforce code requirements rigorously.	AZ, CA, OR, WA, TX
State Appliance Efficiency Standards	State appliance efficiency standards set minimum energy efficiency standards for equipment and appliances that are not covered by federal efficiency standards. Ten states have adopted appliance standards. The potential savings from five products that are not currently covered by federal law or designated under the Energy Policy Act (EPAct) for standard setting by DOE are estimated to be 24.4 terawatt-hours (TWh) of electricity and about 4 quads of primary energy in 2030 if implemented nationally, generating $14.6 billion in net savings for consumers and business owners for equipment purchased through 2030. The direct economic and environmental benefits of state standards are also substantial. One study of 19 California product standards projects savings to California consumers and businesses of more than $3 billion by 2020 and estimates that these standards will reduce the need for three new power plants (ASAP 2004). In New England, for example, a package of state standards is expected to reduce load growth by 14% from 2008 to 2013 and cut summer peak demand growth by 33% (Optimal Energy 2004).	CA, CT, NJ, NY

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

Federal (Central) Government Programs:

United States:

Mandatory and voluntary standards: In about 60 developed and developing countries, including the US, more than 40 household appliances are subject to federal mandatory and/or voluntary energy performance standards.[45] Mandatory minimum energy performance standards have been in place in the US since 1987 and have been periodically tightened since the early 1990s. Figure 10 shows the impact of US federal refrigerator standards where electricity consumption per unit volume declined despite an increase in their average size since 1992. As of 2000, federal appliance efficiency standards had reduced U.S. electricity use by 2.5% and carbon emissions by nearly 2%. By 2020, the benefits from existing standards are expected to more than triple as the stock of appliances and equipment is replaced by more efficient models (Geller et al. 2001)[46]. The appliance standards for 16 products established by the Energy Policy Act of 2005 are expected to yield an additional 2% savings in total electricity use (ACEEE 2005a)[47].

Voluntary US programs, such as Energy Star, work with manufacturers to promote existing energy-efficient products for personal computers, refrigerators, TVs, etc., and develop new ones. Manufacturers can affix an easily visible label to products that meet Energy Star minimum standards. These programs also facilitate the exchange of information between end-users on their experience with energy-saving techniques.

Building efficiency standards and codes focus primarily on the building shell and/or the HVAC (heating, ventilation, and air conditioning) system, and in commercial buildings also on lighting and water heating. While there are no US-wide standards, the Energy Policy Acts of 1992 and 2005 require that States adopt the most recent version of standards established by the DOE. DOE usually adopts the current ASHRAE Standard as its basis. In the US, the most important and widely used standards and codes are:

1. ASHRAE's Standard 90.1-2004 - Energy Standard for Buildings Except Low-Rise Residential Buildings;

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[45] www.clasponline.org
[46] Geller, H, T. Kubo, and S. Nadel (2001) *Overall Savings from Federal Appliance and Equipment Efficiency Standards* ACEEE, February, Accessed June 21, 2005. http://www.standardsasap.org/stndsvgs.pdf
[47] Optimal Energy (2004) *Economically Achievable Energy Efficiency Potential in New England*. Prepared for NEEP, November 17 http://www.neep.org/files/Executive_Summary.pdf

2. International Energy Efficiency Code developed by International Code Council. DOE's $37.5 million investment in the Program has resulted in energy savings of nearly $1 billion per year.

California's Energy Efficiency Standards for Residential and Nonresidential Buildings (also known as Title 24). California's building efficiency standards (along with those for energy efficient appliances) have saved more than $56 billion in electricity and natural gas costs since 1978. It is estimated the standards will save an additional $23 billion by 2013.

DOE's Building Energy Codes Program is an information resource on national model energy codes.[48] It works with other government agencies, state and local jurisdictions, national code organizations, and industry to promote stronger building energy codes and help states adopt, implement, and enforce those codes. Unless the building energy codes are enforced, the potential energy savings from the codes will be lost.

Financing: Generally speaking, there are three different types of financing available to public sector efficiency projects and programs: internal (through standard budgeting), debt, and third-party finance. Third-party finance combined with performance contracting is an attractive and increasingly common way to finance projects. US Federal Energy Management Program’s (FEMP’s) energy service performance contracting (ESPC) projects worth $1.8 billion have been implemented by 18 different federal agencies and departments in 46 states of the US. The improvements achieved through ESPCs save 4,200 GWh annually. The success of FEMP’s Super ESPC program, however, has been very difficult to replicate in other countries in spite of the best efforts of multi-lateral development banks and other international donor organizations. Most efficiency retrofit projects go through the same development cycle, regardless of funding:

- Conduct an energy audit.
- Complete a feasibility study.
- Formulate an investment plan.
- Identify sources of funding.
- Engineering, procurement and construction (EPC).
- Measurement and verification of energy savings.

The long-term success or failure of any alternative financing initiative will depend on streamlining and standardizing each of the above steps. Apart from FEMP’s Super ESPC program and the aforementioned state public benefit charge funded programs, other

[48] DOE Building Code Reference - http://www.energycodes.gov/whatwedo/

financing modes a revolving loan fund in Phoenix, Arizona, and a Bulgarian municipal energy efficiency program are also being experimented with.[49]

Energy-efficient government purchasing strategy (energy efficient procurement in the public sector): This policy has been employed successfully in China, Korea, Japan, Mexico and several European Union countries (sometimes as part of larger “green” purchasing efforts). It takes advantage of the fact that governments are generally very large purchasers. In most countries, government spending represents between 10 and 25 percent of all economic activity. The US government is the world's largest volume-buyer of energy-related products ($10 billion/year). FEMP’s “Buying Energy Efficient Products” program was started in 1996 and federal buyers are now required by the Energy Policy Act of 2005 to purchase products that are ENERGY STAR®-qualified or FEMP-designated. (These products are in the upper 25% of energy efficiency in their class.) The program’s savings potential is estimated to be nearly a quarter of a billion dollars per year.

Besides its informal surveys of federal energy managers, FEMP also looked at data from product manufacturers and their trade groups to determine which types of products had broad ranges of available efficiencies in the market. For instance, FEMP found that the range of efficiencies for commercial ice makers was very wide, while that for residential clothes driers was negligible (at least when considering gas and electric models separately). This helped inform the decision to cover the ice machines and not driers. FEMP’s research effort also considered the efficiency of products for sale compared to the installed base. This was the factor that led to coverage of several plumbing products (showerheads, toilets, and urinals).

Realizing the potential of energy savings from procurement of energy efficient products, the Ministry of Finance of the People's Republic of China has in its communiqué dated December 17, 2004 directed "Government organs at all levels, public sector non-profits units and organizations (collectively “procurers”), when using fiscal resources for procurement, should preferentially procure energy efficient products and gradually eliminate low-efficiency products."[50]

Best Practice: The important lesson here is to utilize resources in a way that, while not perfect, will lead to target products that will have the potential to save government

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[49] Schiller S., C. A. Goldman, and B. Henderson. (2000): “Public Benefit Charge Funded Performance Contracting Programs - Survey and Guidelines” ACEEE 2000 Summer Study on Energy Efficiency in Buildings, Vol. 5, pp. 299-317. American Council for an Energy-Efficient Economy, Washington, DC

[50] For a list of products covered under the procurement directive please see the China Government Procurement website (http://www.ccgp.gov.cn), the China Environment and Resources Information website (http://www.cern.gov.cn), and the China Energy and Water Conservation Certification website (http://www.cecp.org.cn).

significant amounts of energy and money. There are many ways to do this, from experienced facilities managers to industry trade groups to government purchasing data. The key is to utilize what is readily available and not expend resources that can better be used to execute other aspects of the program.

