US-India Clean Energy Deployment Center Assessment

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PREFACE

Building on the India-US Energy and Global Climate Change dialogues, the governments of India and United States of America entered into a strategic partnership by signing a Memorandum of Understanding (MOU) on November 24, 2009 to enhance cooperation on energy security, energy efficiency, clean energy and climate change. The partnership intends to focus on increasing collaboration in energy efficiency, renewable energy, and clean energy technologies with co-benefit for climate change through development, deployment and transfer of transformative and innovative technologies.

The instrument to carry forward this US-India partnership is the ***Indo-U.S. Clean Energy Research and Deployment Initiative (CERDI).*** CERDI is comprised of two primary components, namely:

- **Research:** A **Joint Research Center (JRC)** to promote clean energy innovation by supporting collaborative research through one or more consortia involving university, private sector and national labs partners in each country.
- **Deployment:** Cooperative efforts to accelerate deployment of clean energy technologies, focusing in particular on financing and creating an enabling environment.

A key initial step in creating CERDI is to characterize the existing landscape for barriers and opportunities for clean energy deployment in India by a focused assessment on the organizational, regulatory, financial, and industry structures that will accelerate and sustain the deployment. This was accomplished by three DOE National Laboratory teams that visited India from January 11 through 23, 2010 and held meetings with stakeholders in New Delhi, Mumbai, Bangalore, Hyderabad, and Pune. Members of each team met with federal and state government organizations, industry and industry associations, financial institutions, electricity regulatory commissions, power generation companies, renewable energy development organizations, trade associations, academia, and nongovernmental organizations. The USAID-India Mission sponsored, planned and organized the assessment visit and set up the meetings of the national laboratory teams.

The three teams were organized separately to identify issues in:

1. Creation of a deployment center within CERDI
2. Renewable Energy
3. Energy Efficiency

This report is a collective compilation of the meetings and discussions, and documents their findings. It is divided into three Chapters organized by their respective areas of activity.

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Executive Summary

The US and India recently signed a Memorandum of Understanding to Enhance Cooperation on Energy Security, Energy Efficiency, Clean Energy and Climate Change, launching a new effort of collaboration. Through the key implementing mechanism of the Clean Energy Research and Deployment Initiative (CERDI) the governments have agreed to expand collaboration on clean energy, building on existing efforts, programs and relationships established through the US Agency for International Development (AID), Department of Energy (DOE), Department of Commerce (DOC), Overseas Private Investment Corporation (OPIC), and other organizations.

CERDI includes both a research component and a deployment component, and the first area of focus is on deployment of clean energy, including energy efficiency (building, industrial), renewables (solar, wind, biofuels, geothermal), smart grids, and clean coal. The clean energy deployment vision is transformative: through collaborative efforts on providing technical assistance, creating a supportive business environment, facilitating projects, and providing training, education and outreach, this new Deployment Center will catalyze a shift in India's energy use trajectory. This is no small ambition: India is growing at such a rapid pace that, for example, 70% of the building space that will exist in 2030 has yet to be built.

In July 2008, India released its first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation.[1] The plan pledges that India's per capita greenhouse gas emissions "will at no point exceed that of developed countries even as we pursue our development objectives." The Plan's broad goals are consistent with sustainable development (environmental protection, economic growth and societal benefits) and energy security.

To achieve simultaneous economic growth, energy security, and environmental goals requires: (1) adopting a coordinated and collaborative approach across energy sector stakeholders – addressing the technical, regulatory, market, financial, capacity building, issues simultaneously; (2) understanding the broad scale environment, social, and economic impacts over the life of system; (3) removing current barriers in policy, regulations, and market to facilitate large scale deployment of clean energy technologies and services; (4) building capacity at all levels through outreach, training, and education; and (5) increasing financial investments (leveraging public and private sector resources), developing creative revolving, pooled investment strategies, and leveraging and influencing existing investments.

The vision of the Clean Energy Deployment Center (CEDC) is to work with India towards achieving its goals through catalyzing massive scale deployment of clean energy technologies to simultaneously achieve economic growth while reducing GHG emissions that contribute to climate change. Clean energy technologies are currently available or near commercialization, and with USG technical assistance, these technologies can be more quickly applied across the buildings, industrial, commercial, residential and power

1 http://moef.nic.in/downloads/home/GHG-report.pdf

sectors, both reducing demand for power and contributing low or no-carbon green power to India's electricity grid as well as providing off-grid power and alternative fuels.

During January 2010, a USAID-DOE National Laboratory team visited India and met with federal and state government organizations, industry and industry associations, financial institutions, electricity regulatory commissions, power generation companies, renewable energy development organizations, trade associations, and nongovernmental organizations (Appendix B). The purpose of these discussions was to assess the landscape of opportunities and challenges for rapid deployment of clean energy in India, with a view to identifying the potential activities, structure and organization of a US-India clean energy deployment center. This report is a summary of the team's findings and will help inform design of the center.

The report is divided into three chapters (plus appendices) to reflect the three areas evaluated: assessment of the Deployment Center organization and funding options and key activities; assessment of renewable energy opportunities and barriers; and assessment of energy efficiency opportunities and barriers. Each of these areas is summarized below.

Deployment Center Opportunities and Challenges

Several themes emerged from stakeholder discussions around establishing a US-India Clean Energy Deployment Center:

***The Indian public and private sectors are vibrant and focused on clean energy*.** The Government of India (GOI) has launched the first two of eight missions on solar energy and energy efficiency under the NAPCC and public-private sector efforts have resulted in the installation of about 11,000 MW of wind power and recently resulted in India's first grid-scale megawatt-level solar power plant.

Progress has been limited by not enough technical knowledge; institutional, policy, and regulatory barriers at federal, regional, state, and municipality levels; sound data to inform investment decisions; financial resources and financing mechanisms; trained scientists, technicians, operators and other human resources; utility and grid integration issues including high distribution losses; the capability to monitor and verify energy usage; and limited investment in technology R&D.

A USG-GOI Deployment Center provides a key opportunity for accelerating clean energy deployment by:

- Facilitating the integration and expansion of existing Indian and US public and private sector activities, fostering institutional and commercial partnerships and collaborations
- Supporting development of a favorable business environment for clean energy projects in India
- Facilitating US-India clean energy funds and projects
- Expanding technical, policy, financial, programmatic knowledge about clean energy in India

***Deployment Center activities to achieve this transformation should include*:**

- Strategic planning and analysis to identify a strategy for achieving low carbon growth, reflecting related work at the World Bank, the recently announced Climate Renewables and Efficiency Deployment Initiative (Climate REDI), the recently established Coordinated Low Emissions Assistance Network (CLEAN), the Technology Action Plans developed under the Major Economies Forum on Energy and Climate and other multilateral initiatives.
- Project facilitation and finance -- individual projects as well as creation of pooled fund(s) and revolving fund financing mechanisms for technology demonstrations and services; development of new financial instruments and processes to enhance resource availability for deployment, and encouraging market development and buy-down cost of advanced clean energy technologies.
- Education and training to scale up the capacity building activities especially working with industry associations and universities.
- Outreach and communication to scale up engagement of the energy sector stakeholders especially in government (state and local) and financial sectors.
- Technology demonstrations and pilots especially working with industry in the areas of waste heat utilization; work with agricultural sector across the nation to scale up programs to reduce pumping electricity load; working with major builders and developing ESCOs to create net-zero and positive energy buildings and for creation of district cooling systems for malls; and integrating renewables into electricity generation sector.

The Deployment Center should have a physical presence, supplemented by a virtual center. To be most effective a Deployment Center should bring together government, industry, financial institutions, project developers and others (such as training utility system operators) and this is best accomplished through a physical location, supplemented with a virtual presence such as through Distributed Innovation (DI)[2]. DI accelerates the speed of innovation and commercialization of technology by attacking the problem from multiple intervention points along the value chain, from upstream research to downstream deployment by addressing the technical, market, financial, policy, regulatory, and legal issues along the entire chain.

The deployment center management structure should include an institutional mechanism for running the center; establishing center goals, strategy, and performance metrics; developing programs that are aligned with government initiatives on clean energy; selecting projects; and tracking clean energy deployment progress. One option for leading this effort is through an Advisory Committee composed of the Chairmen of each of the three relevant US-India Energy Dialogue Working Groups (Power and Energy Efficiency, New Technologies and Renewable Energy and Coal) from both the US and India. (The Advisory Committee may also include membership from the private sector and other institutions, although this may raise conflict of interest issues). The Advisory Committee would set priorities and provide overall leadership for the center. This Committee could be supported by a Secretariat, serving as the executive arm of the Advisory Committee

[2] http//www.cleanegroup.org/Reports/ACTII_Report_Final_November2009.pdf

and providing full-time support for the Center, responsible for selecting projects aligned with Advisory Committee guidance, and managing overall Center activities. The Secretariat could be housed and managed as part of an existing institution or could be independently managed and operated by an integrator/NGO or organization currently leading clean energy activities in India.

Although not discussed in most stakeholder meetings, the deployment center assessment team identified four options for organizing the center:

- Centralized structure with activities planned and managed from national center
- Decentralized centers based on technical focus areas (e.g., building efficiency, solar, wind, smart grid, coal) located throughout the country
- Regional or state centers with all technologies covered by each center
- Hybrid structure with some activities conducted and managed out of national deployment center and other activities conducted and managed out of technology-specific centers

Although each option offers pros and cons, the advantage of a hybrid structure is that it best capitalizes on the capabilities and programs of existing centers such as the Green Business Center in Hyderabad. Linking to and expanding on successful ongoing programs and institutions will allow for the quickest impact in deploying clean energy technologies.

Establishing a robust funding mechanism is important to ensuring sustainability of the Deployment Center. The Center should identify resources through fund-raising from public, private, individual and intergovernmental relationships, and create new financial mechanisms for making the resource available, pooling risks, and providing mechanisms for access and use of the resources. Although funding was not a key topic of stakeholder discussions, the assessment team identified four options:

- Clean energy fund—USG and GOI funds (and potentially funds from other sources) are pooled to support Deployment Center projects.
- Separate funding streams—USG funds are used to fund US researchers and equipment and likewise GOI funds support Indian staff and other costs.
- Self-sustaining entity—after USG/GOI seed money is used for establishment, the Center supports itself through energy sector stakeholder memberships, fee-based training, policy analysis and other activities
- Hybrid model—apply the approach that best fits the type of effort (e.g., training, demonstration project)

The options each have advantages and disadvantages, and a hybrid system that allows for flexibility depending on the program area may be most appropriate. Since this was an assessment study and not a design effort, this report does not address governance issues, nor does it provide recommendations on resource allocation, budgets, staffing plans and the like.

Renewable Energy Opportunities and Challenges

More than 15,000 MW of renewable energy capacity have deployed in India to date, with most of the capacity derived from wind, small hydro, and biomass resources. Renewable energy development has been driven by government incentives and state level renewable energy tariffs. There is potential to develop significant additional renewable energy resources in India with targeted efforts to address barriers. Key opportunities and barriers for advancing renewable energy deployment include:

Utility and Grid

- As penetration of intermittent renewable generation increases, there is a greater need to adopt the latest technology in wind forecasting to enable grid operators to better plan and manage wind generation as and when it is available.
- Training of system operators to integrate intermittent generation is needed; grid operators are often not familiar with how best to manage intermittent generation sources.
- There is a need for analysis and evaluation of whether the grid will be able to handle a large quantity of distributed PV.

Institutional and Regulatory

- There is a need for greater coordination between state-level tariffs and government level incentives as well as a need for greater analysis in setting incentive levels.
- There is a need for capacity building with respect to the deployment of renewable energy technologies among regulators, state nodal agencies, and utilities. This could include education and information on technologies, costs, resource assessment data, effective deployment strategies used elsewhere, and effective solutions to barriers.
- A single "window" for approvals or an agency at the State level that could facilitate the acquisition of multiple approvals from different agencies, for siting and permitting RE would facilitate and simplify the approval process for installing and siting such systems.
- To effectively provide incentives, there is a need for administrative simplicity, consistency, and certainty in the level of incentive that is provided.

Data and Analysis

- There is a need for more detailed resource assessment maps, and more readily available data on technology costs, performance, installed capacity, and generation.
- More rigorous analysis could be used in setting incentives and policy goals; greater availability of technology cost and renewable resource data would enable this.

- Greater documentation and assessment of specific barriers and sharing of lessons learned would help regions learn from each other and overcome institutional and regulatory barriers.

Financing

- To encourage greater access to financing, renewable energy should be identified by the government as a priority lending area for banks.
- Loan guarantees, credit lines from development finance institutions to commercial banks, or other forms of guarantees or risk mitigation could be used to encourage commercial lenders to finance renewable energy projects based on the project financials alone without requiring a strong balance sheet.
- Increased access to lower cost financing and longer term financing is needed to enable solar to compete in a variety of applications.
- Because most consumers do not have bank accounts and therefore cannot access credit, there is a need for innovative financing structures to provide access to loans for renewable energy projects.

Rapid Scale-Up and Deployment

- For a massive and rapid scale up of technology, it is important to engage large companies and organizations to make renewable energy commitments.
- Targeting builders and leveraging affordable housing efforts and infrastructure development could accelerate rapid deployment of clean energy technologies.
- There is a need for greater local manufacturing capability to serve the industry. Rapid deployment needs to result in local job creation and to rely on technologies that can be manufactured and maintained locally.

Energy Efficiency Opportunities and Challenges

Energy efficiency has the potential to eliminate India's electricity shortage, reduce environmental pollution in urban areas and rural households, and decrease India's contribution to emissions of greenhouse gases while increasing the country's economic output by as much as $350 billion between 2009 and 2017. Several energy efficiency measures with considerable savings potential involve technologies that are either not available or not yet widely manufactured in India. Targeted efforts are needed to promote the widespread production, availability, and use of such products in appliances, buildings, industry, and smart grid sectors.

Key opportunities include:

Development of Codes, Standards, and Protocols

- Waste heat utilization – Much of the hot gases generated in boilers, kilns, ovens and furnaces could be recovered, and loss minimized by adopting various efficiency measures.
- Appliance labels and standards -- Continued US-India collaboration on developing labels and standards to cover other appliances relevant to India, while

sharing latest technological breakthroughs about practical minimum energy use will be a valuable asset to both countries.

- Building codes -- India is experiencing a 35% annual growth in air-conditioning equipment with only 2% of households featuring AC. This calls for a major national initiative to encourage the use of innovative HVAC technologies (e.g. radiant cooling, GSHP, direct-indirect evaporative cooling, etc.) that has the potential to reduce the energy use by HVAC systems by more than 50%. Since bulk of the buildings will continue to have no AC, adoption of thermal comfort standards that take into account people's adaptive behavior based on outdoor climate as prescribed by ASHRAE will help in improving occupant welfare.
- Standardized documents such as protocols, templates, contracts, etc. for demand-side management (DSM) program designs, load research survey questionnaires, ESCO performance contracts, and measurement and verification protocols and others. Such documents are being developed in both the U.S. and India and collaboration between the two could leverage experience in the two nations for better products.

Demand-side Management (DSM) Programs and Delivery Mechanisms

- Load research – A key element of electricity supply planning and operations is knowledge about the customer demand profile. In India, this knowledge needs to be developed by conducting customer surveys. US-India cooperation can help in institutionalizing such data collection within the Indian power system.
- Appliance market transformation – The barriers include limited access to efficient appliances, high first-costs, low awareness levels, and limited resources (e.g. economic, technical, organizational, etc.) to overcome these barriers. Implementation of DSM programs at state and national scales that would engage utility companies, state and central regulatory commissions and the Bureau of Energy Efficiency (BEE) would be an effective approach to promote market transformation. Within DSM, load research, program design, and monitoring and verification are key areas where collaborative efforts would be effective. A clear legal mandate, however, is essential but lacking for utility companies to participate in DSM programs.

  Regional or even global programs such as the Super Efficient Appliances Deployment (SEAD) a "Golden Carrot" program for the introduction and adaptation of superior energy efficient refrigerators and other appliances can facilitate rapid market transformation. Such opportunities could be realized through innovative financing mechanisms with costs and risks shared among vendors, state utilities and governments. An international scheme to promote such programs would also benefit US and India and lead to significant CO_2 reductions globally.
- Retrofitting buildings through performance contracting mechanism – Unlike the appliance markets transformation programs, a useful mechanism for achieving energy savings in existing buildings is via performance contracting projects. Facilitation of the contracting process involving the building owner, Energy

Service Company (ESCO), and financing entity (e.g. banks or utility companies) can allow the market for energy services to function more efficiently. Increased US-India collaboration in this arena can help educate and create awareness about this delivery mechanism among all relevant stakeholders.

- Demand Response (DR) – In the U.S. there is a long history of utilities and independent systems operators (ISOs) providing programs and incentives to customers to reduce their energy consumption during short periods of time to address system reliability and cost concerns or high spot-market prices without having to build new supply capacity and for increased grid reliability. India faces peak period shortages that are currently resolved by implementing rolling blackouts. DR programs similar to those implemented in the U.S. have the potential of reducing the rolling blackouts by incentivizing at least the large customers to shift their load from peak to off-peak periods. Sharing of DR technologies, policies, and innovative tariff designs (e.g. dynamic pricing) between India and the U.S. would be very useful in reducing potential blackouts and also as a hedge against high spot-market prices.

Pilot technology programs with financial and procurement incentives

- Financial institutions such as ICICI in India have worked over the years in providing revolving funds to set up pilot programs in various sectors. Most of these programs were successful but their scale up has been relatively weak. The pilot programs have large potential and assisting these and other institutions to scale up the successful programs would help speed up the deployment of efficiency technologies.

Analysis and Research, Development, and Demonstration (RD&D)

- Analysis – Conducting in-depth analysis such as estimation of energy efficiency potential, cost-effectiveness, efficiency of program and/or delivery mechanisms, etc. is an ongoing activity where US-India collaboration for sharing information about future technologies, tools/methods, and skills would be valuable.

- Benchmarking – Comprehensive databases of energy efficiency measures, building energy consumption, retrofit projects, case studies, best practices, etc. are very useful in developing the next set of policies, programs, and technologies. Benchmarking of building and industrial processes so that comparisons may be made with global energy efficiency performance would help in informing builders and industry of their potential for improvement.

- Emerging technologies – RD&D with emphasis on technology commercialization and/or adaptation (to adapt foreign technologies to the Indian market) will accelerate the penetration of emerging technologies. Lighting technologies would be a critical item to focus on since lighting in all its applications is the largest cost-effective efficiency potential load in India and the US. Smart grid technologies would be invaluable to reduce distribution loss and to control peak load shortages and offer opportunities for collaboration between the information technology (IT) and control systems industries in the two countries.