India:

Electricity use in the residential and commercial sector increased to 33% of the total consumption in 2004-05 from 24% ten years ago.[51] Energy use in the sector clearly deserves much more attention than has been the case thus far. BEE has several programs to set labels and standards for refrigerators, air conditioners, motors and other appliances. It has a three-pronged strategy for this purpose:

- Evolve minimum energy consumption standards for notified equipment and appliances
- Prohibit manufacture, sale and import of equipment and appliances not confirming to standards
- Introduce mandatory labeling to enable consumers to make informed choice

BEE has formulated energy labeling regulations to promote energy efficiency in the design stage for refrigerators, air conditioners, motors, distribution transformers, agricultural pump sets and fluorescent tube lights. It has the mandate to set mandatory performance standards, and to include building design codes.

Judging from the potential for efficiency improvement for the four products noted in Table 2, refrigerators and distribution transformers appear to be the ones that provide the largest percentage savings.

BEE and the Central Public Works Department (CPWD) are in the process of implementing energy efficiency performance contracting projects in nine government buildings with an estimated annual savings of approx. 30 GWh (~US 3.5 million) with a simple payback of less than two years. BEE has developed model documents such as Performance contract, Bid evaluation, Request for Proposal, and Payment Security Mechanisms for facilitation of project implementation through ESCOs.[52]

Under its statutory authority, BEE is developing an Energy Conservation Building Code in India.[53] One of the lessons learned from the US experience would be to ensure that India avoids the development of more than one energy conservation building code, which

[51] Govt. of India (2006) *Economic Survey, 2006*, New Delhi, India.
[52] Energy Conservation in Central Government Buildings & Establishments, Presented at the Workshop On Energy Conservation Act, 2001 – Role of State Agencies" by S. Ramaswamy New Delhi – 23rd- 24th February, 2005.
[53] Energy Conservation Building Code Progress Reference - http:// www.bee-india.nic.in/aboutbee/Action Plan/09.ta5.html

would not only result in confusion among building designers, developers, and engineers but would also require more resources in terms of support.

Best Practices: Table 4 shows the best practice procedures for the design, implementation and evaluation of energy efficiency programs at the federal or state level. The basic steps are the same at the state and federal level although the funding needed for the program, and the time required for its design and development may be longer in a more complex federal environment. The basic steps required for each of the three stages of a program are similar but their implementation is likely to be context specific. Engaging stakeholders may be a simpler process in a state or country where public input is homogenous, and initiating programs and maintaining funding may be less of a problem in regions where the economy is growing rapidly and there is a public commitment to improving energy efficiency.

The second column in Table 4 outlines steps for design and development of energy efficiency programs.

- Commitment of the legislature and/or regulatory commission has played a key role in instituting programs in the US. Progressive legislatures and commissions in several states for instance have different types of programs (Table 3).
- Involving and assessing the support of key stakeholders for such programs early on is important to ensure that a consensus is built to pursue programs in a transparent and credible manner.
- In each case sound economic and environmental analysis conducted using simple analytical tools and based on publicly available data builds confidence among the key stakeholders that can be effectively communicated to consumers, and industry associations and environmental organizations.
- Longer time frames for such programs permit them to overcome market and funding cycles where there is a temptation to do away with or limit activities that appear to be difficult to support through political changes and economic downturns.
- Setting annual and cumulative targets for programs is important so that their progress can be monitored and tracked on a regular basis allowing for prompt corrective action to be taken where programs are off target. Cumulative targets help in overcoming one or more years of unsatisfactory performance due to factors beyond the implementers control. Targets and goals should be updated if certain elements of the program are either easily accomplished or to accommodate those that are difficult to accomplish.
- A program needs to ensure additionality over and above the energy efficiency improvements already planned in another program, otherwise it would be difficult to attribute reductions to the new program.
- Selection of an effective entity to implement a program is important. In a state setting, the implementer may be the utility company, the state government or a

public-private entity set up explicitly to implement the new program. Blumstein et al. (2003) show that five different models are being pursued in the US for the implementation of PBF programs, and any of these would be appropriate depending on the particular context for implementation.

- Designing, implementing and enforcing building codes requires a high level of expertise that builders, supply companies, and code officials may lack.
- Education and regular training of key participants -- builders, building officials, supply companies, architects and engineers etc., are important since building codes require implementation at many locations within a city or region. One of the lessons learned from the US experience would be to ensure that India avoids the development of more than one energy conservation building code with appropriate consideration for climate zones, building types, use of local material etc. This would avoid confusion among building designers, developers, and engineers and require less resources in terms of support.
- Starting with low-cost, simple and well established programs for readily available commercial technologies, such as efficient lamps, brings credibility to a program and provides assured benefits that are readily observable by the consumer. More complicated technologies or ones whose benefits are cost effective but not so apparent can then be implemented on a graduated basis.
- Monitoring and evaluation (M&E) of energy savings is a particularly difficult element of energy efficiency programs where quantification of baseline energy use is always challenging, and oft-challenged during implementation. It is important that best practices for M&E be prepared with planning and care. Development of a monitoring plan during the design stage, and adherence to it by implementers, with regular verification assisted by third-parties, will ease the tracking of savings and provide a basis for timely adjustment.
- Maintaining a functional database of project energy performance at the program level will provide feedback to program administrators and oversight agencies so that future goals may be adjusted as needed. Setting aside adequate funding for monitoring and evaluation has been a problem in the past but without this support no program can be turned into a business practice, which is essential for replication of successful programs.

Table 4: Energy Efficiency Policies and Programs – Summary of Best Practices

Type of Policy and/or Program	Program Design and/or Development	Program Adoption and/or Implementation	Program Monitoring and Evaluation
All types of programs for the buildings sector	1. Obtain commitment from legislature, utility commission, or other body 2. Evaluate existing building energy code and other laws and options for implementation and enforcement 3. Involve key stakeholders and assess their support early 4. Use sound economic and environmental quantitative analysis – determine cost-effective achievable potential for energy efficiency 5. Start with low-cost well established programs, lighting for instance 6. Set annual and cumulative targets using analysis and stakeholder input, e.g., % of base-year energy sales 7. Establish a long-term frame to overcome market and funding cycles 8. Ensure that workable funding methods are available to meet EEPS target 9. Take care to select the most appropriate entities responsible for program implementation and/or meeting the target and the procurement rules they must follow 10. Assess training needs and other forms of technical support for code officials, builder associations, building supply organizations, auditors, etc. 11. Contact material and equipment suppliers to ascertain availability of code compliant products	1. Use clear basis for assessing compliance. 2. Update goals regularly 3. Ensure additionality over and above existing program commitments 4. Coordinate with PBF programs 5. Ensure that supply-side resource filings reflect the energy savings goals 6. Approve long-term funding cycles (5-10 years) 7. Design programs to meet customers needs in the relevant market 8. Keep program designs simple 9. Educate and train key participants regularly – builders, building officials, supply companies, etc. 10. Provide right resources, code requirements overview, laminated cards, simple software packages, how to conduct plan and site inspections, who to contact for more information. 11.Implementing and enforcing codes requires high level of engineering expertise that many code officials do not have. Contact universities, and architect engineering firms for detailed	1. Use methods proven over time 2. Include key tracking and reporting practices in program design 3. Provide qualitative evaluation in addition to a quantitative one 4. Evaluate programs regularly against stated objectives 5. Utilize a third party verifier 6. Provide for adequate funding for evaluation 7. Provide feedback to oversight agencies and adjust future savings goals as needed 8. Provide for consistent and transparent evaluations 9. Maintain a functional database that records customer participation over time on geographical location and customer class

		analysis of codes. 12. Provide budget and staff for the program, and train staff	

Source: Adapted from information on best practices in US EPA (2006). *Clean Energy Environment Guide to Action*. Pre-publication draft.