US-India State and City Level Cooperation:

- State to state cooperation is important because both in the US and India the electricity sector is primarily governed by the state government. A state has its own independent regulatory commission(s) in both countries, and currently cooperative activities have been initiated in Maharashtra and Delhi with the support of US DOE and State Department. These are ripe for expansion to other states under MOUs signed by India's Forum of Regulators with counterpart commissions in California, and LBNL. Other US states and utility companies are also eager to share information about smart grid and demand response programs.
- City to city cooperation is also ongoing with DOE support and MOUs have been signed between cities in the two countries. DOE/Brookhaven National Laboratory (BNL) facilitated signing a memorandum of understanding (MOU) between the cities of Atlanta, GA, and Ahmedabad in India, initiating the first-ever U.S.-India cities partnership on energy, in March 2008. DOE is working with the GOI to provide technical assistance for developing satellite towns on the concepts of 'zero energy', energy efficient urban planning guidelines, and green building guidelines in the future.

Education, Awareness, and Technical Assistance

- Information sharing - Sharing of knowledge and information about designing and implementing governmental procurement policies for energy efficient goods (e.g., white roofs, lighting, space conditioning) between the two countries would help in accelerating their penetration.
- Training and capacity building – Human resources for implementing energy efficiency activities need to be developed on a massive scale in India. Energy efficiency programs such as DSM are still developing in India and capacity for their design and implementation is sorely lacking. The U.S. has broad and deep experience in most facets of energy efficiency activities. This experience – appropriately adapted to the Indian conditions – is currently being shared with Indian practitioners through training and capacity building workshops. Bringing these up to scale will benefit Indian practitioners from all stakeholder organizations – policymakers, regulators, utilities, manufacturers, evaluators, NGOs, etc.
- Assistance organizations - Establishing test procedures that allow for regular testing and dissemination of results of such technologies would increase consumer confidence. Organizations that serve as technical resources – e.g. architects/designers, legal support, technical support, appliance awareness, demonstration of prototypes, etc. – can leverage the experiences that both India and the U.S. achieve

Energy Efficiency Centers

- Centers that specialize in buildings, industrial furnaces, and appliances have been established in India with support from BEE/NEDO and USAID. These centers are intended to provide support for the development of cutting edge technologies and to foster their market penetration. The development of similar centers for other sectors and technologies would help accelerate their development and penetration in India.

Stakeholders were unanimous in recognizing that opportunities for clean energy in India--specifically those outlined above--are enormous. National and state governments have implemented clean energy policies and financing mechanisms (such as through the Indian Renewable Energy Development Agency). Other public and private sector organizations are increasing involved in clean energy and an overall receptive climate exists. Through its activities and by playing a convening and coordination role, a well-designed and funded Deployment Center can build on this momentum and catalyze massive clean energy deployment in India.

Chapter 1. Clean Energy Deployment Center Assessment

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1 Clean energy deployment center introduction

CERDI will foster innovation and joint efforts to accelerate deployment of clean energy technologies that promote reduction of greenhouse gases, improve energy security, and support climate change mitigation. Priority areas of focus for this initiative include renewable energy, energy efficiency, smart grids, advanced storage batteries and cleaner coal technologies. Guided by the strategic intent and direction of the November 24, 2009 MOU, CERDI will also build upon US Agency for International Development/India's (USAID/I) current bilateral energy programs notably the Greenhouse Gas Emissions Prevention (GEP) project and the Energy Conservation and Commercialization (ECO) program as well as the efforts of the working groups of the U.S.-India Energy Dialogue. It will also refer to the World Bank's low carbon strategy for India.

The deployment center ("Center") under CERDI is envisioned to foster institutional and commercial partnerships and collaborative programs with private sector entities as well as federal, state and city groups, agencies and bodies in both countries. It will assist India in achieving its target of reducing its emission intensity and mitigating its GHG emissions through technical assistance and financing. Broadly, it will focus on enhancing and promoting enabling environments, developing partnerships, promoting technology transfer, promoting policy changes, developing clean energy markets, and providing seed financing in three illustrative core areas:

1. Energy efficiency in energy intensive industry, in the built environment and in utilities through smart grids;
2. Accelerated deployment and scale-up of grid-interactive and decentralized renewable energy technologies, and;
3. Market driven cleaner coal technology development and commercialization program at all stages of the coal-power cycle.

Planning and design of the Center will be a USG and GOI team effort with different agencies having specific and clear responsibilities in collaboration with industry. Given the USAID/India mission's experience of working with the Indian energy sector and understanding of the politics and dynamics of the Government of India (GOI), the mission has taken the lead in developing the deployment component of CERDI. Towards that end, USAID in collaboration with the US Department of Energy organized and funded a DOE National Laboratory Expert Technical Group to conduct an assessment of the opportunities and challenges for this deployment initiative. The group included a team to assess the key barriers, challenges and in accelerating deployment of energy efficiency, renewable energy, and clean coal technologies. This report summarizes findings of the team assessing options for the deployment center design.

In conducting its assessment over two weeks in January (11-22) the deployment center team met with stakeholders in the federal and state government organizations, industry and industry associations, financial institutions, electricity regulatory commissions, power generation companies, renewable energy development organizations, trade associations, nongovernmental organizations, and others (Appendix 2). This report summarizes the findings of this team and may serve as background information and preliminary programmatic recommendations to support the conceptual planning, design and development of the clean energy deployment center to be undertaken by a multi-agency USG team scheduled for March 2010.

2 Rationale for the center

India's current power generation capacity is 160,000 MW and the country aims to increase this to nearly 800,000 MW, representing an approximately 500 MW increase each week over the next 25 years. Furthermore, while, historically energy security was focused only on ensuring reliable supply at reasonable price, today, global climate change concerns are also a major determinant of India's energy agenda. Energy security has taken on a broader meaning to incorporate the diversification of energy portfolio (renewables in addition to fossil fuels), more efficient use of energy in all sectors (industry, commercial, building, rural, urban, etc.), and efficient operations of the energy system.

In July 2008, India released its National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation.[3] The plan identified eight core "national missions" running through 2017. NAPCC's goal is to focus on measures that promote India's development objectives while also yielding co-benefits for addressing climate change. The plan pledges that India's per capita greenhouse gas emissions "will at no point exceed that of developed countries even as we pursue our development objectives." The Plan's broad goals are consistent with sustainable development (environmental protection, economic growth and societal benefits) and energy security. The plan also states that national measures would be more successful with assistance from developed countries. The implementation path to achieve this vision, though, has yet to be defined for the eight "missions."

The challenges to achieve this ambitious goals of scaling up reliable energy supply while at the same time addressing climate change adaptation and mitigation goals in the required time scale are massive.

- It will require rapid (radically speeding up) clean energy technology transfer, adaptation, manufacturing, commercialization. Not only will the processes of transitioning clean energy technologies from research stage-to-market commercialization have to be accelerated, but the processes have to be replicated across multiple clean energy technologies and across multiple energy markets – rural, urban, industrial, commercial, buildings, etc.

- Getting things done requires engagement, participation, and collaboration of stakeholders who can make things happen and get it done. Taking technology from research to commercialization is not easy, requires technologies to be adapted to meet local environment, demonstration of technologies for suitability

3 http://moef.nic.in/downloads/home/GHG-report.pdf

and performance, taking lessons learned from demonstration projects and getting manufacturers to build the technologies, and then getting rest of the industry to buy-in to the technology and use it, creating a knowledgeable, service sector to manage, operate and maintain these systems, etc.

- Technology solutions cannot be integrated without disturbing existing structures (technical, social, and environmental). In order to achieve broad scale clean energy technology deployment, it is important to understand the environmental, social, and economic impacts over the life of system – adopting a truly holistic approach.
- Understanding potential impacts includes multiple sources – technology experts, local sources, and global sources. There needs to be mechanisms established to rapidly disseminate knowledge about technologies' potential benefits and impacts.
- New clean energy technologies maturity takes time – early and accelerated adoption of technology may require creating enabling environments – multiple demonstrations; regulatory environment changes; capacity building at all levels – increasing awareness, technology use and maintenance training; creating financial mechanisms such as loans at very low rate, tax incentives, new financial instruments, processes, and investment pools; reducing risk through pooling, converting long-term obligations into short-term ones or vice versa; creating new services; etc.

. Massive scaling for clean energy deployments will therefore require:

- Standardizing and replication of successful processes: Serving large numbers of concurrent clients (rural, urban, industrial, commercial, residential) with different clean energy technologies within an adequate response time; serving multiple stakeholder groups; (e.g. study successful technology transfer projects in one sector to determine how to achieve similar successes in another sector; or determine how to achieve technology transfer success for a different clean energy technology; replicate successful processes to achieve technology deployment and integration in multiple sectors.
- Scaling of events: Managing large numbers of events - outreach/education/training; round tables; technology and expertise road shows (strategy dialogs among various groups), knowledge management, standards and ratings development - technologies, performance
- Taking advantage of services, products, standards, resources that are available, giving organizations a realistic understanding of how the patterns and strategies can be realized to achieve predictable scalability given their specific local environments and requirements
- Creating a knowledge network: Setting up process, tools, and resources
    - To collect and transfer data/information and transfer it internally and to stakeholders
    - Transfer information from and to clients, suppliers, partners, collaborators

— Identify, share, and implement best practices – provide a forum and incentives for sharing successes
— Share standards and facilitate standards development
— Assemble and transfer knowledge for use in planning process

To achieve simultaneous economic growth, energy security, and environmental goals requires : (1) adopting a coordinated and collaborative approach across energy sector stakeholders – addressing the technical, regulatory, market, financial, capacity building, issues simultaneously; (2) understanding the broad scale environment, social, and economic impacts over the life of system – adopting a truly holistic approach; (3) removing barriers in policy, regulations, and market to facilitate large scale deployment of clean energy technologies and services; (4) building capacity at all levels through outreach, training, and education; (5) increasing financial investments, developing creative pooled investment strategies, leveraging and influencing existing investments; and (6) creating a sustainable energy sector development and US-India collaboration strategies.

Government actions and policy reforms (e.g. Perform Achieve Trade scheme[4], Power Sector Technology Strategy[5]), industry associations actions (e.g. Green Business Center[6]), public and private sector actions (e.g. Prayas[7]), USAID projects (e.g. Distribution Reforms, Upgrades and Management (DRUM)[8], Green House Gas Pollution Prevention (GEP)[9], Energy Conservation and Commercialization (ECO)[10])have successfully demonstrated clean energy technologies deployment approaches. The next step is to develop approaches for building on these successes to scale up clean energy technology deployment strategies, goals, and develop approach for implementation.

A deployment center under CERDI (CEDC) can help bring focused attention to the challenges of achieving the goals of scaling up reliable energy supply while simultaneously addressing climate change adaptation and mitigation goals at an accelerated time scale. The CEDC can help foster institutional and commercial partnerships and collaborative programs with private sector entities as well as federal, state and city groups, agencies and bodies in both countries. It can assist India in

[4] Perform Achieve and Trade scheme is a market-based mechanism for large energy-intensive industries and facilities, The scheme includes the setting of a specific energy consumption (SEC) target for each plant, reduction of energy intensity within a three-year period and trading between consumers who exceed their target and those who fail to meet their target.
[5] Power Sector Technology strategy is aimed to enhance energy efficiency in power plants through adoption of energy efficient generation technologies in new plants, enhancement of energy efficiency in existing plants, roadmap for IGCC demonstration plants, development of know-how for advanced super-critical boilers, and a road map for fuel shift.
6 http://greenbusinesscentre.com/energyeffic.asp

7 http://www.prayaspune.org/peg/energy_home.php

[8] USAID supported bilateral program implemented in close partnership with the GoI's MoP. Project purpose is to demonstrate best commercial and technological practices that improve the quality and reliability of "last mile' power distribution.
[9] USAID project to reduce GHG emissions in India's power sector.
[10] USAID project to help develop and implement policies to enhance the capabilities of the private and public sector to deploy energy efficient technologies and services.

achieving its target of reducing its emission intensity and mitigating its GHG emissions through technical assistance and financing. Broadly, it can focus on enhancing and promoting enabling environments, developing partnerships, promoting technology transfer and providing seed financing in three illustrative core areas.

3 Deployment center vision and objectives

The vision of the Clean Energy Deployment Center (CEDC) is to build upon successes from AID programs such as the Greenhouse Gas prevention Program (GEP), Energy Conservation and Commercialization (ECO), and similar projects to catalyze massive scale deployment of clean energy technologies in India and simultaneously achieve economic growth, energy security, and environmental goals. This will be achieved through targeted planned activities with measureable outcomes in the areas of energy efficiency, renewable energy, and GHG reductions.

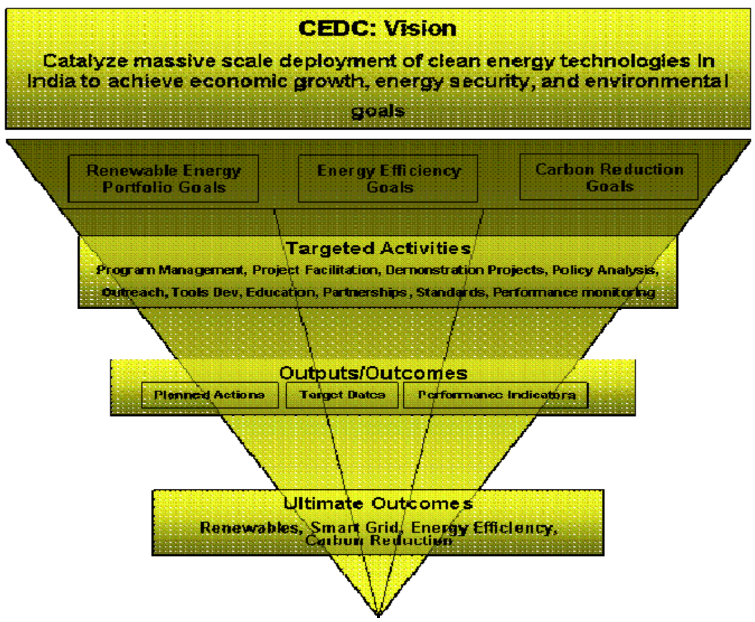

Figure 1.1: CEDC Vision

The primary objective of the Deployment Center is to accelerate the deployment of clean energy in India through US-India collaboration in energy efficiency (buildings, industrial), renewable energy (solar, wind, biomass, geothermal, hydro), smart grid (supply and demand management), and clean coal. To achieve this objective the center will:

1. **Facilitate the integration and expansion of existing Indian and US public and private sector clean energy activities,** fostering institutional and commercial partnerships and collaborations, building on past successes and learning from challenges experienced. Formulating a deployment strategy will require engaging stakeholders, integration of capabilities and resources of multiple stakeholders as shown below in Figure 2.

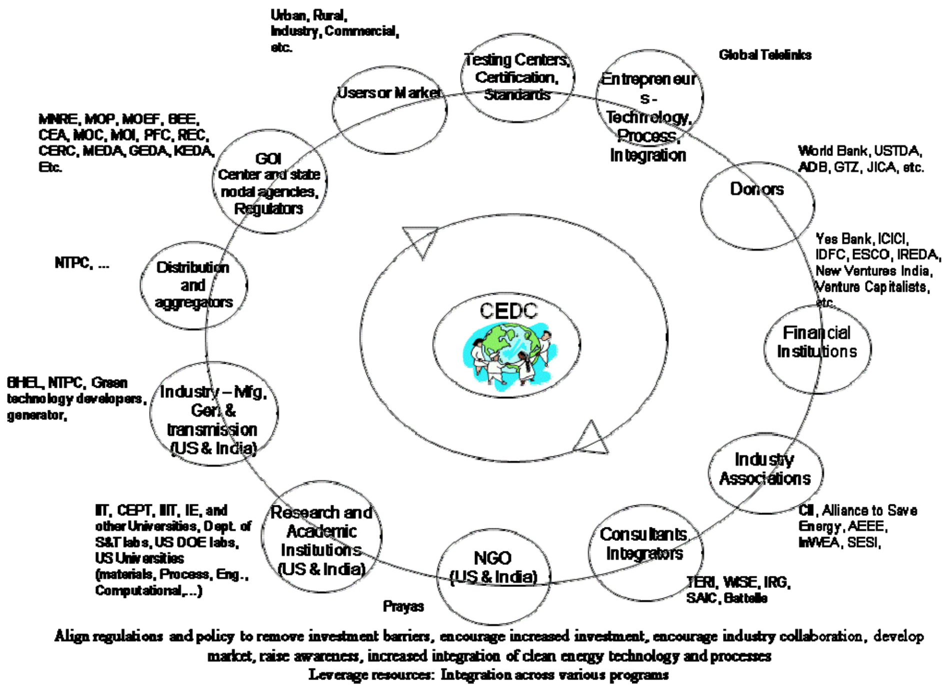

Figure 1.2: Unify and engage multiple stakeholders to catalyze massive scale deployment

As an example, the Electric Power Research Institute (EPRI[11]) was founded in 1973 to bring together industry, institutes for science and research, and leading experts around the world to work together to develop solutions to the many challenges to electricity generation, transmission, and distribution. At the time, the electricity industry R&D activities were distributed across a huge set of laboratories, test center, demonstration projects, etc., and the industry was struggling with how to address nationally environmental regulatory concerns and requirements, become socially responsible, while meeting growing electricity demand economically. EPRI was established as a non-traditional (very first virtual) research and development center that organized, guided, and managed the activities of laboratories, test centers, demonstration projects, and other organizations. GE conducts the R&D, and links to operating utilities, test centers, universities, and research partners across the world. EPRI provides an unbiased objective platform for collaboration, innovation, and thought leadership for broad scale technological and technical development while addressing environmental, social, and economic impacts holistically. EPRI also brings together independent research and technical authorities from around the world for its program review, submits results and reports of studies for outside scientific reviews, and making the results of the research and studies available to all on a nondiscriminatory basis.

[11] http://my.epri.com/

2. **Support development of a business environment** that is more conducive to clean energy investment, including identifying and addressing tariff and non-tariff barriers to US access to clean energy markets; fostering institutional and commercial partnerships and collaborative programs with private sector entities as well as federal, state, and city groups, agencies and bodies in both countries; and removing barriers in policy regulations and markets.

   For example, the Clean Energy Group[12] (CEG), is a U.S. nonprofit organization that promotes clean energy policies, develops low-carbon technology innovation strategies, and creates financial tools for incentivizing GHG reductions. CEG has established and manages (1) Clean Energy States Alliance (CESA) a nonprofit organization comprised of members from 16 clean energy funds and two state agencies and (2) International Initiative on Climate Technology Policy[13] (IICTP). CESA provides information and technical services to its members and works with them to build and expand clean energy markets in the United States. IICTP work on policies to support radical technology innovation, introducing these policy ideas on the agenda of the G8 Dialogue, and developing technology policy initiatives that would address climate stabilization and energy security.