6. Policies and Programs for the Promotion of Energy Efficiency: Industry Sector

About 37% of the primary energy consumed both in the U.S. and globally is used by the industrial sector. Industrial energy efficiency programs may be categorized into information sharing and research, facility assessments or audits and training, financial assistance, benchmarking, voluntary, including negotiated, agreements and target setting, information sharing, tax incentives, and integrative elements.

United States -- State-level Programs:[54]

Many states have general industry and business development programs that can be used to assist businesses in assessing or financing energy-efficient process technology or buildings. Most states have their own energy agency responsible for information dissemination, implementation of regional and local energy policy instruments. Below we summarize selected programs earmarked specifically for support of energy efficiency activities.

Several programs provide financial assistance. The California Public Interest Energy Research (PIER) provides funding for energy efficiency, environmental, and renewable energy projects in the state of California. Although there is a focus on electricity, fossil fuel projects are also eligible. California's Energy Innovations Small Grant Program (EISG) provides small grants for development of innovative energy technologies in California, up to $75,000. The Energy Policy Division of the Indiana Department of Commerce operates two industrial programs. The Industrial Energy Efficiency Fund (IEEF) is a zero interest loan program (up to $250,000) to help Indiana manufacturers increase the energy efficiency of manufacturing processes. The fund is used to replace or convert existing equipment, or to purchase new equipment as part of a process/plant expansion that will lower energy use.

The Distributed Generation Grant Program (DGGP) offers grants of up to $30,000 or up to 30% of eligible costs for distributed generation with efficiency over 50% to install and study distributed generation technologies such as fuel cells, micro turbines, cogeneration, combined heat & power and renewable energy sources. Other programs support companies in the use of biomass for energy, research or building efficiency. Iowa's Alternate Energy Revolving Loan Program (AERLP) was created to promote the development of renewable energy production facilities in the state. Proposals under $50,000 are accepted year round. Larger proposals are accepted on a quarterly basis.

The New York State Energy Research & Development Agency (NYSERDA) operates various financial assistance programs for New York businesses. Different programs focus on specific

[54] Excerpted from Galitsky, C., Price, L, and Worrell, E. (2004) *Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54068)

topics, including process technology, combined heat and power, peak load reduction and control systems. Wisconsin's Focus on Energy Program has energy advisors that offer free services to identify and evaluate energy-saving opportunities, recommend energy efficiency actions, develop an energy management plan for business; and integrate elements from national and state programs. It can also provide training.

Several states offer tax incentive programs, although none exist on the federal level. For example, New Jersey offers a tax exemption for cogeneration facilities on the purchase of natural gas and utility services that are used in the production of electricity. Maryland and Minnesota waive sales tax for the purchases of energy efficient products such as appliances, compact fluorescent lights, heat pump water heaters and efficient heating and cooling systems. Oregon through its Business Energy Tax Credit Program (BETC), Hawaii and California provide tax credits for renewable energy and energy efficiency.

United States and Other Countries—Federal Programs:

In industrialized countries, a recent assessment found that many policies, programs and measures are being pursued in order to improve energy efficiency in industry (Table 5).[55] The assessment found that all countries provide information through a combination of audit or assessment reports, benchmarking, case studies, fact sheets, reports and guidebooks, and tools and software on energy efficiency. Energy management assistance is provided through the use of standardized energy management systems, provision of energy awareness promotion materials, industry experts, training programs and provision of some form of verification and validation assistance for companies to help them to track and report energy use or GHG emissions reductions. Financial assistance for energy-efficient technologies or through assessments is available to industry in each of the countries examined. Target-setting, where companies or industrial sectors determine a goal for energy-efficiency improvement is done through a process of establishing visions and roadmaps as well as with negotiated agreements, which provide the framework for reporting and undertaking actions to increase energy efficiency. Awards and recognition provide positive publicity related to energy efficiency or GHG emission reduction achievements and can consist of logos, awards or articles in the newspapers or newsletters. Energy efficiency standards, such as motor efficiency standards, are used to specify mandatory minimum energy consumption levels for specific types of equipment.

[55] Galitsky, C., Price, L, and Worrell, E., 2004. *Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54068).

Table 5. Industrial Energy Efficiency Policies, Programs, and Measures (Partial List) in Selected Industrialized Countries

Country	Australia	Canada	Denmark	European Union	France	Germany	Japan	Netherlands	Norway	Sweden	Switzerland	United Kingdom	United States
INFORMATION													
Audit or Assessment Reports							X	X		X		X	X
Benchmarking			X			X		X	X			X	
Case Studies	X	X		X			X	X	X	X		X	X
Fact Sheets	X			X						X	X	X	X
Reports and Guidebooks	X	X		X		X	X	X	X	X	X	X	X
Tools and Software	X	X	X	X		X		X	X			X	X
Websites	X	X	X	X	X	X	X	X	X	X	X	X	X
Working Groups		X		X			X	X	X		X		X
Conferences and Trade Shows	X	X		X	X	X	X	X	X			X	X
Demonstration: Commercial Technologies			X		X	X	X	X			X	X	
Demonstration: Emerging Technologies		X		X	X			X		X			X
ENERGY MANAGEMENT													
Energy Management Systems													X
Energy Awareness Promotion Materials	X	X	X		X		X		X	X	X	X	
Industry Experts	X	X	X	X			X		X			X	X
Training	X	X		X	X	X	X	X	X	X	X	X	X
Verification and Validation	X	X		X	X	X		X	X				X
FINANCIAL ASSISTANCE													
Financial and other assistance	X	X	X	X	X	X	X	X	X	X	X	X	X
Subsidized Assessments	X	X	X	X	X	X	X	X	X	X		X	X
Tax Abatement for EE Technologies		X	X			X	X	X	X	X	X	X	X
TARGET-SETTING													
Visions and Roadmaps	X	X					X	X		X			X
Negotiated Agreements	X		X		X	X	X	X	X		X	X	
AWARDS AND RECOGNITION													
Public Recognition	X	X		X	X	X	X			X			X

ENERGY EFFICIENCY STANDARDS													
Motor Efficiency Standards													X

Independent evaluations to determine effectiveness of these types of programs are not a common feature. Several studies have been conducted, however, to gage the effectiveness of voluntary programs.[56] Independent assessments find that experience with VAs has been mixed, with some programs, such as the French Voluntary Agreements on CO_2 Reductions and Finland's Action Programme for Industrial Energy Conservation, appearing to have been poorly designed, failing to meet targets, or only achieving business-as-usual savings. However, the more successful programs, such as the Dutch Long-Term Agreements, the Danish Agreements on Industrial Energy Efficiency, and the UK Climate Change Agreements, have seen significant energy savings and are cost-effective.