3. **Facilitate US-India clean energy funds and projects** by bringing together US and Indian technology companies, financial institutions, and government officials to create immediate, short and longer-term change; integrate organizations and activities across organizations; and coordinate funding (public money and private capital), using federal funding for upstream research and using private sector to move technologies to marketplace. The objective is to coordinate financial resources to move market-ready products to large-scale, full-market deployment. To realize the value of clean energy technology and services, complementary innovations and enablers in infrastructure development, policy modifications, regulations, manufacturing and service capacity development, financing, engineering design and systems, and market development will be required. This means both the integration of organizations and activities of these organizations (Figure 3).

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[12] http://www.cleanegroup.org/
[13] http://www.climate-tech-policy.org/

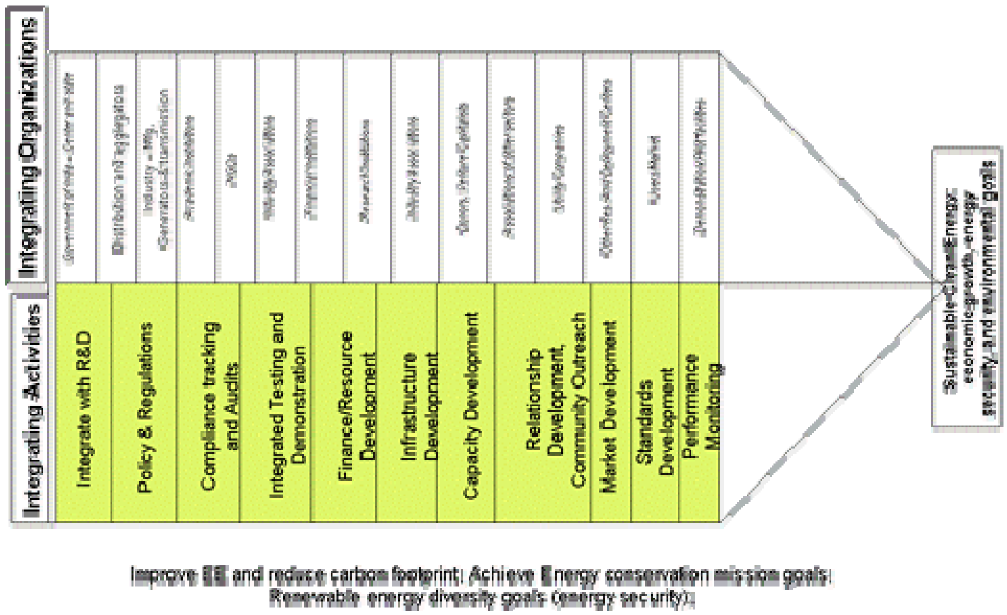


Figure 1.3: CE value realization requires integration of stakeholder organizations and their activities

4. **Expand knowledge (technical, policy, financial, programmatic) about clean energy** with Indian and US government (federal and state) policy makers, the financial community, and clean energy producers, vendors, consumers and other stakeholders and serve as a platform for sharing information, knowledge, and experience and help provide ways to measure and disseminate progress and effectiveness of the clean energy portfolio deployment efforts around the country in various sectors. Another objective is to use internet-based open innovation tools[14] to facilitate knowledge sharing, collaboration, breach institutional barriers and disciplinary silos, disseminate market-research information to researchers, and product pipeline information to market makers.

   The International Energy Agency (IEA) [15] is an example of the type of organization to model CEDC's knowledge center and network capabilities after. The IEA, born in the wake of first oil crisis in 1973-74, addresses energy challenges and act as energy policy advisor to 28 member countries to ensure reliable, affordable, and clean energy for their citizens. IEA's role was to coordinate measures in times of oil supply emergencies and more recent work focuses on climate change policies, market reforms, energy technology collaborations, and outreach The IEA is the world's authoritative reference for energy statistics, and its data and information help produce sound energy

14 http//www.cleanegroup.org/Reports/ACTII_Report_Final_November2009.pdf
[15] http://www.iea.org/

strategies for member and non-member countries. The IEA produces reports that form country governments' reference for developing clean energy policy; serves as a resource for clean energy technology; reviews energy policy of member countries; studies all aspects of energy production, use, and efficiency; recommends approaches for market liberalization; and works to ensure energy supply security.

It is worthwhile to consider the energy efficiency centers established in the formerly planned economies such as Poland, Czech Republic, Russia, Bulgaria, China and Ukraine with funding from USAID and other U.S. agencies with technical support provided by DOE's Pacific Northwest National Laboratory. Each center is a non-profit, non-governmental independent agency (except for BECon, which is a quasi-official). The center concept relied heavily on the value of local experts in partner countries with long-term engagement with American experts. This approach acknowledged the local human resources and expertise in both public and private sectors and helped in sustaining these efforts even after the end of initial funding. These centers work in the following four major areas to promote energy efficiency[16]:

- Market conditioning (policy reform): to provide policy recommendations and model legislation for policy-makers to create incentives for energy conservation

- Private-sector assistance: to identify investment opportunities and possible partners for joint ventures in key energy technology and service areas, and to provide coordination and other support to western companies, including feasibility studies, market analyses, and information on doing business in these countries

- Demonstration projects and training: to build an infrastructure for energy conservation services by training experts in IRP and energy auditing and to demonstrate energy efficiency technologies

- Public education and information: to create and implement information programs on energy efficiency to help consumers and enterprises develop energy-efficient practices, and to promote broad societal awareness of the benefits of energy conservation.

These centers have been key players in drafting basic energy efficiency laws in their respective countries. For example, the Russian Center for Energy Efficiency (CENEf) helped develop the first regional-level code for energy efficient building construction. The Czech Republic Center for Energy Efficiency (SEVEn) helped guide the development of the Czech National Energy Policy and drafted the energy labeling and standards provisions of the Czech Energy Law. The Polish Foundation for Energy Efficiency drafted the region's first utility policy to allow utilities to profit from investing in energy efficiency equipment in their customers' facilities. EnEffect, the Bulgarian Energy Efficiency Center, helped develop the first energy efficiency standards for household appliances in Bulgaria and participated in shaping the Bulgarian National Program for Energy Efficiency. The Beijing Energy Efficiency Center (BECon) provided expertise in integrated resource planning (IRP) to the Shenzhen Utility Corporation and

[16] Energy Efficiency Centers in Six Countries: A Review by Advanced International Studies Unit, Pacific Northwest National Laboratory, November 1999.

persuaded the city to divert investment slated for 600 MW of power plant capacity to demand-side management (DSM). Likewise, the Ukrainian Agency for Energy Efficiency and Rational Energy Use (ARENA-ECO) helped develop Ukraine's Comprehensive Energy Conservation Program, and assisted in preparing the First National Communication to the Framework Convention on Climate Change. See Appendix A for details on these and other energy centers.

In recent years, energy finance centers have been set-up in Turkey and Croatia. These centers are located within the U.S. Embassies and are staffed by U.S. Trade and Development (TDA), the Overseas Private Investment Corporation (OPIC) and Export-Import Bank to identify the potential projects that needs feasibility study, finance and insurance coverage.

4 Deployment center activities, priorities, and sustainment

Clean energy technologies and services will benefit from complementary innovations and/or enablers in infrastructure development, energy sector reforms, capacity building, developing mechanisms for demonstration, cost-buy-down, financing, and market development.

4.1 CEDC Activities

Inputs and recommendations on CEDC activities, gathered through the meetings with energy sector stakeholders in India, could be grouped under the following broad categories:

- Strategic planning and analysis
- Project facilitation
- Education and training
- Outreach and communication
- Demonstrations and pilots
- Performance monitoring and reporting
- Forge partnerships between US & Indian institutions

The following subsections details each group and provide some specific type of activities within each group.

4.1.1 Strategic Planning and Analysis

Energy is tightly linked to economic growth, environment and national security. Since there is no single clean technology to address the energy-climate-security-economic challenge, a portfolio approach was recommended in the various meetings. Strategic planning and analysis involves defining goals and objectives and developing a plan for center activities based on an analysis of the technological, political, social, environmental, and/or legal constraints and barriers that have to be addressed to facility wide-spread adoption and deployment of clean energy technology in all sectors. Specific activities may include:

- Road mapping, deployment strategy development, integrating stakeholders and resources, etc.

- Conduct policy analysis to influence policy changes and development of new policies and regulations impacting project developers and financiers, especially, to promote competition, open markets, and influence early adoption of CE technologies.
- Facilitate meetings, collaborations, write white papers and proposals to develop deployment strategies - identify barriers, risk, program opportunities for developing CE technologies, etc.
- Determine combination of coal, energy conservation, demand management, energy portfolio diversity, rural electrification, household and industrial modernization required to achieve economic growth, energy security, and environmental goals.
- Develop/customize standard software tools (e.g. ECBC, EnergyPlus, energy simulation - IBPSA India, GIS tools)
- Promote and conduct CE technology cost-benefits analysis based on life cycle approach where the total cost is composed of economic, environmental, and social cost elements. This would help eliminate the CE technology deployment barrier related to the higher first cost. .

4.1.2 Project Facilitation

In order to create a medium for long-term cooperation, project facilitation includes building relationships and resources across various stakeholders/organizations and their clean energy-related activities to deliver and accelerate deployment. For example, as with the CEG's CESA [17] organizations described above, the CEDC could facilitate the establishment of a pooled clean energy fund from multiple energy sector stakeholders (members) and help manage this for the members. The pooled resources could be used to help provide technical services and information to its members, work with the members to expand the clean energy market and deployment in India, buy-down-cost of advanced technologies, and work on policies that will remove CE technology market barriers across state. A CEDC project or program (e.g. Cleaner Coal, Smart Grid) may be thought of as a crosscutting "primary mission area" for the center, which will require (1) development of EE, RE, and carbon reduction performance goals; (2) identifying barriers and risks; and (3) developing approaches to mitigate risks through lowering performance targets, defining and aligning activities among various stakeholders and partners (Figure 4).

[17] http://www.cleanegroup.org/

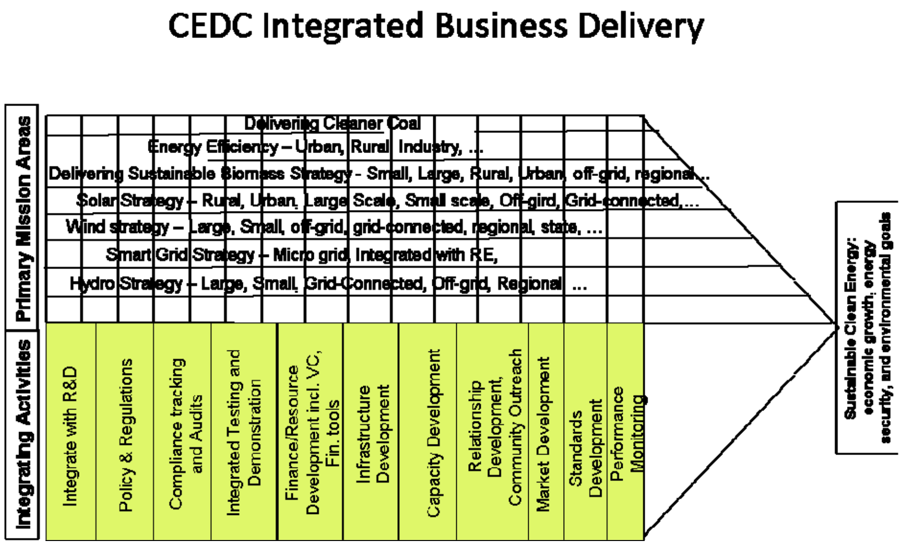


Figure 1.4: Primary "mission areas" are crosscutting programs – integrating organizations, stakeholders and activities

Specific activities may include:

- Engaging and unifying the stakeholder community to help organize and guide the various clean energy deployment activities including; engaging with stakeholders to develop joint projects, especially for demonstration and pre-commercial deployment of innovative clean energy technologies, capacity building, integrated assessment, institutional innovation, and setting standards to reflect their public benefits.
- Facilitating the development of new financial instruments, processes, and investment pools to enhance resource availability to scale clean energy deployment, develop infrastructure, encourage market development, and buy-down cost of advanced CE technologies. Reducing risks, pooling risk, converting long-term obligations into short-term ones or vice versa – enabling investors to increase investments, making markets more efficient. Creating collaborations with premier business schools and institutions, (e.g. MIT's Sloan School, IIM, ICICI Bank, Yes Bank) to develop new financial instruments and processes.
- Integrated analysis to determine specific performance goals and barriers in achieving these deployment goals in each mission area.
- Scaling up "New Ventures India" type activities – investors, entrepreneurs, industry, institutions, media.
- Cost and benefits analysis for CE solution alternatives – Life cycle assessment, Return-on-Investment analysis, assess carbon footprint, etc.

4.1.3 Education and Training

Education and training will include investing in human resources development activities to build capacity, in all sectors, to achieve rapid and massive scale design, development, and integration of CE infrastructure, technologies and services. Specific activities may include:

- Facilitate the creation of educational partnerships, development and implementation of education and training programs.
- Strengthening national institutions – technical colleges, universities, Centers of Excellence to provide educational services, exchange of personnel to train experts in the CE fields.
- Investments (incentives and financial support) in education for technicians, engineers, policymakers, elected officials, finance and public administrators who help develop, manager and maintain CE programs – in CE energy (RE, EE, Smart Grid) development, integrated system design and operations, technology management and maintenance.

4.1.4 Outreach and Communication

Outreach and communications activities are undertaken to expand visibility and awareness of CE technologies and services and to develop requirements; enrich the process of knowledge transfer; reach out to various stakeholders, agencies, and engage in effective dialogue. Specific activities may include:

- Assembly and transfer knowledge. Facilitate information exchange on various activities, resources, technology performance, and lessons learned; facilitate interaction with experts, policy makers, government, industry partners, deployment partners, R&D centers, testing and certification centers, etc. This would help improve the availability of objective and unbiased information and help remove barriers resulting from inadequate or hyped up information.
- Create self-service touch points for stakeholder interactions and access to status of CE deployments, experts, resources, results, data, discussion forums, workshops, round tables, training, etc.
- Access to CE technology options, access to results of analysis, risks, scope and limitations, pilot/demonstration studies, user groups, experts, installation teams, training resources, etc.
- Access to technology developers, manufacturers, testing and certification, incentives availability, investment opportunities, availability of financial resources and mechanisms, VC, policy, regulations, goals, etc.
- Develop data requirements, standards, and gather and disseminate benchmark data sets.

4.1.5 Demonstrations and pilots

Invest in demonstrations and pilot projects in order to test new technologies, policies, and/or processes to demonstrate and/or test feasibility and effectiveness of technologies, policies, or processes. Specific activities may include:

- Demonstrations/pilots for integrated solutions, e.g., solar and natural gas or biogas, zero energy buildings and communities
- Operational test and evaluations of technology and integrated solutions, to remove uncertainties about performance based on local conditions and environment for advanced CE technologies.

4.1.6 Performance monitoring and reporting

A crosscutting activity to manage the development of performance indicators and the collection, review, analysis, and dissemination of CE activities related performance data. The data can be used to determine how well CE related goals of reducing GHG emissions that induce climate change, improving energy security, and sustainable development are being achieved through the various programs. Specific activities may include:

- Determine Energy Efficiency Estimates, Energy Alternatives (RE goals), Carbon accounting, etc. metrics,
- Compliance Tracking and Audits; developing compliance tracking and audit requirements, associated systems, and data requirements,
- Develop reporting guidance (e.g. CERC, MERC, DERC, etc.).

4.1.7 Forge Partnerships between US & Indian institutions

Develop ways to bring together individuals and organizations to encourage pooling of skills, money, risks, and other resources to accelerate CE development and deployment. Some specific activities may include:

- Creating capabilities network – Testing centers, Think tanks, Training centers, Manufacturing, Centers of Excellence, Demonstration Facilities , Pilot sites, R&D centers, standards developers, certification developments centers.
- Facilitating the movement and interactions of highly skilled individuals from different areas – this is more important than patents, publications, data movement – creating an intellectual resource network.
- Linking US and Indian Universities, and US and Indian research facilities, and US technology developers and deployment projects.
- Creating mentoring networks. Allow for participation in boundary spanning activities - the processes of knowledge brokering at multi-levels, involving individuals, organizations, and networks – for example three extramural boundary-spanning mechanisms typically available to start-ups are avenues for bolstering their access to external ideas and resources: hiring on the technical labor market, affiliating with venture capital (VC) networks, and engaging in equity strategic alliances.

4.2 CEDC Sustainability and Priorities

The CEDC could provide the mechanism for long-term cooperation/collaboration among energy sector stakeholders to support the implementation of the NAPCC as follows: (1) being an independent, objective, and open organization with membership from a very broad range of businesses, regulatory, environment, international, academic, and environmental organizations to shape clean energy technologies development and deployment programs across the nation; (2) providing the thought leadership and over-arching strategic vision for integrating the energy sector activities and resources to achieve development, climate change mitigation, and energy security goals in a fast pace; and (3) becoming a one-stop location for clean energy technologies and expertise related information collection and dissemination in a nondiscriminatory fashion. The center can be sustained: (1) by GOI helping defray some of CEDC staffing cost; (2) through CEDC memberships; (3) through creation and management of revolving pooled funds/resources that would serve a cross section of stakeholders across the country; (4) through the design, development, and management of collaborative demonstration, training, and assessment projects that would benefit cross section of stakeholders; (5) helping manage independent, objective studies and reports and dissemination of these report to benefit cross-section of stakeholders; (6) helping set up and also potentially manage innovative services for the growing technology services market (e.g. Energy Efficiency Services); and (7) providing consulting service to SDAs through its members; etc.

Drivers for prioritizing CEDC activities are first to focus on the low-hanging fruit of opportunities that are immediately available. Priority activities may include facilitating projects that are ready for implementation but need project assistance, along the model of the first grid-connected megawatt-scale solar facility in India brought online with assistance from the USG, and expanding the efforts of the GBC and other organizations currently working on clean energy projects in India. Medium-term opportunities include working with industry in the areas of waste heat utilization; scaling up programs to reduce agricultural pumping electricity load; and working with major builders and developing ESCOs to create net-zero energy buildings and for creation of district cooling systems for malls.

At the same time, longer terms efforts are needed, starting with strategic analysis and planning to identify a path to achieving low carbon growth, reflecting the full energy spectrum. This analysis should be informed by related activities of the World Bank, the recently announced Climate Renewables and Efficiency Deployment Initiative, the recently established Coordinated Low Emissions Assistance Network, the Technology Action Plans developed under the Major Economies Forum on Energy and Climate and other multilateral initiatives.