The most effective agreements are those that set realistic targets, include sufficient government support – often as part of a larger environmental policy package, and include a real threat of increased government regulation or energy/GHG taxes if targets are not achieved. Similar agreements could also be instituted between BEE and Indian industry associations, and also between regulatory commissions and industry associations.

US DOE's Industrial Technologies Program (ITP) works with U.S. industry to develop and deliver advanced technologies that increase energy efficiency, improve environmental performance and boost productivity. ITP consists of several programs, including the Industries of the Future, Cross-cutting Technologies, Industrial Energy Systems, BestPractices Program, Industrial Assessment Centers, and the Save Energy Now program[3]. The latter three are described in below, along with the products, services, and delivery mechanisms each provides.

The Best Practice Program works with industry to identify energy and process efficiency opportunities.[57] Its products and services include informational resources and tools, technical assistance, and demonstrations of emerging technologies. It conducts plant-wide assessments, where plants are selected through a competitive solicitation process. Plants agree to a 50% cost-share. A BestPractices team conducts the analysis. A quarterly newsletter Energy Matters provides news, technical tips and case studies from industry professionals.

Industrial Assessment Center (IAC) Program supports teams of engineering faculty and students from 26 universities who conduct free comprehensive energy audits or industrial assessments.[58] Audits last from one to two days and are free of charge to small to medium sized companies (generally 20 to 499 workers). Companies pay for all recommendations that they

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[56] Price L. 2005. *Voluntary agreements for energy efficiency or GHG emissions reduction in industry: An assessment of programs around the world*. Proc. of the 2005 ACEEE Summer Study on Energy Efficiency in Industry

[57] US DOE's BestPractice Program website: http://www1.eere.energy.gov/industry/bestpractices/

[58] Industrial Assessment Center (IAC) Program website: http://www.oit.doe.gov/iac/

implement. Over 8,000 audits and assessments have been performed since 1978. Confidential assessment reports are provided to IAC customers within 60 days from site visit. Plant-wide assessment summary report is published to facilitate replication of recommended energy conservation strategies. An IAC database of plant and related assessment information is maintained without identifying individual plants. The purpose of the Save Energy Now assessments is to identify immediate opportunities to save energy and money, primarily by focusing on steam and process heating systems. These processes consume nearly 80% of the energy used by U.S. industry.[59]

Industrial Energy Systems-such as motors, steam, compressed air, pumps, fans, process heating, combustion, and combined heat and power-account for about 80% of industrial energy use. Improving the efficiency of these systems can yield large energy and cost savings throughout U.S. manufacturing. The Industrial Technologies Program is (1) developing tools to help industry identify energy savings opportunities; (2) conducting cost-sharing R&D on combustion and heat recovery; and (3) working to improve systems, components, and materials that are essential to saving energy in manufacturing-from mining and primary metals to downstream product finishing.

Energy Star is an EPA voluntary partnership program between government and industry.[60] It provides Information on energy management strategies and an energy efficiency best practice guide for focus industries. It provides an energy performance indicators tool to compare plants within an industry, and consultants who work with industries to provide information on energy efficiency and energy management. It also provides an ENERGY STAR logo and awards for good performance.

The International Energy Agency's Demand Side Management Programme (IEA-DSM) is an international collaboration of several North American, European, and Asian countries working together to develop and promote opportunities for DSM.[61] IEA-DSM established Task XIII to evaluate DRR practices from around the world and develop recommendations on best practices for integrating DRR into regular market activities. IEA-DSM has also developed several tool-kits for estimating DR potential and its valuation.

India:

The Energy Conservation Act, 2001 calls for the setting up of industry-specific task forces on energy conservation. In some sectors, the BEE and others are already implementing benchmarking programs. BEE is currently leading the Indian Industry Programme for Energy Conservation. The activities of this project related to the cement industry for example include

[59] http://www.eere.energy.gov/industry/saveenergynow/
[60] ENERGY STAR Program website: http://www.energystar.gov/
[61] IEA website: http://dsm.iea.org

formation of a Cement Task Force, energy audits, identification of best practices, and development of energy consumption norms (BEE, 2004). BEE has set up Task Groups for textiles, cement, pulp and paper, fertilizer, chlor-alkali and aluminum sectors. Industry members participate in this project to share information about best practices, declare their voluntary targets and adopt benchmarks for their processes. A benchmarking tool being developed through the Indo-German Energy Efficiency & Environment Project will provide cement manufacturers with information regarding their relative energy consumption level compared to their peers and to industry average.[62]

A key tool for achieving improved energy efficiency is to build capacity, train, encourage, and/or mandate the *benchmarking of energy consumption* at the plant level. This would expand BEE's cement activity to other sectors. Benchmarking will help plant owners to realize the level of their own specific energy consumption relative to similar plants elsewhere in India and the world. Once a facility has participated in a benchmarking exercise, it requires more detailed information about the energy savings and costs of specific energy-efficiency improvement measures that can be adopted. Information from the Indian case studies and best practice examples, combined with international information on energy-efficiency technology energy savings and costs, could be provided to Indian manufacturers in the form of an energy management guide (similar to those produced by the U.S. Environmental Protection Agency's Energy Star Industry program) or could be integrated into a benchmarking tool in order to provide projected savings for an individual plant given the adoption of a chosen set of energy-efficient technologies and practices.

Financing and information programs can play a central role in promotion of energy efficiency particularly in the small and medium enterprises (SMEs). SMEs are typically run by non-professionals who lack the wherewithal to seek technology upgradation, and often are deemed as riskier investments. A GEF project on the small-scale steel re-rolling sector is focused on providing technical information, demonstration of new technologies, and capacity building and training of plant personnel. Financing is being made available through SIDBI and other banks for credit-worthy operations, and could serve as an example for small scale enterprises in other sectors.[63]

7. The Way Forward:

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, and the country may continue 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

[62] IGEEP, n.d.
[63] www.undpgefsteel.net.

by such disruptions. Energy efficiency offers a cost-effective solution to overcoming this risk that is almost entirely within the control of the Indian government and private sector. A US-India strategic partnership in building capacity to plan and implement energy efficiency programs will help advance India's energy security and mitigate the environmental impact of unbridled energy growth, specifically coal. Improving the country's energy productivity will require a concerted effort by all sectors. This review of technologies and programs suggests the following activities that could assist the country in achieving this goal.

Comprehensive Approach:

All entities need to participate: India has made great strides in improving the energy productivity of its economy since the early 1990s. The progress made in the US and China and in specific sectors in India offers valuable lessons on efficiency improvement for the rest of the Indian economy. Energy efficiency is being promoted in US and China at all levels. Federal and state governments, utility companies and regulators, private industry and non-profit associations, and energy service companies, all play an important role in promoting 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. India needs to pursue a similar comprehensive approach that establishes and promotes the energy conservation ethic within central and state government agencies and all consumer classes, while maximizing the participation of the private sector in the implementation of energy efficiency activities.

States have a strong role to play: In India, the thrust on energy efficiency has largely focused at the central government level with some delegation of roles to the state government. Recent steps by Indian states to introduce state-wide energy conservation programs are a welcome development that need to be encouraged. It is reflective of the growing understanding that centralized planning and design of energy efficiency (EE) programs that are the responsibility of the Bureau of Energy Efficiency (BEE) must be supported by a strong and vigorous decentralized program at the state level. These programs should aim at setting up responsible state agencies, passing enabling legislation, training professionals, establishing technology demonstration centers and offering energy efficiency services. Indeed, anticipating such a need, the Energy Conservation Act 2001 provides for the establishment of state energy conservation agencies to plan and execute energy programs.

State government agencies, state utility companies and regulatory commissions all need to participate in the promotion of energy efficiency. The need, content and strategic thrust of a state energy conservation program will 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-subsidized losses that contribute to the state's fiscal deficit. 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. As in the US, utility companies and regulators, and state governments themselves have a strong stake in the promotion of efficient energy use.

Energy efficiency portfolio standards (EEPS) for ministries and state entities: Several states in the US have adopted the EEPS approach, which works by setting explicit targets for the penetration level of energy efficient devices or energy savings (Table 3). A functionally similar approach may work in the relatively disaggregated ministerial and center/state set up in India. Each ministry and relevant state agency or regulatory commission could be asked to design a plan for reducing energy growth for entities under its jurisdiction. A monitoring plan would accompany this design and be used to track progress towards meeting annual and cumulative targets during implementation.

Targeting Energy Efficiency Opportunities

Advancing EE in high priority areas: Where ever the cost of power supply and distribution is greater than the revenue realized from the sale of power, introduction of energy efficiency must be the foremost priority. Public use of electricity for street lighting, public buildings, water pumping, municipalities, hospitals and schools together with subsidized electricity supply to farmers represent a major claim on public finances. These public and subsidized uses of electricity should receive priority action.

Among these, agricultural efficiency programs that include rectification of existing pumpsets, use of efficient equipment in new installations and metering of pumpset electricity use merit attention. Agricultural efficiency programs represent a unique challenge in that they need to be integrated with utility programs aimed at strengthening the rural distribution network.

Separate short- and long-term options: 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 followed by the planting of energy efficiency seeds that will yield longer term benefits.

Combine Energy Efficient Procurement with Technology-Specific Building Retrofits: Lighting technologies are ideally suited for this strategy. The technologies are simple and reliable, and ESCOs do not need to possess a high degree of engineering expertise. Lighting retrofit projects are more amenable for private sector financing because of the use of standard, reliable technology and little or no likelihood of degradation of savings. This way, one can develop the energy services market in small incremental fashion allowing the key stakeholders to get familiar and comfortable with the concepts and risks involved with performance contracts.

Triggering EE Market Transformation: Several energy efficiency measures with considerable savings potential involve technologies that are either not available or not yet widely manufactured in the country. Targeted efforts are called for to promote the widespread production, availability and use of such products. Such efforts are referred to as energy efficiency market transformation strategy whose key elements include:

- Research, development and demonstration projects (RD&D) with emphasis on technology commercialization and/or adaptation (to adapt foreign technologies to the Indian market).
- Technical and financial assistance to manufacturers including corporate tax incentives (e.g., 100% accelerated depreciation) to users of energy efficient technologies, equipments and devices.
- Selective reductions in import duties and sales/excise taxes. Relief could be provided on manufacturing equipment needed to produce EE products domestically and on limited quantities of actual products so that a sufficient market demand could be created to catalyze domestic manufacture.
- Prescribing mandatory efficiency standards and compulsory labeling for selected energy consuming equipments (e.g., refrigerators, electric pumps and motors, lighting equipment, etc.)
- Moving governmental procurement policies to reflect life cycle costing principles over least first cost; introducing performance based contracting with shared/guaranteed savings as the revenue stream for the energy efficiency service provider
- Opportunities exist in India for "golden carrot" programs for the introduction and adaptation of superior energy efficient refrigerators and other energy consuming devices and equipments. Such opportunities could be realized through innovative financing mechanisms with costs and risks shared among vendors, state utilities and governments.

Financing and capacity building:

Financing: Access to competitive financing and trained manpower and institutional infrastructure is critical for initiation and replication of energy efficiency programs. Financing through international and national development banks, public charge type funds, government subsidies, and tax rationalization is already practiced in India. It is important to bear in mind though that the borrower and lender may be looking beyond merely reducing energy costs. Reducing total costs, improving infrastructure, and/or establishing credit worthiness are often the main goals that can and are being pursued through EE finance. Improving a borrower's credit worthiness may be particularly important when lending to small and medium scale enterprises and municipalities. More recently carbon finance has emerged as a way of buying down the interest rate charged by lending institutions. Carbon finance can play an important role given that the carbon price for clean development mechanism projects is around $12 per t C ($45 per t CO_2) or about 1 cent/kWh, and should be accessed wherever feasible.

Energy service companies (ESCOs) are an important route to providing market-based solutions for energy efficiency. They have thus far been mostly small size companies that are engineering-oriented. The industry needs to be revived and transformed from a blue-collar engineering operation to a white-collar one that is able to better understand and undertake financial risks. Bundling of projects through financial and other entities and standardization would reduce transaction costs and risks of energy efficiency projects.

Expand best practices within and across industry and buildings sectors:: BEE has taken important steps towards building capacity through its programs for certifying energy managers and energy auditors. The Indian GBC also offers training, technical assistance, and other capacity building programs. Widespread implementation of energy efficiency requires that programs at the national and state level be instituted that are widespread in their scope. Industry associations and industries have and continue to play an important role, as witnessed by examples of best-in-the-world office buildings and industrial plants that are being set up in India.

Demonstrations of such facilities are important but their replication requires capacity building and training of builders, industry managers, analysts, and other professionals to ensure that the gains are captured and sustained. Benchmarking, voluntary agreements, financing of SMEs, are some of the thrust areas where large gains are possible. Given the sharp rise in building electricity consumption and air conditioning peak loads, particular attention needs to be given to this sector. Benchmarking is one activity that needs to be expanded to the commercial buildings sector.

Data, Analysis and Planning:

Regularize data collection and analysis: Finally, we would not wish to end this paper without emphasizing above all the role of data and analysis that can help quantify technology performance, its cost-effectiveness, role of barriers, identification of beneficiaries, and targeting of government and industry policies, programs, and measures. In the US such activities are routine and include the use of generation planning models, and implementation of least-cost planning that includes end-use efficiency measures.

Further, the US Federal Energy Regulatory Commission and Department of Energy, and state energy agencies, collect and/or collate annual data on individual power plant performance and attributes of other forms of energy supply. Demand-side data are collected through triennial or quadrennial surveys of households (Residential Energy Consumption Survey), commercial (Commercial Buildings Consumption Survey), and industrial (Manufacturers Energy Consumption Survey) sectors. Utility companies gather hourly data on load shapes. In India, however, utility data are only now starting to be collected to a limited extent by the more progressive states. Data are a two-edged sword; they sometimes reveal facts that are uncomfortable to one's favorite programs, but without quantitative analysis there will be no firm basis for future improvements in energy efficiency.

Monitoring, evaluation and verification to ensure that energy savings are quantifiable, reliable and creditable is key to all energy efficiency programs and measures. Without these activities, no amount of promotion can turn energy efficiency into a business practice.