These activities may include road mapping; setting up knowledge management system for gathering and dissemination of information and for engaging and collaborating with EE and PV sector stakeholders; and setting up policy analysis studies to help understand current barrier and develop programs that will promote competition and open markets for EE and/or PV technologies.

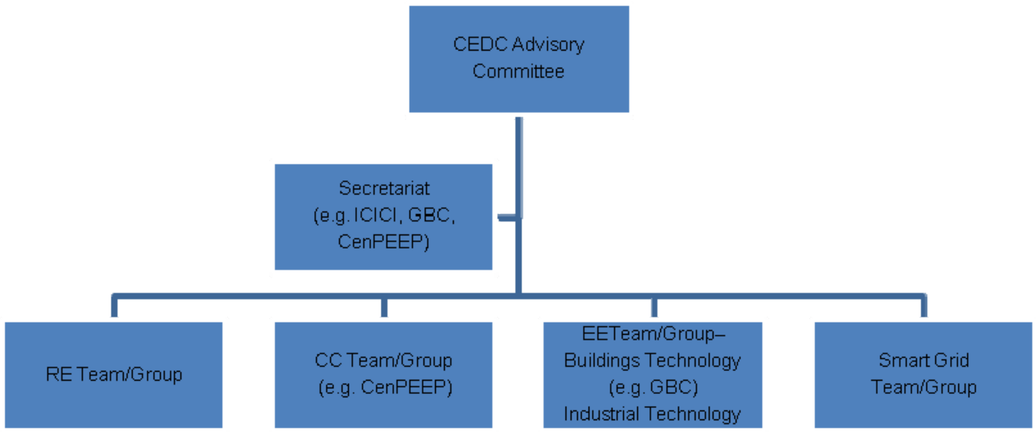
To develop and sustain longer-term clean growth, technical education and training to build capacity is needed. Also outreach and communication in government (state and local) and financial sectors will also be important.

5 Deployment center design options

Bringing together industry, financial institutions, project developers and others (such as training utility system operators) is best accomplished through a physical place, hence the general consensus from stakeholders was that a physical center is needed, supplemented by a virtual center. Distributed innovation (DI)[18] is defined as "the process of managing innovation both within and across networks of organizations that have come together to co-design, co-produce and co-service the needs of customers." The objective is to accelerate the speed of innovation and commercialization of technology by attacking the problem from multiple intervention points along the value chain, from upstream research to downstream deployment by addressing the technical, market, financial, policy, regulatory, and legal issues along the entire chain. Examples of successful DI product strategies include the iPod, the Linux operating system, and the Human Genome project. Since the energy sector has many of the same characteristics as sectors that have benefitted from DI, CEDC could apply DI concepts for accelerating the deployment of CE technologies, (see footnote 18 for details of implementation approach). The main elements of DI strategy are captured in the Section 3 of this report.

In order to be effective in accelerating deployment of clean energy technologies, a deployment center management structure should include an institutional mechanism for running the center; establishing center goals, strategy, and performance metrics; developing programs that are aligned with government initiatives on clean energy; selecting projects; and tracking clean energy deployment progress.

Since the intent of CERDI is to build on existing US-India clean energy collaboration through the US-India Energy Dialogue, one option for leading this effort is through an Advisory Committee composed of the Chairmen of each of the three relevant Dialogue Working Groups (Power and Energy Efficiency, New Technologies and Renewable Energy and Coal) from both the US and India. (The Advisory Committee may also include membership from the private sector and other institutions, although this may raise conflict of interest issues). The Advisory Committee would set priorities and provide overall leadership for the center.



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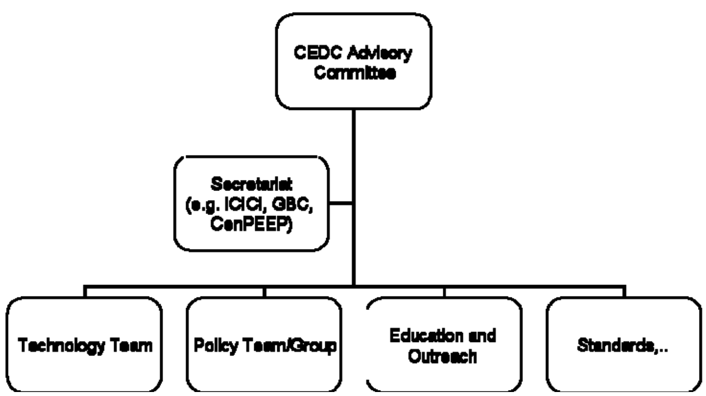
[18] http//www.cleanegroup.org/Reports/ACTII_Report_Final_November2009.pdf

This Committee could be supported by a Secretariat, serving as the executive arm of the Advisory Committee and providing full-time support for the Center, responsible for selecting projects aligned with Advisory Committee guidance, and managing overall Center activities. The Secretariat could be headed by a General Secretary, assisted by a few key administrative staff selected by the General Secretary. The Secretariat could be housed and managed as part of an existing institution (such as ICICI Bank) or could be independently managed and operated by an integrator/NGO or organization currently leading clean energy activities in India such as CII's GBC or CenPEEP.

Setting up CEDC as part of ICICI bank might provide some advantage over setting up this office in GBC or CenPEEP. Couple of critical functions of CEDC will be setting up and managing revolving, pooled CE funds and also facilitating government procurement of services and technology - competing, evaluation, award, and management of CE related projects. Being a financial institution, ICICI banks already has expertise and experience in help raise funds, manage and administer pooled revolving funds for targeted energy services. Based on their experience in managing and administering World Bank energy sector projects, USAID energy sector projects does have good experience in the energy-climate challenges, they will need to shore up expertise (technical support) in CE technologies through the technical teams. ICICI bank may not charge for serving CE funds, since successful technology demonstration projects might get translated into the business for the bank's commercial financial operations. Core business for bank is the financial component of the energy sector; this will ensure that projects are implemented through technical experts in their respective areas.

The technical teams, supporting the Secretariat could be organized along technology areas, i.e. renewables, energy efficiency, clean coal, and smart grid (see above). Alternatively, the technical teams supporting the Secretariat could be established along center activities, i.e., technology development, policy, education and outreach, finance, standards, etc. as follows:

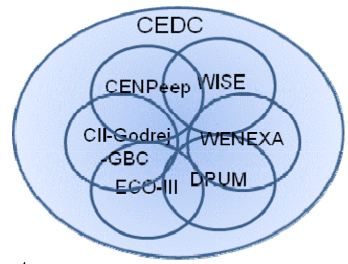


Members of each team will be leaders and experts, working on a voluntary basis to the extent possible, from industry, GOI ministries, private sector (e.g. Tata Power, Godrej, Infosys, Wipro, Reliance), US DOE, representatives from the user community working in relevant areas). This model offers the advantage of supporting cross-fertilization of skills, ideas, and stakeholders between the clean energy technologies but may be more difficult to implement.

5.1 CEDC Organization

CEDC can be structured as a centralized, functionally decentralized, state-based decentralized, or hybrid organization.

5.2 Option 1: Centralized structure

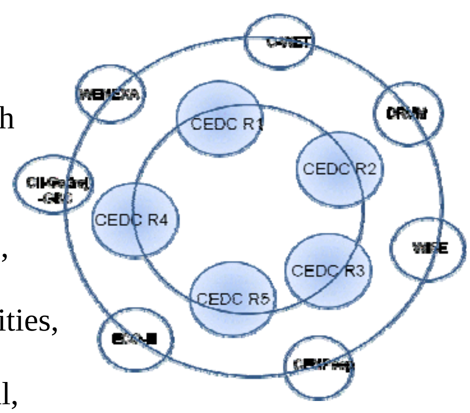


- Create "Centers of Excellence" based on lessons learned from existing centers. Integrate the existing centers, with all CE activities performed and directed by the national CEDC
- Pros: A centralized structure could lead to the development of an integrated, national approach for CE deployment strategies for each technology or for a system of technologies.
- Con: This design does not fully leverage and/or build upon current successes.

5.3 Option 2: Decentralization based on technical focus areas

- Integrate the "island of excellence" and then expand to create new centers where essential; these individual centers direct and perform activities in that clean energy focal area
- Interface with existing centers including;
    - — CenPEEP – cleaner coal
    - — CII-Godrej-GBC - energy efficiency, renewables
- Pros: Will result in a national strategy for each CE energy and technology alternative
- Con: Difficult to develop and implement an integrated CE portfolio) deployment strategy

5.4 Option 3: Spatial/Regional center



- Create regional or state-level centers and integrate with the "State" or "regional" initiatives
- Pros: deployment strategy and implementation can take into consideration regional interests and demands, state regulations and political realities, local industry requirements and resources, make use of local capabilities, and ensure adaptation of technology solutions to local conditions. For some CE technologies (e.g. geothermal, biomass, hydro) a localized solution will be more appropriate.
    - — For example bilateral Energy Conservation and Commercialization (ECO) project helped catalyze the development of the regional centers of excellence in energy efficiency - green buildings and windows center in Ahmedabad; efficient electric motors center in Hyderabad; efficient home

appliances center in Kolkata; and industrial appliances of energy efficiency in Nagpur.

- Cons: solutions and lessons learned address regional/local requirements and can not necessarily be extrapolated to rest of the country.

5.5 Option 4: Hybrid structure

- Some activities are centralized and some activities decentralized, for example knowledge center activities, integrated policy analyses and development, standards (e.g. Buildings Technology), technology testing center activities; integrate "Island of Excellence" in Smart Grid
- Pros: Cross-cutting issues addressed centrally using pooled resources and facilitates development of national strategies, while regional issues are addressed locally.
- Con: May be difficult to determine which activities most appropriately centralized versus decentralized.

5.6 Resource options

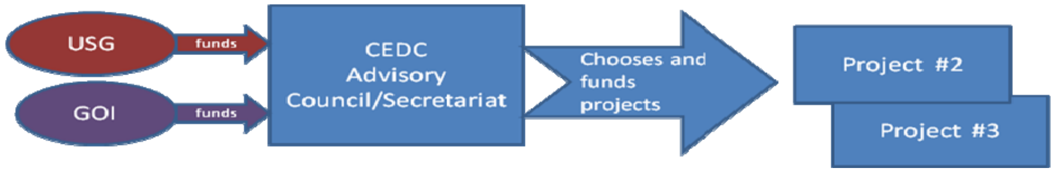
Ensuring adequate and sustainable funding sources is a significant challenge to scale up CE deployment and may involve:

- leveraging activities and funds from various sources
- developing project risk assessment approach based on project viability and not necessarily business viability
- developing tools and processes to set up public guarantees for loans for clean energy projects
- supporting the development of tax incentives for clean energy projects and development activities
- developing approaches for loan forgiveness to encourage educational partnerships,
- Setting up fund raising activities, etc.

Not all of the options described below will meet USG and/or GOI requirements regarding how funds are allocated and limitations on how they may be used.

5.6.1 Option 1 –Create Creating a Clean Energy Fund

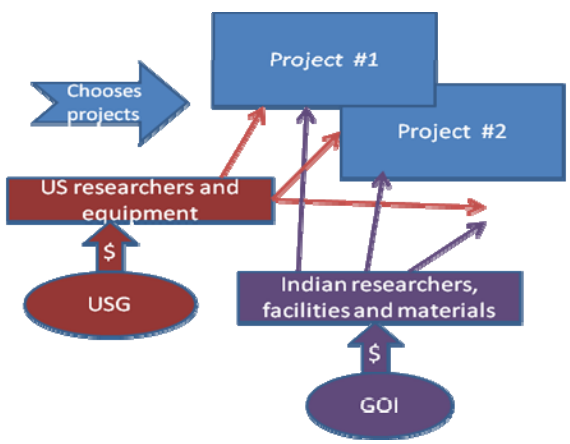
In this approach, resources from the USG and GOI (and potentially other sources such as the Clinton Climate Initiative) are pooled and distributed in accordance with the CEDC Advisory Committee and Secretariat which selects the activities/projects for funding. Funds could be managed out of the Secretariat, or a financial entity (e.g. ICICI bank) could administer these funds and perform due diligence on project viability.



The advantage of this approach is that a pooled resource would help bring attention and focus to clean energy activities, allowing coordinated marketing and fund raising activities, potentially yielding multi-year pledges from donors. It could also support an approach (such as implemented by ICICI with USAID and World Bank funding) for reinvestment of repaid funds. In this example repaid funds ("reflows") from USAID projects are captured in one "pot" and reinvested in additional projects that meet the criteria of maximum impact and replicability across the sector. To date, of $62M disbursed, $54M has been returned for reallocation. This arrangement was implemented through an MOU between USAID, the GOI and ICICI. The challenge of this approach is that there may be restrictions on how USG funds are used that limit the extent to which they may be combined with GOI funds. .

5.6.2 Option 2 – Leverage Leveraging existing commitments and coordinating activities

The Advisory Committee supported by the Secretariat develops the priority activities, and the Secretariat selects the projects for funding based on financial commitments for each priority area by both the USG and the GOI. For example, if solar PV standards and testing is established as a priority activity, the USG and the GOI (and any other funding entities) may each commit resources to that effort. The Secretariat would then solicit, review, select and fund projects to support that priority area based on these specific commitments. There is no pooling or transfer of funds, but each funding organization benefits by leveraging the other's funding.



This approach has the advantage that USG funding restrictions are easily accommodated since each donor entity administers its own resources. The model has been successfully used in the Centre for Power Efficiency and Environmental Protection (CenPEEP) which is funded by USAID and DOE (which provide manpower and equipment) jointly with the National Thermal Power Corporation (NTPC) which provides labor, facilities and materials. The disadvantage of this approach is that it may not as readily support activities which cut across sectors.

5.6.3 Option 3 – Create self-sustaining entity

This funding model is best demonstrated by the Confederation of Indian Industry's Green Business Centre in Hyderabad. This GBC has been instrumental in the expansion of green building in India, which now number 425 (310 million square feet) throughout the country, and is also active in the related areas of energy efficiency, renewables, water management and other areas. The GBC was launched in 2000 and is self-sustaining through various services it offers on a consulting basis.

The advantage of this approach is that once established, the organization does not need additional funds to operate. Given the growing international interest in working on clean energy in India, a well-conceived and operated institution could achieve self-sufficiency with relative ease. On the other hand, many of the types of activities needed to accelerate the deployment of clean energy in India are not well suited to this approach. For example, developing and sharing outreach materials (website, wiki platform, success stories, etc.), would not be best served by this model.

5.6.4 Option 4 – Hybrid model of all three approaches

As noted above, there are advantages and disadvantages to each of the three approaches described. This fourth option applies each of the models to the application to which it is best suited. For example, one of the key activities of the Center is to conduct workshops and other training, some of which may be linked to industrial certification (e.g., installation and maintenance of solar panels). Also, the GOI has funded organizations (such as WISE) to conduct policy analysis on a variety of renewable policy issues (RPOs, tariffs, etc.) These kinds of activities could be conducted on a cost-recovery basis (Option 3).

As noted above, an example appropriate for Option 2 is CenPEEP. This arrangement of USG and GOI separately funding these activities has been extremely successful, resulting in significant reductions in GHG emissions. The CEDC could expand the support to this program, increasing and enhancing its effectiveness. An example of a project appropriate for a clean energy fund (Option 1) would be a demonstration project such as a CSP (concentrating solar power) project.

The advantage of this fourth option is that it is flexible, accommodating a variety of existing as well as new activities. On the down side, administering the different streams may be complicated and therefore more difficult and time-consuming.

6 Key deployment center opportunities

The US-India MOU identified priority areas for collaboration, including energy efficiency (buildings, industrial), renewable energy (solar, wind, biofuels, geothermal), smart grids and clean coal. Solar energy is called out as a particular area for cooperation, underscored by the GOI's recently announced National Solar Mission that sets an ambitious goal of 22 GW of solar power by 2022. The GOI also recently announced a National Mission for Enhanced Energy Efficiency, the second of eight planned missions under India's National Action Plan on Climate Change. These are areas where the GOI is focused and committed towards immediate action, and may therefore offer the greatest opportunities for collaboration.

In the stakeholder discussions, key opportunities for immediate and near-term collaboration were mentioned and are summarized and covered in the RE and EE assessment sections. Additional collaboration needs and opportunities, that are not necessarily covered in renewable energy or energy efficiency but address clean energy needs holistically, also emerged in our interactions with government and industry leaders, roundtable discussions, think tank presentations, and from reviewing results of other studies. These are grouped based on potential center activities and are listed below:

- Strategic planning and analysis
  - Develop a central (single window) repository of data, information, and analysis tools that can be used for policy analysis, resource assessments, technology assessments, designing clean energy systems to meet target goals, etc. Develop approaches to interface with existing sources of data, information, and analysis tools both in India and in US (e.g. IREDA, WISE, TERI, IREDA, InWEA, CII-GBI, ECO-III, CERC). Customize and disseminate software tools developed by USDOE (energy efficiency, energy policy analysis, life cycle cost analysis, etc.).
  - Prepare national and state level clean energy strategies, blueprints or road maps. – identify sector specific bottlenecks, successes, develop scale up requirements, identify marketing challenges, institutional challenges, and policy changes to be addressed, and identify financial requirements and opportunities.
  - Assess what clean energy technologies and associated components manufacturing capabilities and services that have to be establishing in India, identify collaboration requirements, risk, barriers, and enablers.
  - Smart Grid technologies are currently costly; develop strategic approaches to encourage private sector investment with minimal investment from government in this area. Government may help in outreach and facilitating role.
- Project facilitation
  - Facilitate assessment to determine transmission infrastructure needs; help develop conceptual design, planning, and deployment of large scale projects to build transmission infrastructure in interior areas of India, and conversion of current grids to smart grid.
  - In order to address financial requirements for clean energy technologies, develop financial tools, incentives, risk pooling approaches, investment prioritization mechanisms, and integration with developers and integrators. Enable banks, financial institution, and venture capitalists to lend loans (at low interest and for longer terms) to individuals, Small and Medium Enterprises, developers, and integrators based on technology maturity and project benefits and not just based on loan requestor’s balance sheets.
  - Develop approaches for building clean energy related capacity in GOI, nodal agencies, regulatory commissions, utilities, community developers, financial institutions, banks, etc.

    - Develop approaches for supply and market development for small mature clean energy technologies, for example solar cooker is a mature technology, however, this technology is not easily available.
- Outreach and communication
    - Help disseminate technical publications, data, information, and tools more widely – to US and Indian energy sector stakeholders (e.g. WISE publications and books, US DOE technical publications).
    - Survey and analysis of best practices in policy and regulations in clean energy to help propagate these in India.
    - Develop clean energy priorities outreach and communication campaigns to raise awareness, sensitize these stakeholders to clean energy needs, and build collaborative projects with banks and financial institutions, venture capitalists, US and Indian government bodies at central, state, and municipalities levels; engage large companies like Tata, Reliance, and Infosys to potentially fund and achieve large scale deployments.
- Demonstrations and pilots
    - Replicate policies and programs from US to India, e.g. Green Cities program, "Save Energy Now," "Energy Star," Energy Smart Schools, etc.
    - Develop demonstration or pilot sites for micro-grid and/or mini-grid integrated with renewables and storage.
- Forge partnerships between Indian and US institutions
    - Develop a joint US-India collaboration for technology enhancement/development and commercialization. Some initial technologies to be considered include - low wind speed turbines; biomass gasifier technology for efficiently processing mixed waste streams (agricultural residue, forest waste, solid waste, etc.) to generate both fuel gas and electricity to village grid; combine water heating and PV; R&D for desalinization technology.
    - Develop academic-industry interface, both with Indian industry and US industries, to accelerate development and adaptation of technologies for local conditions.
    - Develop exchange programs for Indian engineering students to intern in US research, academic institutions, and energy policy think tanks.
    - Develop programs for US and Indian educational institutions to build joint clean energy curriculum, re-train faculty, and for developing short-term web-based courses.
    - Develop program for joint US-India collaboration for energy storage technologies to achieve renewable energy goals. Energy storage solution is critical for renewal energy strategy to succeed. Furthermore energy storage without "batteries" is key for storage technologies to succeed in India, because of end-of-life disposition requirements and its impact on environment.

7 Next steps

The timing of the CEDC is right: discussions with stakeholders indicate that the opportunities for expanding existing bilateral collaboration as well as supporting GOI and private sector efforts to accelerate clean energy deployment are enormous. Government organizations, regulatory commissions, industrial associations, private sector organizations, financial sector organizations, educational institutions, international venture capitalists and international donors and others are working hard to ensure that India's massive projected growth is implemented in as clean and sustainable a manner as possible.

In order to move forward quickly and effectively, USG agencies involved in the Deployment Center need to develop approaches to addressing programmatic issues which emerged during discussions:

- **What is the major clean energy driver: development or climate change?** Several Indian stakeholders opined that from their perspective the impetus for clean energy is providing more access (and better quality) energy to its citizens, whereas in the US, development is perceived as a co-benefit of clean energy activities. Will CEDC efforts be focused on providing more consistent better quality power to the rapidly expanding urban population or on expanding access among rural populations without power? And therefore will there be more emphasis on centralized or distributed generation?
- **How should natural resource issues be addressed holistically?** As a static resource in a growing population, there is much sensitivity about clean energy options which require significant land and water resources. Even when contemplated for "marginal" lands, this is a concern for biomass crops. Deforestation is another hot-button issue, and CERC efforts should not aggravate this issue (e.g., cellulosic or gasification technologies should not rely on woody feedstocks). The energy-water nexus is a well-know concern, particularly relevant for solar (e.g. cooling CSP systems) in arid northwestern India, clean coal as well as other technologies.
- **What performance goals and metrics should be established and how is success defined?** What you can't measure, you can't manage so clear articulation of metrics and performance goals have to be set up for the center, its activities, and for measuring progress clean energy deployment activities. There is need to: (1) determine the cost and benefits gained from different clean energy technologies; (2) identify energy efficiency gains (including quality of power); (3) identify renewable energy penetration as a percentage of overall energy generated; (4) identify carbon savings; etc.
- **What should be the scope of technology or project or program?** Successful and effective deployment of clean energy technologies can be achieved only if the deployment plans takes into consideration technology adaption needs based on local social, economic, and environmental factors, and clearly articulate the benefits to the community. There will be a need to determine whether a centralized and/or decentralized deployment strategy needs to be adopted for a technology. For example, a decentralized strategy for bioenergy may be more effective than a centralized strategy.

- **What role should utilities play in a clean energy deployment center?** Currently utilities are not fully engaged and integrated in a significant manner yet are important in terms of both power demand and supply.
- **What are the Center's priorities for immediate action, and what is the prioritization strategy?** Many opportunities exist and ideally immediate actions will include both projects with immediate payoff (such as project facilitation) and those with longer-term gains (analysis to support clean energy policies, training, etc.)

Also, the USG should map out how each agency will participate, identifying the roles and responsibilities of each, such as:

- Which agencies should be involved? AID, DOE, State, Commerce, OPIC, Ex-Im, USTDA, USTR, NSC, and others?
- Who is the lead agency for the USG?
- What kinds and amounts of resources is each of the agencies willing to contribute?
- What are the restrictions on how the various resources are used?
- What should the reporting and review mechanism be for the advisory committee and CEDC?
- How should resources from other funding agencies and donors (e.g. World Bank, IMF) be handled?

In order to make the in-country time most productive, these issues should be resolved in advance of the March mission. It is also important to encourage the GOI to consider these same issues, so that the March meetings can quickly and effectively move forward design and implementation of the CERDI Deployment Center.

8 Summary

Several themes emerged from these meetings:

The Indian public and private sectors are vibrant and focused on clean energy. The Government of India (GOI) has launched a National Action Plan on Climate Change including the first two of eight missions on solar energy and energy efficiency. The Confederation of Indian Industry's Green Business Center, with support from USAID, has been instrumental in catalyzing one of the largest green building markets in the world. The Centre for Power Efficiency and Environmental Protection, a US-India collaboration on clean coal which has avoided GHG emissions by more than 90 million tons in the period 1996-2007. Public-private sector efforts have resulted in the installation of 11,000MW of wind power. In spite of these successes, there was lack of knowledge on how much some of these technologies contribute to and could potentially contribute to the overall reductions of GHG emissions that contribute to Climate Change. There is a lack of overarching strategy that drives CE deployment initiatives. The goals while tying to sector specific or region/state goals do not provide insights into how it will help achieve the national economic, GHG emissions, and development goals.

Progress has been limited by limited technical knowledge; institutional, policy, and regulatory barriers at federal, regional, state, and municipality levels; sound data to inform investment decisions; financial resources and financing mechanisms; trained scientists, technicians, operators and other human resources; utility and grid integration issues including high distribution losses; the capability to monitor and verify energy usage; and limited investment in technology R&D.

A USG-GOI Deployment Center provides a key opportunity for accelerating clean energy deployment by:

- Facilitating the integration and expansion of existing Indian and US public and private sector activities, fostering institutional and commercial partnerships and collaborations
- Supporting development of a favorable business environment for clean energy projects in India
- Facilitating US-India clean energy funds and projects
- Expanding technical, policy, financial, programmatic knowledge about clean energy in India

Deployment Center activities to achieve this transformation of the Indian clean energy market should include:

- Strategic planning and analysis to define and develop an overarching direction in which to steer the energy sector stakeholder activities and making decisions on allocation of joint resources; setting up knowledge management system for gathering and dissemination of information and for engaging and collaborating with energy sector stakeholders; and setting up policy analysis studies to help understand current barrier and develop programs that will promote competition and open markets for CE technologies.
- Project facilitation, to include creation of pooled fund(s) and setting up a revolving fund financing mechanisms for CE technology demonstrations and services; development of new financial instruments and processes to enhance resource availability for CE deployments, encourage market development, buy-down cost of advanced CE technologies, etc.
- Education and training to scale up the capacity building activities especially working with industry associations and universities.
- Outreach and communication to scale up engagement of the energy sector stakeholders especially in government (state and local) and financial sectors.
- Technology demonstrations and pilots especially working with industry in the areas of waste heat utilization; work with agricultural sector across the nation to scale up programs to reduce pumping electricity load; working with major builders and developing ESCOs to create net-zero and positive energy buildings and for creation of district cooling systems for malls; integrating renewables into electricity generation sector – e.g. integrate solar heating in power plant to heat feed water to show potential reduction in GHG emission, reduction in coal use, transportation, etc.

The Deployment Center should have a physical presence. To be most effective a Deployment Center should bring together government, industry, financial institutions, project developers and others (such as training utility system operators) and this is best accomplished through a physical place, supplemented with a virtual presence following the concept of Distributed Innovation[19].

Since the intent of CERDI is to build on existing US-India clean energy collaboration through the US-India Energy Dialogue, one option for leading clean energy deployment effort is through an Advisory Committee composed of the Chairmen of each of the three relevant Dialogue Working Groups (Power and Energy Efficiency, New Technologies and Renewable Energy and Coal) from both the US and India. The Advisory Committee would set priorities and provide overall leadership for the center with a Secretariat serving as its executive arm and providing full-time support for the Center, responsible for selecting projects aligned with Advisory Committee guidance, and managing overall Center activities. The Secretariat could be housed and managed as part of an existing institution (such as ICICI Bank) or could be independently managed and operated by an integrator/NGO or organization currently leading clean energy activities in India such as CII's GBC or CenPEEP.

Although not discussed in most stakeholder meetings, the deployment center assessment team identified four options for organizing the center:

- Centralized structure with activities planned and managed from national center
- Decentralized centers based on technical focus areas (e.g., building efficiency, solar, wind, smart grid, coal) located throughout the country
- Regional or state centers with all technologies covered by each center
- Hybrid structure with some activities conducted and managed out of national deployment center and other activities conducted and managed out of technology-specific centers

Although each option offers pros and cons, the advantage of a hybrid structure is that it best capitalizes on the capabilities and programs of existing centers such as the Green Business Center in Hyderabad. Linking to and expanding on successful ongoing programs and institutions will allow for the quickest impact in deploying clean energy technologies.

Establishing a robust funding mechanism is important to ensuring sustainability of the Deployment Center. The Center should identify resources through fund-raising from public, private, individual and intergovernmental relationships, and create new financial mechanisms or modalities for making the resource available, pooling risks, and providing mechanisms for access and use of the resources. Although funding was not a key topic of stakeholder discussions, the assessment team identified four options:

- Clean energy fund—USG and GOI funds (and potentially funds from other sources) are pooled to support Deployment Center projects.

[19] http//www.cleanegroup.org/Reports/ACTII_Report_Final_November2009.pdf

- Separate funding streams—USG funds are used to fund US researchers and equipment and likewise GOI funds support Indian staff and other costs.
- Self-sustaining entity—after USG/GOI seed money is used for establishment, the Center supports itself through energy sector stakeholder memberships, fee-based training, policy analysis and other activities
- Hybrid model—apply the approach that best fits the type of effort (e.g., training, demonstration project)

The options presented in this report each have advantages and disadvantages, and a hybrid system that allows for flexibility depending on the program area may be most appropriate. Since this was an assessment study and not a design effort, this report does not address governance issues, nor does it provide recommendations on resource allocation, budgets, staffing plans and the like.

Stakeholders were unanimous in recognizing that opportunities for clean energy in India are enormous, and extend from industrial efficiency (waste heat was mentioned in many discussions), building efficiency (need for working with builders and developers), solar energy (building on the GOI National Solar Mission), wind energy (capturing the low wind resource and higher elevation resource), geothermal (in states like Maharashtra), biofuels (for distributed applications), smart grid and grid integration (to handle growth of intermittent renewables) to improving the efficiency of coal thermal power plants. National and state governments have implemented clean energy policies and financing mechanisms (such as through the Indian Renewable Energy Development Agency). Other public and private sector organizations are increasing involved in clean energy and an overall receptive climate exists. Through its activities and by playing a convening and coordination role, a well-designed and funded Deployment Center can build on this momentum and catalyze massive clean energy deployment in India.

Chapter 2. Renewable Energy Assessment

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1 Renewable energy assessment introduction

This assessment of the status of renewable energy in India provides an overview of the current market and policy environment and identifies key barriers and opportunities for expanding the deployment of renewable energy in India. It provides background information and preliminary programmatic recommendations that can feed into a clean energy assessment and design for a Deployment Center of the Indo-US Clean Energy Research and Deployment Initiative (CERDI) program.

The findings in this report are derived from information gathered through meetings held with a variety of stakeholders including representatives from industry, financial institutions, central and state government, electricity regulatory commissions, power generation companies, renewable energy development organizations, trade associations, and nongovernmental organizations (see Appendix A for a list of entities interviewed). From January 11-22, the renewable energy assessment team met with more than 150 individuals representing approximately 30 organizations in Delhi, Bangalore, Pune and Mumbai. The outcomes of those meetings as well as information available in public documents and relevant lessons from U.S. experience are presented in this report.

The objective of this effort was to collect information regarding the on-the-ground realities related to deploying and implementing renewable energy in India and how to achieve rapid, large-scale expansion. Interviews with stakeholders covered barriers and issues related to regulatory and institutional frameworks, policy implementation challenges and needs, data availability and gaps, financing issues, research and development needs, and commercial or near-commercial technologies that may be appropriate to evaluate for adoption in the Indian context. The key issues and needs identified by stakeholders and the assessment team are summarized here to help enable USAID India to identify areas in which it could intervene to address barriers and create an enabling environment for deployment of renewable energy (RE) technologies.

2 Status of renewable energy development in India

As of October 31, 2009, there was 15,475 MW of renewable energy capacity deployed in India; Table 1 shows the distribution of this installed capacity by resource. According to the Eleventh Five Year Plan, there was approximately 132,000 MW of total generating capacity in India in 2006.[20]

Table 2.1: Total Renewable Energy Deployed in India (As of October 31, 2009)

[20] Government of India. Planning Commission. *Eleventh Five-Year Plan, Chapter 10: Energy. http://planningcommission.nic.in/plans/planrel/fiveyr/welcome.html*

(Excludes 67 MW of Waste-to-Energy Capacity)

Renewable Energy Technology	Status as on 31.10.2009 (MW)
Wind	10891
Small Hydro (upto 25 MW)	2520
Grid Connected Solar Thermal	6
Off-grid Solar PV and thermal	
Biomass	817
Co- generation (Bagasse)	1241

Source: Ministry of New and Renewable Energy (MNRE), Government of India

2.1 Renewable energy development policy environment

In recent years, most of the new renewable energy development in India has been focused on wind, small hydro, and biomass applications. Renewable energy development has been driven by government incentives and state level renewable energy tariffs. This is especially the case for wind generation, which has been driven by tax incentives in the form of accelerated depreciation – 100% of the capital cost can be depreciated in the first year. Because this incentive has encouraged new capacity but not the development of the best sites or highest output of the renewable energy facilities, the government just recently introduced a scheme of generation-based incentives (GBI) in which the incentive is based on the production output of the renewable energy facility.

This shift toward generation-based incentives should encourage more efficient renewable energy generation once they take effect; however, the accelerated depreciation incentives are still available and may continue to be the dominant incentive choice, unless completely phased out. To make the two incentives equivalent; there is a cap on the generation-based incentive that is equivalent to the tax savings achievable through the accelerated depreciation incentive; however the cap on the GBI is based on a 21% capacity factor for wind projects, which is slightly higher than the national average to date.

In addition to available government incentives, the central and state electricity regulators have established tariffs at which the utilities must purchase renewable energy. CERC has issued tariff regulations for all technologies, except solar. Tariffs include annual escalation, as is done for conventional power.

Finally, states have adopted renewable purchase obligations (RPO) policies requiring the utilities to procure renewable for a certain fraction of its electricity sales, as required under the Electricity Act of 2003. These range from 2% to 10% in 2008/2009.[21] A few states have met their existing requirements, but most have not. Enforcement of RPO policies varies among states and most do not have penalty provisions specified in the law. To address these issues, CERC is examining the legal authority to enforce the RPO's through existing regulatory powers and trying to create a more uniform regulatory environment for renewable energy across states.[22] CERC is also developing rules to allow states to trade renewable energy certificates (RECs) to enable those states with modest wind resources to be able to procure wind energy to meet the RPO obligation from other states. These regulations are currently under development.

2.2 Wind energy

As shown in Table 1, approximately 11,000 MW of wind have been installed in India to date, with another 4000 MW expected in the next few years.[23] Capacity factors have generally been modest, with an average of about 20%.[24] Wind development has been concentrated in a small number of states, those with the greatest wind resource, including Karnataka, Maharashtra Gujarat, and Tamil Nadu.

Integration of intermittent renewable energy generation is expected to be a more significant issue, but manageable, going forward as higher penetrations of renewable energy generation are added to the grid. One state (Karnataka) has 10% wind on a generation basis today, although most others are much lower. CERC is working on guidelines for grid operators to address issues of non-dispatchable resources.

2.3 Solar energy

To date, very little solar energy has been developed in India, with only 6 MW of installed capacity as of October 2009 (see Table 1). Solar photovoltaics (PV) have been used to a small degree in solar lighting projects in village applications. There has been increased interest in larger scale PV and concentrating solar thermal power (CSP), with several megawatts of capacity recently constructed or planned for the near term. In addition, solar hot water heating has been used widely in residential and commercial applications.

Distributed solar PV has the benefit of avoiding distribution losses, which is in the order of 40% or more in some areas, and off-grid applications have significant potential for reaching the un-electrified regions of India. Solar hot water heating is economical in

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[21] Baker & McKenzie and World Institute of Sustainable Energy (WISE), 2008. *Identifying Optimal Legal Frameworks for Renewable Energy in India*, Funded by the Australian and U.S. Governments under the Asia- Pacific Partnership, Renewable Energy and Distributed Generation Task Force (REDGTF), APP Project REDG-06-09. November.

[22] Central Electric Regulatory Commission (CERC), 2010. Meeting with Dr. Pramod Deo, Chairperson, January 13.

[23] Indian Wind Energy Association (INWEA), 2010. Meeting with V. Subramanian, CEO & Secretary General; Manish Singh, Secretary, January 19.

[24] Baker & McKenzie and World Institute of Sustainable Energy (WISE), 2008.

India; the main barrier to adoption has been the expense of retrofitting plumbing in households and commercial facilities.[25]

Recently, the Government of India announced the new Jawaharlal Nehru National Solar Mission, with the objective of creating conditions, through "rapid scale-up of capacity and technological innovation to drive down costs towards grid parity" by 2022.[26] The Solar Mission focuses on utility grid-connected projects, solar heating and off-grid applications. Table 2 summarizes the Solar Mission goals.

Table 2.2: Jawaharlal Nehru National Solar Mission Goals

	Phase 1 Target 2010-2013	Phase 2 Target 2013-2017	Phase 3 Target 2017-2022
Solar collectors	7 million sq. meters	15 million sq. meters	20 million sq. meters
Off-grid solar	200 MW	1,000 MW	2,000 MW
Utility grid power, including rooftop PV	1,000-2,000 MW	4,000-10,000 MW	20,000 MW

Source: Jawaharlal Nehru National Solar Mission, 2009.