Setting up centers of excellence in energy efficiency: An energy conservation center at the state level will have the prime function of ensuring the proper implementation and monitoring of energy efficiency programs adopted by the government. International experience has shown that such a center operates more effectively as an independent, unbiased body under an autonomously managed structure. The center should preferably function with direct industry participation and besides its prime function; its activities could include conducting awareness campaigns, facilitating technology information sourcing, showcasing energy efficiency technologies, promoting technology cooperation and transfer, and organizing audits.

There is considerable evidence that a state energy conservation center is useful in supporting a national energy efficiency program by mobilizing existing private and public institutions to provide the information and technical expertise needed by energy consumers. To have maximum impact, centers should be constituted and staffed to reflect the nature of the state's industrial sector, its energy/power sector reform and restructuring plans, the potential for energy savings and the ability to mobilize market forces and capital markets. For example, Karnataka state power utilities in cooperation with the Indian lighting industry and USAID/India proposes to establish a Lights Museum and Energy Center (LIMEC) for end-users at Bangalore. LIMEC would be part of a broader electrical DSM institution aimed at promoting awareness and advancing efficient illumination technologies through a world-class exhibition of efficient lighting products and systems.

International Cooperation

Cooperation between US and India requires that entities with common energy efficiency goals and activities exist in the two countries, which is not the case today. At the federal level, the US 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 efficiency 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 India would require that entities with similar functions (not necessarily the same structure) exist in the country. A concerted effort on part of the Indian government and private sector to establish energy efficiency expertise at relevant entities and/or the creation of new entities will go a long way towards improving collaboration with the US and other countries.

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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.

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

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

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.

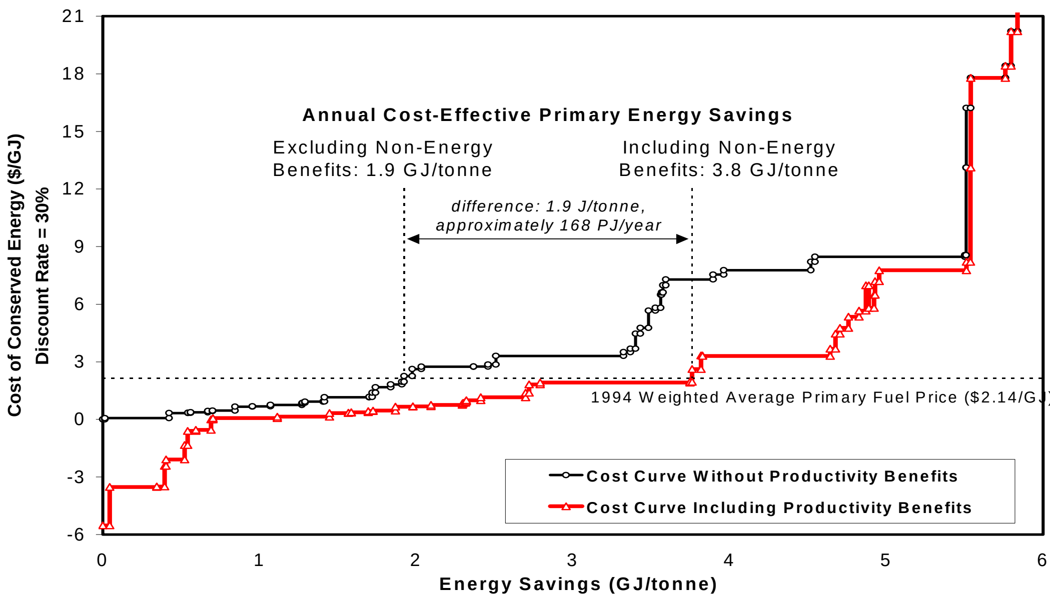
$$CCE = \frac{I \cdot q + M}{ES} ----------------(2)$$

Where

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

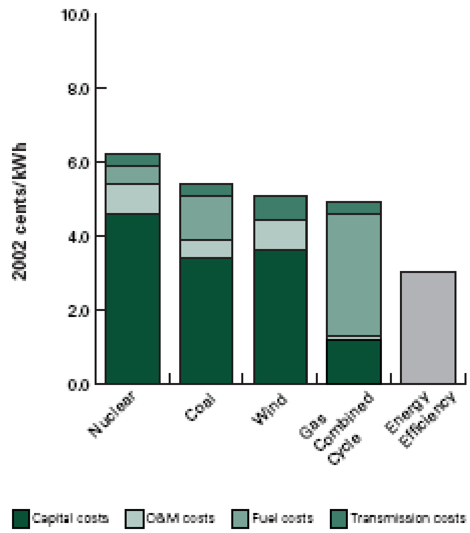
Accounting for such "hidden benefits" requires that bottom-up models look beyond the energy markets and examine the cost considerations in light of their impact on other resource markets. One example is reported by Worrell et al. (2003) for the US iron and steel industry.[64] They report a cost effective 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 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)



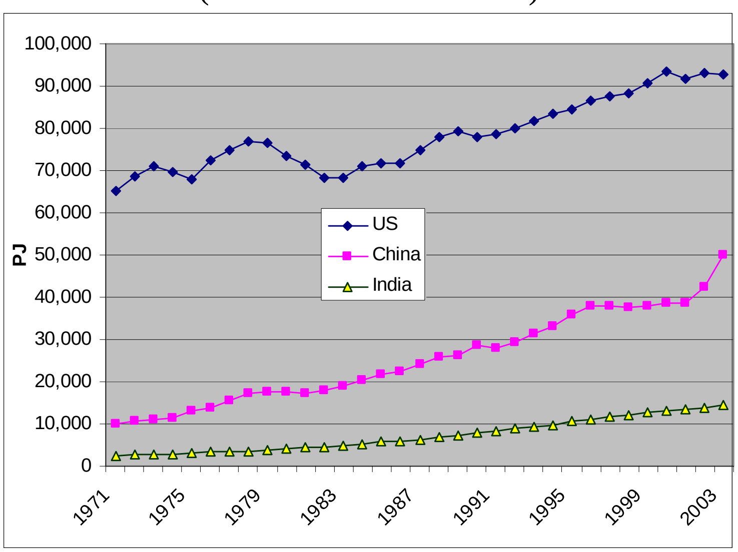
64 Worrell, E. J.A. Laitner, M. Ruth and H. Finman. 2003. "Productivity Benefits of Industrial Energy Efficiency Measures" *Energy* 11, 28**,** pp.1081-1098 (2003).

Figure 1: Energy efficiency is competitive with generation technologies



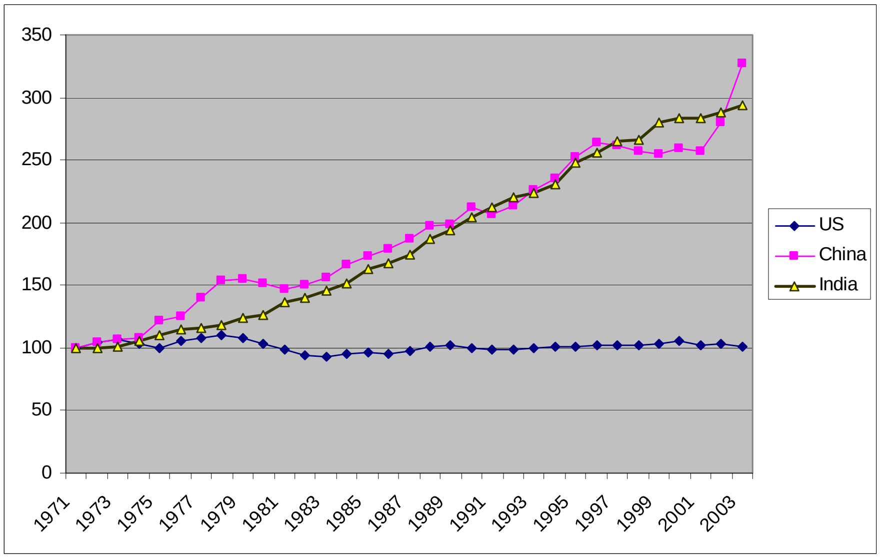
Source: US EPA (2006). *Clean Energy-Environment Guide to Action*. Pre-publication draft.