The Mission calls for state electricity regulators to modify renewable energy generation targets established under the Electricity Act of 2003 and the National Tariff Policy of 2006 to include a percentage target for the purchase of solar power of at least 0.25% in the first phase of the Mission, increasing to 3% by 2022.[27] The CERC has recently issued guidelines for fixing feed-in-tariffs for the purchase of solar power taking into account current cost and technology trends. These incentives at 18 rupees/kWh for PV and 13 rupees/kWh for CSP are generous and expected to incentivize development and will be reviewed on an annual basis. The CERC has also stipulated that Power Purchase Agreement between utilities and solar energy project developers should be for a period of 25 years.[28] To encourage the uptake of distributed PV systems by residential and commercial customers, net billing rules are under development and metering will be done with two meters.

The National Solar Mission also designated NTPC Vidyut Vyapar Nigam (NVVN), a subsidiary of NTPC, as the central nodal agency of the Ministry of Power (MOP) for entering into Power Purchase Agreements (PPA's) with renewable energy project developers. NVVN will handle all transactions for power fed into the grid at 33 kV and above. NVVN will follow the tariff rules set by the CERC and the MoP will allocate the megawatt capacity to NVVN out of the unallocated quota of low-cost generating capacity that NTPC power stations provides to states. NVVN will bundle the low-cost

[25] Government of India (GOI), 2006. *Integrated Energy Policy: Report of the Expert Committee*, Planning Commission, New Delhi. August.
[26] Jawaharlal Nehru National Solar Mission. Towards Building Solar India. 2009
[27] Jawaharlal Nehru National Solar Mission. 2009
[28] Jawaharlal Nehru National Solar Mission. Towards Building Solar India. 2009

conventional power allocation with the solar power and sell it to the states utilities to keep the total cost of generation low.

For off-grid applications, the goal of the Solar Mission is to support solar lighting and stand-alone rural solar power plants. The goal is to provide solar lighting systems under the ongoing remote village electrification program of MNRE to cover about 10,000 villages and hamlets by providing 90% subsidy in areas without grid access and facilitating the availability of low-cost credit for systems in villages which are connected to grid. The Mission also aims to facilitate the development of stand-alone rural solar power plants in remote and difficult areas such as Lakshadweep, Andaman & Nicobar Islands, and the Ladakh region of Jammu and Kashmir. The program also aims to encourage other off-grid solar applications, such as hybrid systems to meet power, heating and cooling energy requirements currently being met by use of diesel and other fossil fuels.[29] In order to address financing barriers, the Solar Mission proposes to use government funds to provide re-financing support through the Indian Renewable Energy Development Agency (IREDA). IREDA would provide refinance to banks and financial institutions with the condition that it is on-lend to the consumer at rates of interest not more than 5 percent. The Mission would provide annual appropriations for refinancing operations for ten years at the end of which the funds would be transferred to IREDA as capital and revenue grants for on-lending to future renewable energy projects.[30]

2.4 Biomass energy

There have been some attempts to develop municipal solid waste combustion or gasification projects. The quality and consistency of the waste has posed problems for power generation as most of the high value combustibles are extracted for recycling before it is available for power generation.[31]

More than 1200 MW of bagasse cogeneration plants were installed by October 2009, according to MNRE (see Table 1). Incentives have been more than adequate to drive these projects. In fact, many have been able to achieve relatively high internal rates of return.

There are number of projects underway to examine the potential for biomass gasification for rural applications. According to the Integrated Energy Policy Report, about 70 MW of biomass gasification plants were installed at the end of 2005.[32] NTPC has studied the feasibility of 20, 40, and 100 kW systems in 10 cases using agricultural residue from rice and corn harvests. But a consistent supply chain and access to the waste in an economically viable "radius of availability" is an issue. Also, detailed biomass resource assessments of available feedstocks and costs are not available; such data is essential for enabling more widespread application of the technology.

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[29] Jawaharlal Nehru National Solar Mission. Towards Building Solar India. 2009
[30] Jawaharlal Nehru National Solar Mission. Towards Building Solar India. 2009
[31] Indian Renewable Energy Development Agency (IREDA), 2010. Meeting with Debashish Majumdar, Chairman & Managing Director, January 12.
[32] Government of India (GOI), 2006. *Integrated Energy Policy: Report of the Expert Committee*, Planning Commission, New Delhi. August.

2.5 Small hydropower

There has been development of more than 2500 MW of small-scale hydropower (defined as up to 25 MW) capacity in India, according to MNRE (see Table 1). The main barrier to the future development and expansion of these projects going forward is access and availability of water resources and competing uses for sites. There is a need for a detailed survey of potential sites to determine future development potential.[33]

3 Barriers to renewable energy development

There are a number of barriers that have impeded the development of renewable energy technologies in India. Some of these barriers apply to all technologies, while others relate to particular technologies or to either grid connected or off-grid applications. Below, key barriers have been grouped in the following categories: Utility and Grid; Institutional and Regulatory; Data and Analysis, and Financial. Utility and grid

- Grid operators are not familiar with forecasting techniques and tools for handling intermittent generation sources and best practices in how to manage them.
- The grid is not robust in many areas and integrating large quantities of distributed generation may be a challenge, this may require additional analysis.
- There are challenges with moving generation among regional grids, and because renewable energy resource potential varies among regions, this can pose challenges.

3.1 Institutional and regulatory barriers

- There is a need to develop single process for acquiring multiple approvals from state and central agencies. Acquiring land acquisition rights and other permits is complex and the agencies that administer permits vary across states; this makes it difficult for developers to easily operate in multiple regions.
- Allocation mechanisms, whereby states have allocated development rights for a certain amount of capacity to individual developers, have delayed development in some cases or provided certain companies with excess market power, because allocations were done on a first come, first serve basis and the development timelines (often 3 years) were not enforced.
- There is a need for better coordination among policies at the state and central level as well as coordination of government incentive structures and state tariffs. For example, state regulators enforce RPO at different levels of intensity, making some targets more binding/viable than others.
- There is a need for better maintenance and servicing of systems installed in rural areas past. In some instances, technologies that have been deployed have been

[33] Government of India (GOI), 2006. *Integrated Energy Policy: Report of the Expert Committee*, Planning Commission, New Delhi. August.

dysfunctional because they have not been well integrated with cultural practices or they have not been adequately maintained (or resources were not available to provide maintenance).

3.2 Data and analysis barriers

- There is a requirement of readily available comprehensive renewable resource assessments, and data on technology costs, performance, installed capacity, and generation in India.
- The shortage of widespread availability of renewable energy resource data limits the ability of regulators and policymakers to use more rigorous analysis in setting incentives and policy goals.
- There is a need for documentation and assessment of barriers to renewable energy deployment.

3.3 Financing barriers

- In some cases existing incentives for renewable have not been properly utilized by developers because of administrative complexity and lack of certainty in the incentive (e.g., caps or limits on the availability of the incentive).
- Subsidies for kerosene have impeded the ability for solar to compete in rural applications.
- Lack of bank financing for viable renewable energy projects in some cases, because banks have been interesting in lending only to companies with strong balance sheets to minimize their risk, rather than lending based solely on the merits and future income streams of the proposed project.
- Consumer access to loans in rural India has been a barrier to the development and installation of small, distributed systems. The ability for consumers to access loans, has been a greater difficulty than the cost of the loan, as about 65% of households in India don’t have bank accounts.
- Limitations on the length of loan terms have hampered the ability for renewable energy technologies to compete in certain applications. For example, access to loans of less than 10-years in duration, limits the ability of solar to compete against diesel generators and to use solar for water pumping; currently, most loans for PV and hot water in rural areas are for 5 year periods. For commercial systems, loan terms have been inadequate in some cases to enable distributed renewables compete.
- While the availability of long-term tariffs are generally low risk and appealing to banks to provide financing for projects, government plans are subject to change, so some contractual risk remains. For example, in one instance, power purchase agreements with utilities based on established state wind tariffs were subsequently invalidated and renegotiated from their original terms. Such practices create uncertainty in the market and risk for lenders.

- While long term tariffs are generally sufficient to finance commercially available technologies, they are not sufficient for financing emerging technologies, which carry additional risk.

4 Need for expansion and widespread deployment of renewables in India

This section discusses needs to address barriers and to encourage more wide-spread deployment of renewable energy technologies in India. In each section, we have italicized the needs that are most significant or are judged by the assessment team to be highest priority.

4.1 Utility and grid

- *As penetration of intermittent renewable generation increases, there is a greater need to adopt the latest technology in wind forecasting to enable grid operators to better plan and manage wind generation as it is available. Currently, advanced forecasting methods that are available in the U.S. and elsewhere are not used in India.*
- *Training of system operators to integrate intermittent generation is needed; grid operators are often not familiar with intermittent generation sources and how to best manage them.*
- *There is a need for analysis and evaluation of whether the grid will be able to handle a large quantity of distributed PV.*

4.2 Institutional and regulatory

- *There is a need for greater coordination between state-level tariffs and government level incentives as well as a need for greater analysis in setting incentive levels. In some cases, the relationships between regulators and government are not clear and there is a need for greater interagency coordination and accountability. Also, there are differences in the willingness and ability of regulators to enforce rules.*
- *There is a need for capacity building with respect to the deployment of renewable energy technologies among regulators, state nodal agencies, and utilities. This could include education and information on technologies, costs, resource assessment data, effective deployment strategies used elsewhere, and effective solutions to barriers. In some cases, staff members do not have adequate experience to address challenges.*
- *A single "window" for approvals, or an agency that could facilitate the acquisition of multiple approvals from different agencies, for siting and permitting systems would remove administrative barriers and simplify the approval process for installing and siting systems.*
- *To effectively provide incentives, there is a need for administrative simplicity, consistency, and certainty in the level of incentive that is provided. In some cases*

existing subsidies have not utilized because of complexity in getting the incentive and a lack of certainty in obtaining the incentive because of caps/limits. One possible solution is to rely more heavily on low interest financing administered through banks rather than capital incentives for technologies.

- Eliminating or removing barriers associated with the process of allocating renewable energy development capacity would promote more market competition and minimize the risk that the recipients of the allocations would gain undue market power. Modification of these processes is already underway in some states.
- There is a need for incentives that encourage efficient generation from renewable energy facilities, rather than upfront, capacity-based incentives. The movement to generation-based incentives (GBI) is designed to address this issue. However, if existing accelerated depreciation incentives remain, then developers opt for the tax incentives in lieu of the new GBI incentives, which will not change the current focus on capacity to a more value added focus on generation.
- Lack of protection of intellectual property rights is a hindrance to the investment in renewable energy in India and the development of advanced facilities.

4.3 Data and analysis

- *There is a need for more detailed resource assessment maps, and more readily available data on technology costs, performance, installed capacity, and generation. Some renewable energy resource data is available, but it is not comprehensive and resource maps are not yet available digitally. Also, wind resource data at 80 meters is not widely available, which is more relevant to the current wind turbine hub heights. To enable future biomass gasification development, there is also a need for a detailed study of available biomass feedstock sources and cost by location (i.e., supply curves for biomass fuels).*
- *Widespread availability of renewable energy resource data would enable greater analysis of renewable energy potential for establishing reasonable and achievable RPO goals, incentives, and other policies.*
- *More rigorous analysis could be used in setting incentives and policy goals; greater availability of technology cost and renewable resource data would enable this. Policies are the single largest driver for renewable energy development; therefore policy analysis and evaluation is important for developing a robust market for renewable going forward.*
- *Greater documentation and assessment of specific barriers and sharing of lessons learned would help regions learn from each other and overcome institutional and regulatory barriers. IREDA plans to conduct a study in 2010 on the barriers to investment in renewables; more studies of this type would be helpful in achieving rapid future deployment.*

- To enable future offshore wind development, there is a need for data on offshore wind resources on the west coast in particular. Assessment of wind project viability off the east coast, given the frequency and severity of storm events, would be useful in determining to what extent wind development should be explored in that region.

4.4 Financing

- *To encourage greater access to financing, renewable energy should be identified by the government as a priority lending area for banks. Banks are required by the central government to have 40% of their loans made in priority areas; currently, renewable energy is not one of these. If it were a priority area, banks would have greater incentive to provide capital to renewable energy projects.*
- *Loan guarantees, credit lines from development finance institutions to commercial banks, or other forms of guarantees or risk mitigation could be used to encourage commercial lenders to finance renewable energy projects based on the project financials alone without requiring a strong balance sheet. Currently, banks provide lending only to companies with strong balance sheets; they do not lend on the merits of the project alone, because of the risk. Increased access to lower cost financing and longer term financing is needed to enable solar to compete in a variety of applications. For small-scale applications in rural areas (e.g., replacing diesel generators, water pumping), there is a need for greater access to low interest loans and loan terms longer than 5 years. Longer term financing (more than 10 years) is also needed to enable solar to compete against diesel generators in commercial applications.*
- *Because most consumers do not have bank accounts and therefore cannot access credit, there is a need for innovative financing structures to provide access to loans for renewable energy projects. Access to credit is perhaps a larger issue than the cost of credit in India, although both are an issue for wide scale renewable energy deployment.*
- There is a need for an evaluation of financial instruments that could be used to support financing for renewable energy development in rural areas and for small consumers. Micro-financing should be considered.
- There is a need for training of lenders and equity investors that covers renewable energy technologies and risks (e.g., training done with the reserve bank of India may be a good model).
- Public benefits funds, which use funds generated from a small surcharge on electricity bills, could be considered for supporting renewable energy development. Such funds are being developed in Delhi and Maharashtra and have been used widely in the U.S. One advantage to these funding mechanisms is their flexibility and ability to focus on deployment needs.

- Revolving loan funds are another mechanism that could be examined to support renewable energy projects in India. These funds operate by providing a loan to cover the capital costs of projects and using the energy savings to repay the loan. Such funds have been operated widely in U.S. states to encourage efficiency and renewable.
- There is a need for financing mechanisms for emerging technologies, as these generally involve too much risk for commercial banks to finance. While long term tariffs are generally sufficient to finance commercially available technologies, they are not sufficient for financing emerging technologies.
- Loan softening programs could be utilized to encourage lending in the sector, such as grants to commercial financial institutions to encourage them to lend their own capital to end-users on concessional terms.
- Banks have limited capacity to process large scale, rapid deployment of clean technologies. There is a need for capacity-building and education among the financial industry to enable rapid deployment.

4.5 Technology and R&D

Biomass

- *To enable the development of a robust market for biomass gasification in rural areas, there is a need for access to processed fuels. One of the major challenges in developing gasification projects is gaining access to processed fuels at stable prices; often the demand for the feedstock results in price escalation for the fuel. Collection and transport of fuels is a challenge and generators prefer access to already prepared fuel; however, no supply chain exists. Firewood, which is currently used for cooking, could be more efficiently utilized with less pollution if it was gasified; however, there are cultural issues with making this shift that would need to be addressed.*
- *To enable widespread use of biomass gasification, there is also a need for 1) gasifier designs that can accept various types of biomass feedstock inputs, 2) fuel processing that has lower power requirements, and 3) access to technologies to pelletize fuel, which exist globally but not in India.*

Wind

- *Because India has primarily low speed wind resource (class 2 and 3), expanded research on low wind speed turbines or examination of technology options for utilizing low wind speed sites may be warranted.*
- Transporting large blades for wind turbines over roads with sharp bends and unimproved surfaces is a potential problem. As movement toward 2 MW and larger (4-5MW) machines occurs; this issue will become increasingly problematic

and will need to be addressed at the state level and information shared with developers to identify early barriers to large wind farm development.

Solar

- *There is a need for standards and certification for solar modules in India.*
- Solar PV could be used for water pumping in shallow areas; however, one challenge is that water recedes every year. Use of solar would lead to more efficient pumps.
- Water availability may be a barrier to deployment of concentrating solar thermal technologies in some regions of India, as access to water is limited in some areas, thus focus may be directed to technologies that address water use concerns.

Other

- *Hybrids renewable energy systems should be considered to achieve constant power supply in remote areas. Rather than an emphasis on solar PV for lighting, larger systems are needed in villages and remote areas to supply power all day, every day. A variety of hybrid system types could be used, including CSP/pumped hydro; natural gas/CSP systems, and biomass/ solar hybrids.*
- Heat pumps that tap heat from the ground and use it efficiently for space cooling and heating have potential in India, and methods for advancing their uptake should be explored.
- Mini-grids for rural areas could be explored to help manage loads intelligently. One vision that could be explored is to connect mini grids to the transmission system, whereby the technology owner (ESCO or village) could connect at cost and be compensated by selling into the utility grid.
- Smart grid. While regulators have started to look at smart grid, training and education of regulators on the elements of a smart grid and its benefits and costs would assist them in crafting regulation that fosters its widespread adoption.
- There is a need for understanding the role of energy storage in facilitating the large scale deployment of renewable energy by regulators and system operators. System specific studies are needed to clarify this role and monetize its value to facilitate its use. Emerging battery technologies such a lithium and hybrid lead-acid hold potential for cost reductions and performance improvement and should be monitored for use as well as creating an indigenous manufacturing base.

4.6 Rapid scale-up and deployment

- *For a massive and rapid scale up of technology, it is important to engage large companies and organizations. For example, Tata Power has established a goal of obtaining 10% of its energy generation from green energy. For large scale deployment to be successful, a larger number of companies need to be engaged and those that have made commitments should be encouraged to go further.*

- *Rapid deployment of clean energy technologies could be accelerated by targeting builders and leveraging efforts in the area of affordable housing and infrastructure development. Widespread and consistent use of clean energy technologies in new building infrastructure would create a large market in the near term.*
- *There is a need for greater local manufacturing capability to serve the industry. Rapid deployment needs to result in local job creation and to rely on technologies that can be manufactured and maintained locally. There is some local manufacturing capacity of solar PV, but additional manufacturing in India could help achieve cost reductions. Currently, there are no manufacturers of CSP components in India.*
- There is a need for maintenance/service technicians to achieve rapid, large-scale deployment. Educational organizations will need to train technicians, engineers, and service providers.
- For widespread adoption of renewable energy technologies, there is a need to increase awareness of the technologies and that they work. This requires a multi-faceted education and awareness effort that targets consumers, industry, policymakers, financial institutions, and other key stakeholders.
- For large scale deployment, there needs to be consideration of and planning for waste streams (e.g., mercury from CFLs; cadmium from PV) associated with the new technologies.

4.7 Solar-specific needs for rapid deployment

- To achieve the targets of the solar mission in particular, there is a need for all states to develop a plan to promote solar and to form partnerships to help deploy it.
- In order to service a substantial number of distributed systems in remote locations, there is a need to train a sufficient number of installers and maintenance technicians. Many installers/servicers have their own training programs, but additional training resources will be required if a large scale deployment of solar is to be achieved.
- To encourage the use of solar to replace backup diesel generators, one policy option is to free the customer from power cuts (reductions in power allotment in times of shortages) if they install and operate a renewable energy system. Solar PV is able to compete on a cost basis against diesel generation as a backup generation source. (INWEA 2010).