Figure 2: Primary Energy Supply (PJ)
(Excl. traditional biomass)



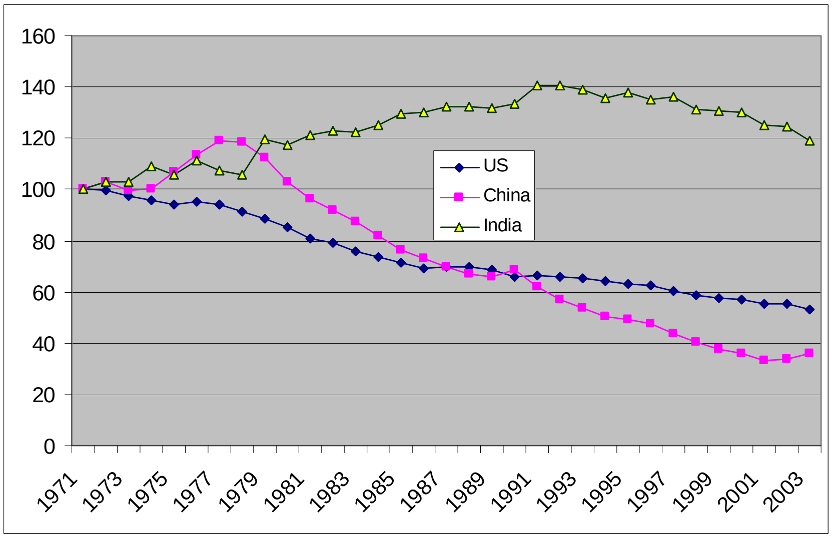
Source: International Energy Agency, Paris, France.

Figure 3: Primary Energy Supply per Capita (Excl. traditional biomass)
(Indexed to 1971=100)



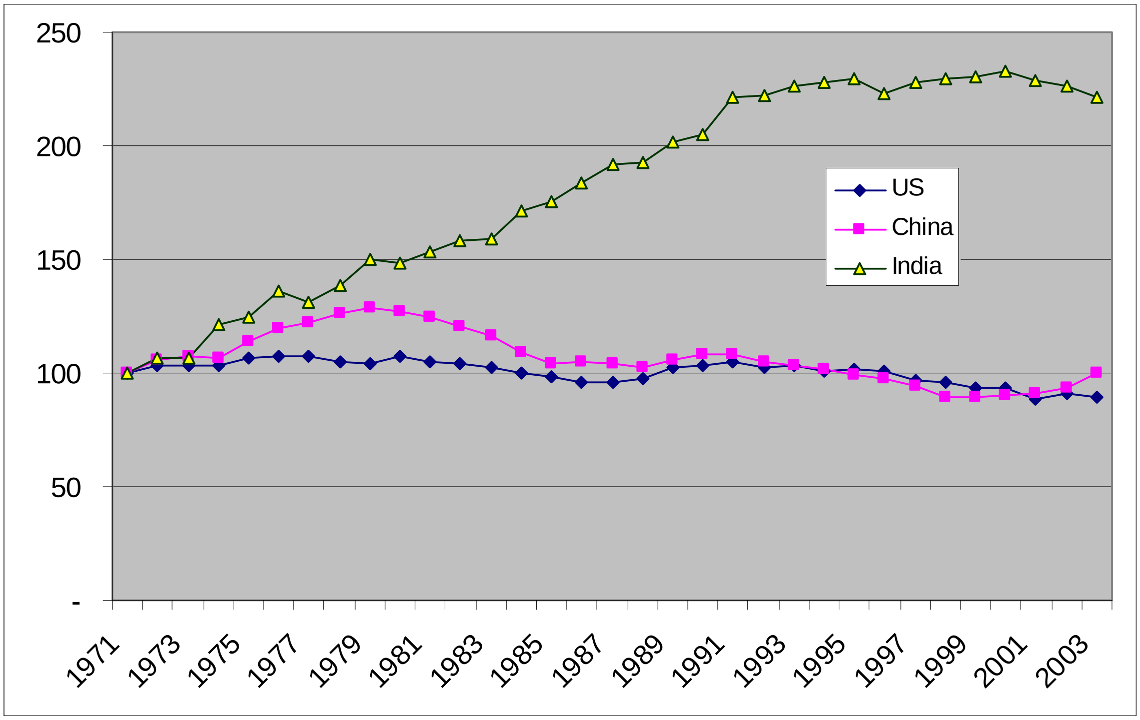
Source: International Energy Agency, Paris, France.

Figure 4: Primary Energy Supply /GDP
(PJ/2000 US $; Excl. traditional biomass Indexed to 1971=100)



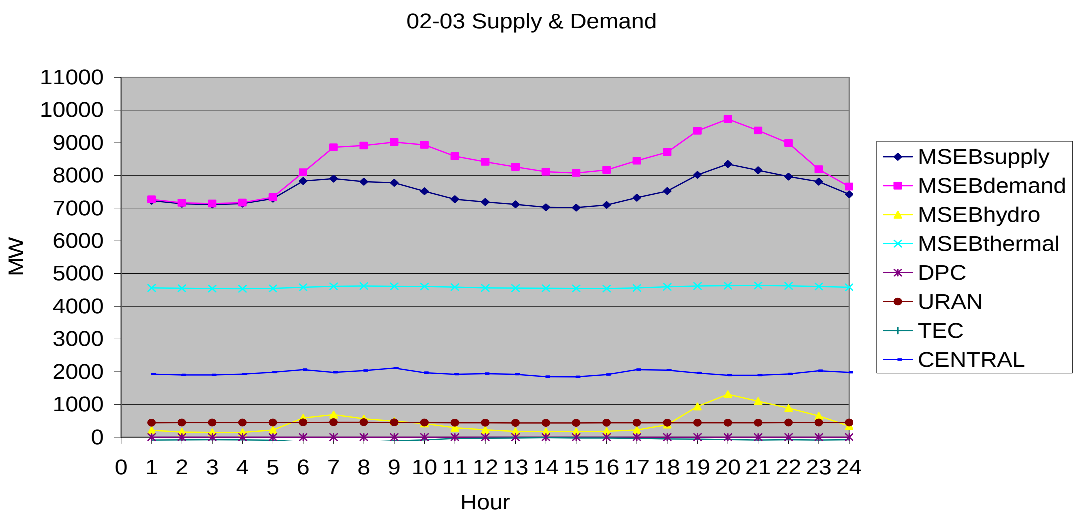
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 5: Electricity Generation/GDP
(kWh / 2000 US $, 1971=100)