5 Relevant US Renewable Energy Deployment Lessons and Experience

There are some lessons from the U.S. renewable energy development experience that may be transferable or of use to consider in the Indian context. The following is a list of lessons and ideas that may warrant consideration in developing plans for encouraging accelerated deployment of renewable energy in India. This preliminary list may warrant further examination and consideration.

- Renewable portfolio obligations can be most effective for encouraging renewable energy development if they have long-term, substantial targets and penalties for noncompliance. In addition, RPO's by themselves may not be fully effective in driving renewable energy deployment if other barriers exist, such as barriers to siting projects or lack of access to transmission. It is necessary to address other renewable energy development barriers in addition to setting targets.
- It is important to have stable incentive policies to encourage long term investment in renewable and consistency in the market development. In the U.S., the short term (one to three year) extensions of the production tax credit have posed challenges for the renewable energy industry and have created boom and bust cycles when the industry awaited reauthorization when the incentives expired. Stability and consistency in incentives and policies can help create a market conducive to development and investment in manufacturing.
- Access to transmission or the need for new transmission can pose significant challenges for renewable energy resource development. Because renewable energy resource potential for renewable such as wind and CSP in particular may be in remote regions or far from existing transmission lines, there may be a need to coordinate transmission planning with assessment of renewable resource potential to plan lines to the areas with the most productive resources (i.e., windiest sites). In the U.S., there have been recent efforts to evaluate the potential for planning transmission to renewable energy resource zones to facilitate development of renewables to some of the best resource areas.
- Public benefits funds, which use funds generated from a small surcharge on electricity bills, could be considered for supporting renewable energy development. Such funds are being developed in Delhi and Maharashtra and have been used widely in the U.S. One advantage to these funding mechanisms is their flexibility and ability to focus on deployment needs.
- Revolving loan funds are another mechanism that could be examined to support renewable energy projects in India. These funds operate by providing a loan to cover the capital costs of projects and using the energy savings to repay the loan. Such funds have been operated widely in U.S. states to encourage efficiency and renewable.
- Many recent large-scale PV projects have used the third-party financing model in which a third party owns and operates the PV system, while the host facility provides the rooftop or land for the facility and purchases the electric

output. Such arrangements have been viable because of the availability of investment tax credits and other state incentives. While this has been an effective financing innovation that has emerged in the market and spurred significant development in the U.S., heavy reliance on tax credits has posed challenges in economic downturns because of insufficient tax appetites and lack of access to capital to fund projects.

- A recent innovation in solar financing for residential and small commercial facilities is to enable consumers to obtain financing through municipalities, which is financed through the issuance of municipal bonds. Consumers then repay the loan through their annual property tax payments and the payments and the system remain with the residence or business.
- Regional or state working groups are one mechanism for educating and organizing stakeholders to enable them to address local barriers to renewable energy development. This concept has been used in the Wind Powering America program to disseminate information to local and regional stakeholders and to facilitate sharing of lessons learned across regions and localities.
- Renewable energy certificate trading is one mechanism for minimizing the cost of complying with renewable portfolio obligations or to enable regions that have ample, low-cost renewable energy resources to supply renewable to other areas to meet targets. While RECs can potentially help reduce compliance costs, the specific design details are very important for making such programs effective. In the U.S., markets have been extremely fragmented, and there is a lack of transparency in the markets, as trading volumes are generally not large.

6 Organizations for potential collaboration for renewable energy

The following is a selected list of potential national and state level organizations that may be important to engage in any large scale deployment of renewable energy in India. Note that this list is not comprehensive. This list includes existing organizations that play a role in supporting renewable energy development in India currently and may be interested in future collaboration, such as government agencies and organizations, financial institutions, science & technology groups, nongovernmental organizations, and public/private utilities.

- Ministry of Power, Ministry of New and Renewable Energy, and State Renewable Energy Development Agencies
- MNRE Solar Energy Centre and Centre for Wind Energy Technology (CWET)
- Indian Renewable Energy Development Agency (IREDA)
- Central Electric Regulatory Commission (CERC) and State Electric Regulatory Commissions
- Nongovernmental organizations such as: World Institute of Sustainable Energy (WISE), The Energy Research Institute (TERI), Center for Science Energy

Technology and Policy (CSTEP), and Prayas Initiatives in Health, Energy, Learning and Parenthood,
- Financial Institutions, such as ICICI Bank, Yes Bank, and Infrastructure Development Finance Company (IDFC), as well as development financial organizations such as World Bank
- Educational institutions, such as India Institute of Technology (IIT)
- Electric utilities, including NTPC and state electric utilities
- Trade associations and renewable energy industry members, such as Indian Wind Energy Association.

7 Summary

This assessment of the status of renewable energy in India provides an overview of the current market and policy environment and identifies barriers and opportunities for expanding the deployment of renewable energy in India. It provides background information and preliminary programmatic recommendations that can feed into a clean energy assessment and design for a Deployment Center of the Indo-US Clean Energy Research and Deployment Initiative (CERDI) program.

The objective of this effort was to collect information regarding the on-the-ground realities related to deploying and implementing renewable energy in India and how to achieve rapid, large-scale expansion. The findings in this report are derived from information gathered through meetings held with a variety of stakeholders including representatives from industry, financial institutions, central and state government, electricity regulatory commissions, power generation companies, renewable energy development organizations, trade associations, and nongovernmental organizations. Interviews with stakeholders covered barriers and issues related to regulatory and institutional frameworks, policy implementation challenges and needs, data availability and gaps, financing issues, research and development needs, and commercial or near-commercial technologies that may be appropriate to evaluate for adoption in the Indian context. The outcomes of those meetings as well as information available in public documents and relevant lessons from U.S. experience are presented in this report.

The key issues and needs identified by stakeholders and the assessment team are summarized in the report to help enable USAID India to identify areas in which it could intervene to address barriers and create an enabling environment for deployment of renewable energy (RE) technologies. A few of the key needs and barriers are the following.

Utility and Grid

- As penetration of intermittent renewable generation increases, there is a greater need to adopt the latest technology in wind forecasting to enable grid operators to better plan and manage wind generation as and when it is available.
- Training of system operators to integrate intermittent generation is needed; grid operators are often not familiar with how best to manage intermittent generation sources.

- There is a need for analysis and evaluation of whether the grid will be able to handle a large quantity of distributed PV.

Institutional and Regulatory

- There is a need for greater coordination between state-level tariffs and government level incentives as well as a need for greater analysis in setting incentive levels.
- There is a need for capacity building with respect to the deployment of renewable energy technologies among regulators, state nodal agencies, and utilities. This could include education and information on technologies, costs, resource assessment data, effective deployment strategies used elsewhere, and effective solutions to barriers.
- A single "window" for approvals, or an agency at the State level, that could facilitate the acquisition of multiple approvals from different agencies, for siting and permitting RE would facilitate and simplify the approval process for installing and siting such systems.
- To effectively provide incentives, there is a need for administrative simplicity, consistency, and certainty in the level of incentive that is provided.

Data and Analysis

- There is a need for more detailed resource assessment maps, and more readily available data on technology costs, performance, installed capacity, and generation.
- More rigorous analysis could be used in setting incentives and policy goals; greater availability of technology cost and renewable resource data would enable this.
- Greater documentation and assessment of specific barriers and sharing of lessons learned would help regions learn from each other and overcome institutional and regulatory barriers.

Financing

- To encourage greater access to financing, renewable energy should be identified by the government as a priority lending area for banks.
- Loan guarantees, credit lines from development finance institutions to commercial banks, or other forms of guarantees or risk mitigation could be used to encourage commercial lenders to finance renewable energy projects based on the project financials alone without requiring a strong balance sheet.
- Increased access to lower cost financing and longer term financing is needed to enable solar to compete in a variety of applications.

- Because most consumers do not have bank accounts and therefore cannot access credit, there is a need for innovative financing structures to provide access to loans for renewable energy projects.

Rapid Scale-Up and Deployment

- For a massive and rapid scale up of technology, it is important to engage large companies and organizations to make renewable energy commitments.
- Targeting builders and leveraging affordable housing efforts and infrastructure development could accelerate rapid deployment of clean energy technologies.
- There is a need for greater local manufacturing capability to serve the industry. Rapid deployment needs to result in local job creation and to rely on technologies that can be manufactured and maintained locally.

Chapter 3. Energy Efficiency Assessment

Jayant Sathaye, Lawrence Berkeley National Laboratory

1 Energy efficiency assessment introduction: 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, China and other countries, 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 more than 70% of its oil needs, possesses limited natural gas reserves, and faces chronic electricity shortages. The gap between electricity supply and demand in terms of both capacity (i.e. kW) and energy (i.e. kWh) has been steadily growing in India. The extent of shortage reported by India's Ministry of Power (MOP) in its Annual Report for 2007-08, has increased from 7% to 10% (energy) and from 11% to 17% (capacity) in the last five years [34] The lack of reliable power supply, particularly to business consumers, has prompted increased use of captive power generation that often uses diesel fuel. The rising demand for petroleum products is expected to be met through imports. India has discovered new natural gas resources in offshore areas, which will reduce its projected dependence on the imports of this fuel. Coupled with poor 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. 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.

1.1 Electricity supply and demand

Installed electricity generation capacity in India was 148 GW in 2009 (Table 3.1), including 23 GW or 15% in the private sector. Over half of the capacity was coal fired and hydro, natural gas and renewables constituted much of the remaining share. Renewable sources constitute the largest increase in share of capacity since 2004-05 from 6.1 GW (Sathaye et al. 2006). Due to 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.

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34 http://www.powermin.nic.in/indian_electricity_scenario/policy_initiatives.htm

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 less than 1 MW was 23,000 MW in 2004-2005.[35], while that greater than 1MW was reported to be 24,986 MW by 2008-09.[36] Depending on the PLF, diesel consumption for captive electricity generation is estimated to be between 3-8% of the country's total diesel consumption of 39.7 million tonnes in 2004-05.

Table 3.1: Electricity Generation Capacity, India

	Generation Capacity (April 2005)		**Generation Capacity (April 2009)**	
	(MW)	(%)	(MW)	(%)
Coal	68,434	55.5	77,949	52.6
Natural Gas	12,430	10.0	14,877	10.0
Oil	1,201	0.9	1,200	0.8
Hydro	32,135	26.0	36,878	24.9
Nuclear	3,310	2.7	4,120	2.8
Other (Renewables)	6,158	4.9	13,242	8.9
Total	123,668	100	148,265	100
Captive (>1 MW)	19,103	23.8	24,986	
Captive (< 1 MW)	23,000	76.2		
Total Captive	30,195	100		

Source: Economic Survey, Govt. of India (2006), CEA (2005)[37], CEA (2009)[38]

Note: Captive power estimates for <1 MW are for 31 March 2004, and >1 MW are for 31 March 2005 and 2008

1.2 Energy efficiency benefits

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.[39] The higher penetration of energy efficiency technologies reduces the construction of power plants thereby reducing fuel imports and India's CO_2 emissions by 300 Mt CO_2/year by 2017, the end of the 12th Five Year Plan.[40] A recent report by the Ministry of Environment and Forests illustrates findings from five independent carbon emissions models. Four of these models show that India's emissions in 2030 would range under 4 t CO_2/capita or below the worldwide average level today.[41] More importantly, provision of adequate electricity supply to business consumers adds

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

36 CEA (2009).

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

38 http://www.cea.nic.in/power_sec_reports/Executive_Summary/2009_04/27-33.pdf

39 Sathaye J., A. Gupta, and A. Phadke (2009) Reducing Electricity Deficit through Energy Efficiency in India: An Evaluation of Economic and Emissions Benefit. LBNL Draft Report.

40 A recent report by McKinsey has observed that GHG emissions would increase from roughly 1.6 billion tonnes carbon dioxide equivalent in 2005 to 5.0-6.5 billion tonnes in 2030 (reference case). The report concludes that India could make a step change in its efforts to lower emissions by 30-50% to approx 2.8 billion – 3.6 billion by 2030 through an aggressive GHG abatement program.

41 http://moef.nic.in/downloads/home/GHG-report.pdf

substantially to economic growth and increases tax revenue to state and national governments. Sathaye et al. (2009) show that energy efficiency offers a way to alleviate the deficit while potentially increasing India's economic output by US $320 to 500 billion and employment opportunities by over 11-33 million person-years over the next eight years by the end of the Twelfth Five Year Plan (2012-2017). A similar analysis of macroeconomic benefits for India's 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.[42]

Economic analyses of energy efficiency, including demand response (DR)[43], technologies often portray these as being cost-effective when compared with supply alternatives (Figure 3.1). 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?

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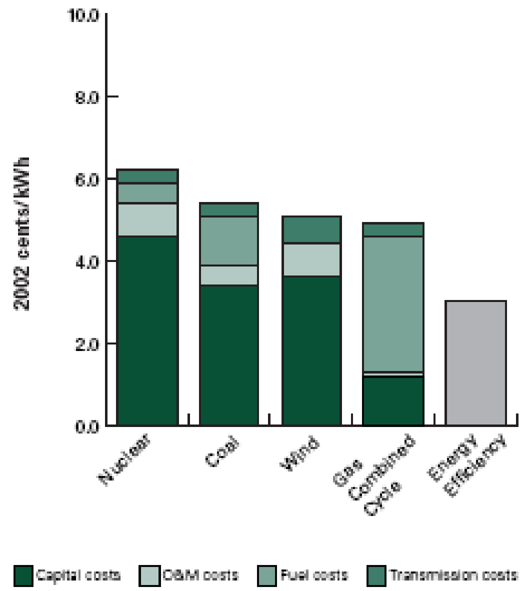
42 Phadke A., Sathaye J. and Padmanabhan S. (2005) Economic benefits of Reducing Maharashtra's electricity shortage through end-use efficiency improvement. LBNL Report 57053.

43 There are two ways of reducing the peak electricity demand (Demand Response) - 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.

Figure 3.1: Energy efficiency is competitive with generation technologies



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

1.3 Goal of the chapter

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.

This report was prepared to provide an assessment of the energy efficiency opportunities in India. It builds on the information provided in the EE background report for the 2009 conference[44] and highlights energy efficiency technologies, barriers, and policies and deployment and market transformation strategies that could be pursued in India under the US-India Clean Energy Research and Development Initiative (CERDI). The paper discusses the lessons to be learned from these experiences, conditions that would accelerate and scale up energy efficiency penetration in India, and ways to foster cooperation between the two countries at the national, state and city level in the buildings, industrial and power sectors.

A team composed of staff from four US DOE national laboratories visited India in January 2010 and met with about 200 experts from central and state governments, industry, power sector, and financial and academic institutions. Their inputs were invaluable for the preparation of this document particularly in drafting the final section

44 Sathaye et al. (2009). Energy Efficiency and Sustainable Development –Potential for US-India Collaboration in Buildings, Industry and the Smart Grid, LBNL-xx

on the analysis of gaps and recommendations about ways to overcome the many barriers that are noted in this report.

1.4 What the chapter covers

The next section of the report illustrates the Indian government's vision and the institutions the country has established to design and implement its energy efficiency mandates. It also focuses on the role of the private sector and USAID's efforts in India's aspiration for development. The next section (Section 3) lays out the type of technologies that would form the core of energy efficiency programs in the country. discusses the key barriers to energy efficiency promotion, which is followed by Section 4 and Section 5 that describe Indian policies and programs for the buildings and industry sectors respectively. Section 6 describes the key barriers that prevent the scale up of energy efficiency technologies and programs. Section 7 describes the potential for deploying EE technologies and services to set up a center that would help institutionalize the above activities through collaboration between US and Indian institutions.

2 India's Energy Efficiency Vision: Government, Industry and Civic Org

In July 2008, India released its first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation.[45] The plan identified eight core "national missions" running through 2017. NAPCC's goal is to focus on measures that promote India's development objectives while also yielding co-benefits for addressing climate change. It notes that plan would be more successful with assistance from developing countries. The Plan includes eight missions, one of which is on energy efficiency – National Mission on Enhanced Energy Efficiency (NMEEE), which is described in Section 2.1.

The Plan's broad goals are consistent with the three pillars of sustainable development – economic, social and environmental, which all need to be addressed in the provision of adequate energy supplies. Articulating such a vision and making it implementable in the field of energy efficiency is a challenge faced not only by India but also by other major countries. The NMEEE builds on over 30 years of experience with energy efficiency programs in India that are summarized below.

In recognition of the importance of energy conservation, the Indian government created the Petroleum Conservation Research Association (PCRA) in 1978[46]. 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[47]. BEE's mission is to develop programs and strategies on self-

45 http://moef.nic.in/downloads/home/GHG-report.pdf

46 http://www.pcra.org/

47 http://www.bee-india.nic.in/index1.php

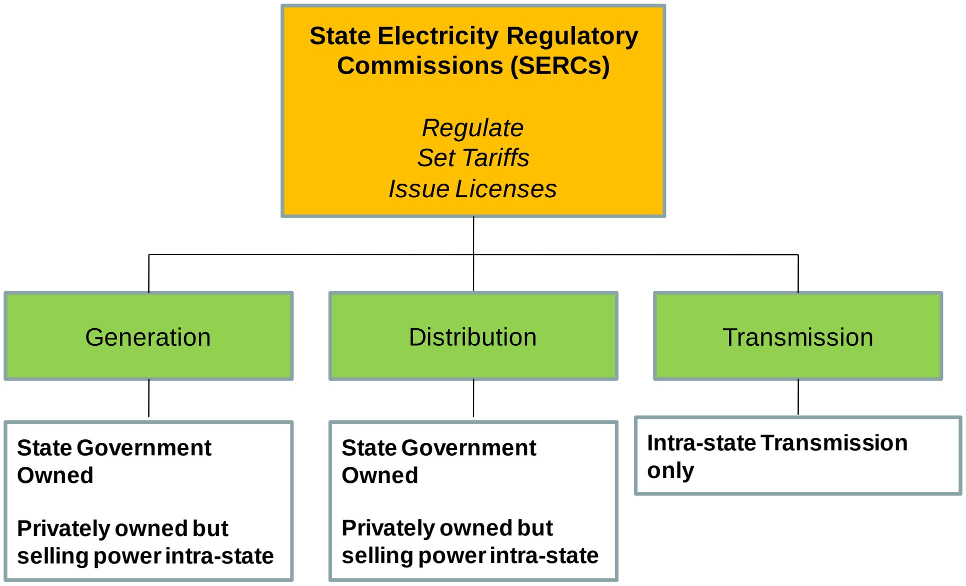
regulation and market principles with primary objective to reduce the energy intensity of the Indian economy. BEE is developing regulatory and voluntary programs and strategies with primary objective to reduce the energy intensity of the Indian economy. Some key activities that BEE is pursuing include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

The Indian Parliament also passed the Electricity Act in 2003 (referred to as the Act) under which the Government of India is directed to prepare the National Electricity Policy and Tariff Policy, in consultation with the State Governments and the Central Electricity Authority (CEA) for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, hydro, and renewable sources of energy.[48] The Act 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 Indian central government enacted the Electricity Regulatory Commission Act in 1998 that established state electricity regulatory commissions (SERC) (Figure 3.2). The law mandated that the SERCs will promote competition, efficiency, and economy in the power sector, and regulate tariffs of power generation, transmission and distribution and to protect the interests of the consumers and other stakeholders. The SERCs rule on the tariffs proposed by the electricity distribution company ensuring that the criteria specified in the law are obeyed.