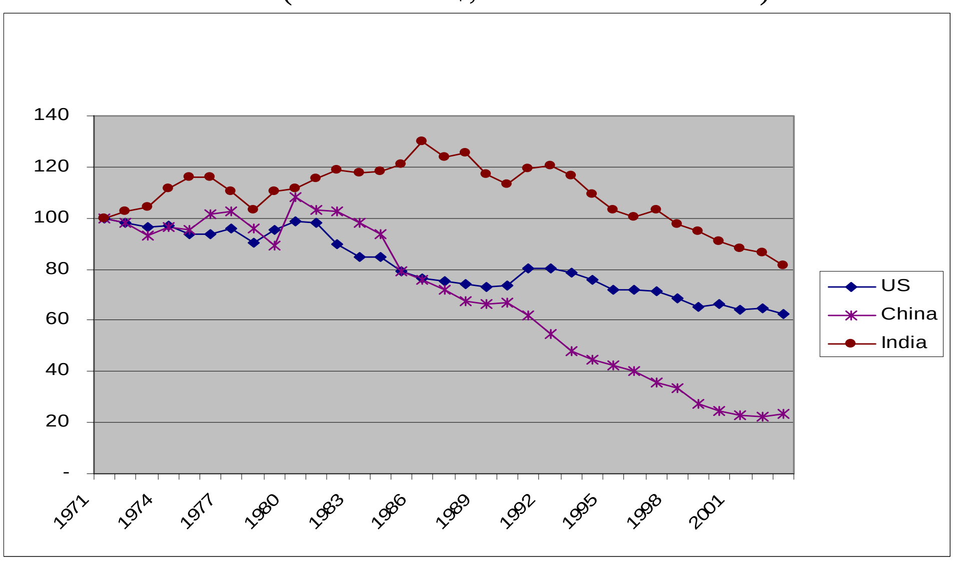
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 6: Maharashtra State Electricity Board – Available Capacity and Demand
(Annual average 2002-03)



Source: Phadke A., J. Sathaye and S. Padmanabhan (2005) Economic Benefits of Reducing Maharashtra's Electricity Shortage through End-Use Efficiency Improvement. LBNL-57053

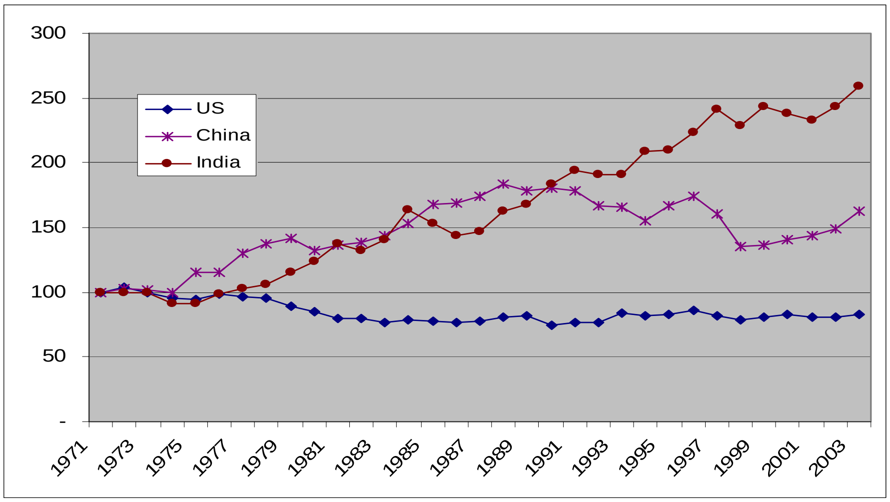
Figure 7: Primary Industrial Energy Consumption /Value Added (PJ/2000 US $; Indexed to 1971=100)



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

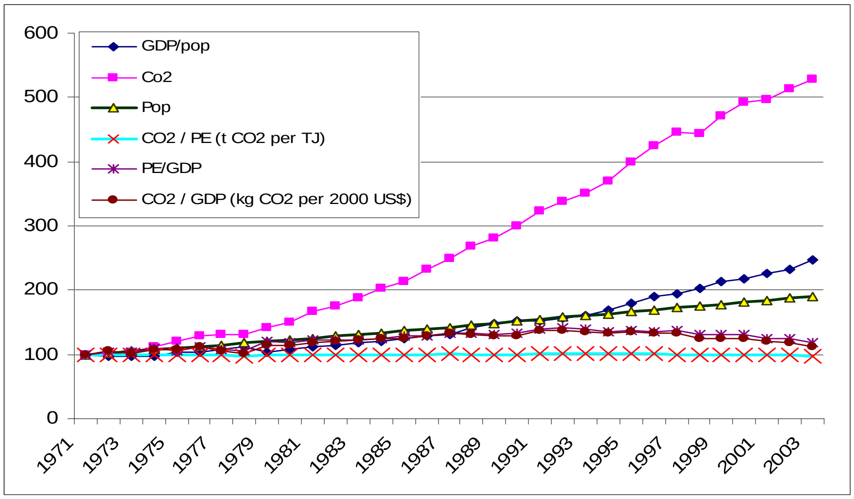
Figure 8: Residential Primary Energy Consumption per Capita

(Excl. traditional biomass; 1971=100)



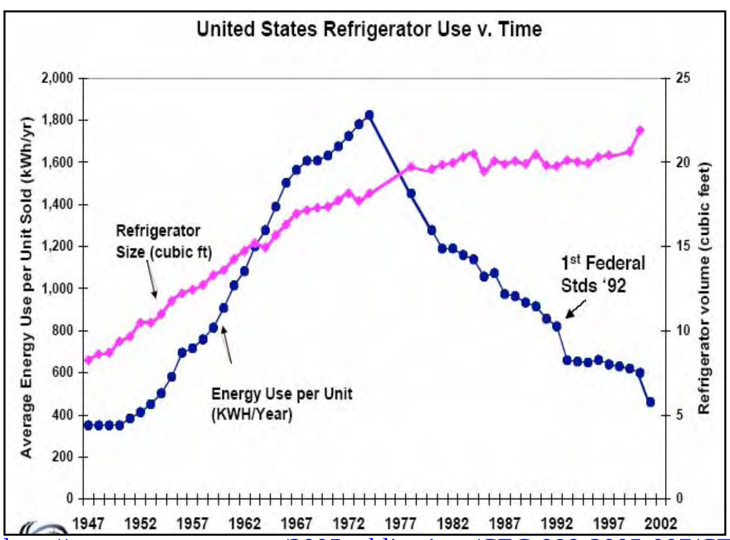
Sources: International Energy Agency, Paris, France, and The World Bank, Washington DC

Figure 9: Decomposition of India's CO_2 Emissions
(Primary energy excludes traditional biomass)



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

Figure 10: US Historical Refrigerator Electricity Consumption



Between 1974 and 2001, the energy consumption of the average refrigerator sold in the United States has dropped by 74% driven by market forces and regulations. From 1987-2005, the U.S. Congress and agencies promulgated labels or minimum efficiency standards for over 40 residential and commercial product types. Canada and Mexico also have many product labels and efficiency standards, and a program is currently underway to harmonize standards throughout North America in connection with NAFTA.

Source: http://www.energy.ca.gov/2005publications/CEC-999-2005-007/CEC-999-2005-007.PDF, slide 7