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

Figure 3.2: State Electricity Regulatory Commissions' jurisdiction



The Central Electricity Regulatory Commission (CERC) regulates the tariff of generating companies owned or controlled by the Central Government and those that have a composite scheme for generation and sale of electricity in more than one state (Figure 3.3). CERC regulates and determines the tariff of inter-state transmission of electricity, and issues licenses to persons to function as transmission licensee and electricity trader with respect to their inter-state operations. CERC specifies the grid standards and enforces the standards with respect to quality, continuity and reliability of service by licensees. CERC also serves in an advisory capacity to the Central government on the formulation of National electricity policy and tariff policy; promotion of competition, efficiency and economy in the activities of the electricity industry; and promotion of investment in electricity industry.

Central Electricity Regulatory Commission (CERC) does not have direct authority over the decisions of state commissions and utilities unless the issues span more than one state. However CERC convenes the Forum of Indian Regulators (FOR) - a statutory body consisting of the chairperson of all the SERCs - that can provide support and guidance on DSM to the SERCs (Figure 3.4). The objective of FOR is to evolve a common and coordinated approach to various issues faced by the SERCs.

In June 2008 FOR decided to constitute a Working Group on "DSM and Energy Efficiency" that consisted of commissioners from CERC, 3 SERCs, and the Director of BEE. The Working Group would consider the relevant provisions of the National Electricity Policy, Tariff Policy and various initiatives taken by the SERCs and give its recommendations on the following issues:

- Components in the tariff structure for providing incentives to energy efficiency;
- Institutionalizing energy efficiency in the organizational structure of distribution utilities;
- Load Research, load forecasting and appropriate DSM options;

- Preparation of DSM plans and how to implement them; and

Special measures for promoting energy efficiency in pumping ground water for agricultural use.

Figure 3.3: Central Electricity Regulatory Commission’s jurisdiction

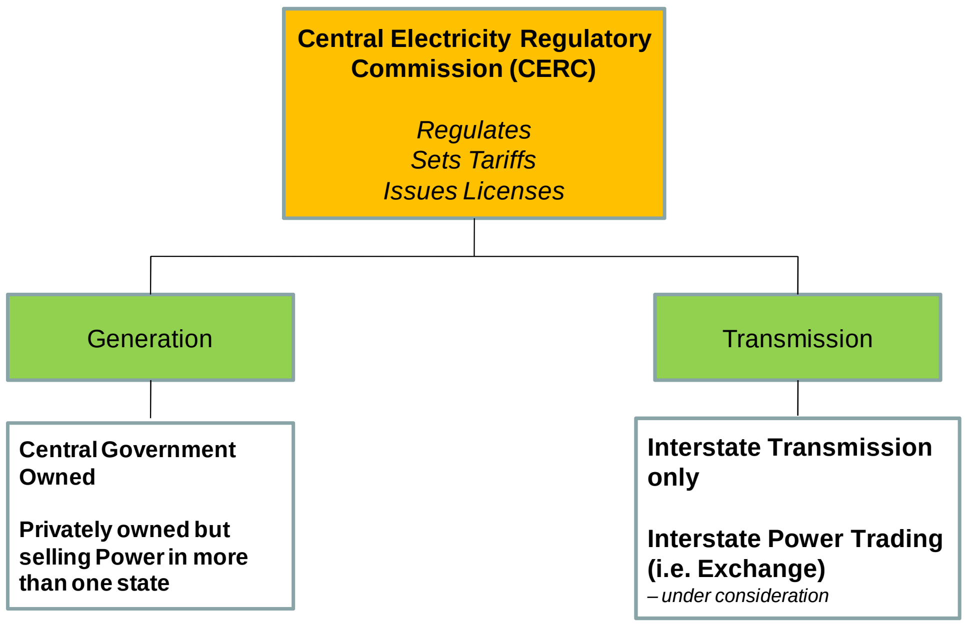
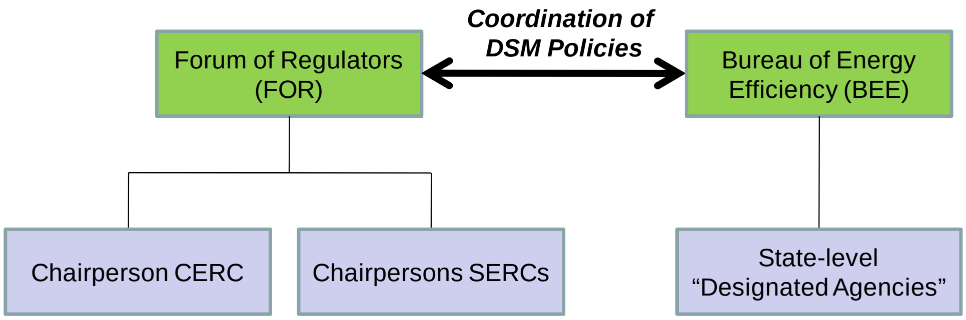


Figure 3.4: Coordination of DSM policies in India



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[49]. 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 upgrading. Private companies mobilized and set up the Alliance for Energy Efficient Economy (AEEE) in 2008 to network, provide input to policy makers, support business development, and disseminate information on energy efficiency. AEEE[50] was created for the specific purpose of facilitating collaboration among India's energy efficiency industries and service providers and to help promote an energy-efficient economy through research, policy advocacy, and education.

In addition to the public and private sectors playing a role in promoting energy efficiency several civic organizations too are taking on this challenge. Prayas Energy Group[51] is one of these organizations playing a prominent role in providing technical and analytical support to many institutions in order to ensure that programs are designed and implemented equitably.

The government's strong push for the use of energy efficient devices is also matched by consumer interest in their purchase, where electricity tariffs or energy prices are not heavily subsidized. For instance, recent data show that the saturation of CFLs in an average urban household has reached 2.3 lamps. This has occurred primarily due to the low price of CFLs and the associated cost advantage to the consumer. The sustainable development vision of the government needs to factor in the growing interest in energy efficient products and promote policies to encourage the private sector to manufacture and implement plans for the sale and use of efficient products. The market for such

49 http://greenbusinesscentre.com/energyeffic.asp

50 http://www.aeee.in/

51 http://www.prayaspune.org/peg/energy_home.php

products is easily of the order of tens of billions of dollars and could eventually match the current IT industry.

2.1 National Mission on Enhanced Energy Efficiency

Recently (24 August 2009) the Indian Prime Minister's Council on Climate Change approved “in principle” the National Mission on Enhanced Energy Efficiency (NMEEE). It is said that this Mission will enable several billion dollars worth of transactions in energy efficiency. In doing so, it will, by 2015, help save about 5% of annual energy consumption, and nearly 100 million tonnes of carbon dioxide every year. NMEEE is one out of eight missions, planned under the National Action Plan on Climate Change. Following is a brief overview of the planned actions that are envisaged by BEE under NMEEE, which takes into the EC Act 2001:

<u>Perform Achieve and Trade (PAT)</u>

The Perform Achieve and Trade scheme is a market-based mechanism to enhance energy efficiency in the ‘Designated Consumers’ (large energy-intensive industries and facilities). The scheme includes the setting of a specific energy consumption (SEC) target for each plant, reduction of energy intensity within a three-year period (2009-2012), and trading between consumers who exceed their target and those who fail to meet their target. Not meeting the target may result in penalties. Energy consumption is based on external audit and BEE verification.

<u>Market Transformation for Energy Efficiency (MTEE)</u>

Accelerated shift to energy efficient appliances in designated sectors will be enabled through innovative measures. These products would be made more affordable. This target would be achieved by DSM measures, supported with CDM financing wherever possible. The initiative includes the following activities: National CDM Roadmap, Programmatic CDM, Standards and Labeling, Public procurement, Technology program, Energy Conservation Building Code (ECBC), ESCOs Promotion, Capacity building and information, and Policy transparency.

<u>Financing of Energy Efficiency</u>

The initiative focuses on the creation of mechanisms that would help finance demand side management (DSM) programs in all sectors by capturing future energy savings. The initiative includes the following activities:

- Fiscal instruments: Tax exemptions for ESCOs and Venture Capital funds. Reduction of VAT for energy efficient equipment (e.g. CFLs)
- Revolving fund to promote carbon finance
- Partial Risk Guarantee Fund for loans made for energy efficiency projects by commercial banks

<u>Power Sector Technology Strategy</u>

This strategy is aimed to enhance energy efficiency in power plants through adoption of energy efficient generation technologies in new plants, enhancement of energy efficiency in existing plants, roadmap for IGCC demonstration plants, development of know-how for advanced super-critical boilers, and a road map for fuel shift.

Other initiatives

In addition to the above mentioned activities, following activities will supplement the overall plan.

- Set up a public sector implementing company -- Energy Efficiency Services Ltd.:
- Strengthening of State Designated Agencies (SDAs):
- Strengthening of BEE funding for infrastructure creation to implement 8 new projects/ schemes.
- Awareness Programs

USAID India Energy Efficiency Efforts

For better access to clean energy and water, USAID works with Indian partners to increase viability in the power sector, conserve resources, and promote clean technologies and renewable energy. USAID facilitates sharing of energy and environment best practices between the U.S. and India and among South Asian countries.[52] USAID has been actively engaged in the energy sector since 1980. During the 1980s, it initiated several programs to foster commercialization of energy technologies in India. These included the PACER program which provided investment support to banks that provided revolving loan funds to initiate pilot programs. During the 1990s, the thrust of the program shifted to climate change and in the last decade USAID has focused its efforts on clean coal, power sector reform and energy efficiency. The latter energy efficiency programs include:

- Three demonstration models of excellence in electricity distribution created in partnership with power utilities in four states.
- Executive Business Management Degree Program in Power Distribution institutionalized at one of the top business schools in India. The project increases professional skills of change agents working in the sector – ensuring viability of the power sector.
- Best practices in rural electrification propagated through a collaborative partnership between the U.S. Rural Utilities Service and India’s Rural Electrification Corporation.
- Over 34,000 engineers and managers are now trained in electricity distribution in technical and management best practices to reduce losses in the power sector.
- Development of an innovative business model for agricultural demand side management projects aimed at reducing the water energy consumption in groundwater irrigation -- Water Energy Nexus Activity (WENEXA).
- USAID supported a pilot project on waste water recycling and reuse developed to promote large scale non-potable industrial applications.
- A venture capital fund initiated by Indian financial institutions to support clean technology activities in the private marketplace. ICICI Bank committed $25 million to the “green” fund.

[52] http://www.usaid.gov/in/our_work/program_areas/energy_environment.htm

- The Indian Parliament passed the Energy Conservation Act, a bill developed by the Bureau of Energy Efficiency in partnership with USAID which supports the conservation and efficient use of energy.

USAID and the Ministry of Power and Bureau of Energy Efficiency as (BEE) launched the Energy Conservation and Commercialization (ECO) project earlier in the decade. The ECO project aims to promote widespread commercialization of energy efficiency technologies and services in India, thereby contributing to the reduction in growth of greenhouse gas emissions.[53] It has two main components: (1) Energy Efficiency Market Development and Financing ("Markets" Component), and (2) Energy Efficiency Policy and Institutional Reforms ("Policy" Component). To achieve the purpose of the project, a series of program approaches and activities at the central and state levels were established under the two components. Examples of these include

- Energy efficient and environmentally sound building practices were utilized in the creation of the Green Business Center, the first building to receive the "greenest building in the world" award outside of the United States. Over 60 Indian buildings are now on track to achieve "green" certification.
- State-level Energy Conservation Plan developed and implemented in Maharashtra state, and under development in Punjab and Gujarat states.
- National Energy Conservation Building Codes (ECBC) developed for each climatic zone in the country and launched by Government of India.
- Promoting energy efficiency in existing buildings, municipalities, SMEs, DSM programs and establishment of regional energy efficiency centers

Energy Efficiency Activities of Other Selected Donors

Several other donors have played an important role in supporting EE activities in India over at least two decades. These include multilateral donors such as the Asian Development Bank, Global Environmental Facility (GEF), UNDP, and the World Bank, and bilateral donors such as GTZ. Each has independent offices within India with expertise in energy efficiency and climate change. GTZ also has support staff located at BEE. Examples of activities supported by these donors are noted below.

The World Bank (WB) current energy activities respond to the Indian government's sector development strategy underpinned by Electricity Act 2003 and sector policies.[54] These include energy efficiency support for coal-fired power plant rehabilitation, T&D loss reduction, DSM program on SME chillers and agricultural pump sets. It also supports analytical programs such as the low carbon growth analysis that is being used by the Planning Commission. Overall, South Asia FY 2010 lending is targeted at US$4.8 billion. Earlier WB activities have focused on the role of ESCOs in promoting EE in Brazil, China and India and in setting up a financing mechanism for training and supporting energy efficiency activities in SMEs.

53 http://www.eco3.org/

54 http://siteresources.worldbank.org/INDIAEXTN/Resources/events/359987-1162549840551/SalmanPresentation.pdf

GTZ set up the Indo-German Energy Programme (IGEN) in 2003 in cooperation with Implementation Partners Bureau of Energy Efficiency (BEE) and Central Electricity Authority (CEA), Ministry of Power, Government of India. Its main goal is to improve energy efficiency in the generation and use of electricity, oil, gas, coal and renewable energy in all sectors of the society, contributing to sustainable energy management and climate protection. The primary beneficiaries/stakeholders will be Energy suppliers and consumers as well as manufacturers of appliances. It also set up GTZ-CDM India through a joint agreement between German Technical cooperation (GTZ) and Bureau of Energy Efficiency (Ministry of Power), Government of India, under the Indo-German Energy Program at the same time. GTZ-CDM India is been technical Cooperation partner to National CDM Authority, Ministry of Environment and Forest, Government of India for capacity building and developing carbon market in India since its inception.

GEF too has been active in India since the 1990s. It conducted analytical activities and established projects such as the efficiency improvement of small and medium steel enterprise clusters spread across India and the BERI project on use of biomass for generation of electricity through wood gasifiers among other applications.

3 Current state of energy-efficient technologies and services

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 or in the installation of large commercial buildings that require unique HVAC systems.

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 C). 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. [55,56,57,58] A recently completed analysis by McKinsey confirms this finding noting that India's carbon emissions could be reduced by 30-50% or 2-3 billion tons CO_2/yr by 2030.[59] Table 3.2 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 motors, lighting and air conditioning systems, and variable speed drives are increasingly being utilized. These are cost effective in many applications.[60]

55 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.

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

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

58 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

59 McKinsey and Company Inc. (2009). Environmental and Energy Sustainability: An Approach for India. August, Mumbai, India.

60 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.

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.

The energy efficiency benefits claimed by manufacturers are not always sound, and any commercially available technology needs to be tested to ensure that at a minimum it meets such claims. An example of such testing of LED lamps may be found at a US DOE website.[61] It shows that while the average performance of LEDs has improved from 2007 to 2009, a large number of lamps still fall well below the manufacturer's own claims.

An 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.

One area where India can set the pace is by adopting thermal comfort standards that are more appropriate for tropical countries. After much debate and undertaking a large research program involving more than 21,000 measurements taken primarily in office buildings in tropical countries, ASHRAE[62] prescribed an optional method to quantify thermal comfort that takes into account people's adaptive behavior based on outdoor climate that can be significantly different from thermal responses in buildings with centralized HVAC systems. This combined with the fact that India is experiencing a 35% annual growth in air-conditioning equipment, which is a trend that has been predicted to last until 2016[63]. This reflects a steady rise in the number of air conditioning systems,

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61 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_round_8_summary_final.pdf

62 ASHRAE 55 (2004): "Thermal Environmental Conditions for Human Occupancy", American Society of Heating, Refrigerating, and Air-conditioning Engineers, Atlanta, USA

63 Bradsher, K.: Push to fix ozone layer and slow global warming, March 15 2007, New York Times

which are indispensable in the tropical climate in India with air temperatures up to 50°C in summer. In 2007, 2.3 million of air conditioners have been sold, which is approximately 3 % of the global production[64]. In spite of this, nowadays a little more than 2 % of the Indian households feature a/c, compared to 20 % in Indonesia, 24 % in China, 40 % in Thailand and 45 % in Malaysia[65]. The effect of global warming with predictions of rising temperatures up to 6.4 °C until 2100[66] will push the sales, additionally. This calls for a major national initiative to encourage the use of innovative HVAC technologies (e.g., Radiant Cooling, GSHP, Direct-Indirect Evaporative Cooling, etc.) that has the potential to reduce the energy use by HVAC systems by more than 50%.

In a recent study focusing on public sector efficiency prospects, LBNL estimated the size of the public sector buildings market. Government owned buildings and other public sector buildings account for over 30% of the existing stock of commercial floor space in India, and consequently a significant proportion of the energy use. Given its relatively large size, this sector presents a unique opportunity to study the savings potential from implementing specific efficiency measures. In addition to the scope for improvement, the public sector plays a leadership role in demonstrating or leading by example towards a greener and more energy efficient path. LBNL's preliminary analysis of the opportunities to reduce total energy consumption indicates that cost-effective savings of at least 9% can be achieved through improvements in selected technologies for space cooling and lighting for replacement in existing buildings and new construction in hospitals, offices, and schools.

Table 3.2: 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%
Agricultural – 8 HP**	9987	4244	42.5%
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%

64 JARN 2008: 2007 World Air Conditioner Market

65 Construction World - Indian Edition 2006: How Cool is That?

66 IPCC: Summary for Policymakers, 2007

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 ; ** Based on USAID 2008[67].

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

As part of its ongoing efforts in this sector, BEE has initiated energy audits in public buildings. Under the 1st phase of the Govt. Buildings Programme, nine public buildings of high visibility were audited for potential savings opportunities. Energy saving potential in the range of 23% -46% has been identified through energy audits conducted in government/public buildings. In the 2nd Phase of this program, 17 additional Government buildings have been recently undertaken using performance contracting model under the ESCO route. The program is continuing presently.

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. Specific final energy consumptions in all major energy intensive industries have reduced considerably over the last 20 years. For example, in the case of iron and steel, final energy consumption decreased from 45 GJ/tcs (excluding energy used for coke making), to an estimated 29.1 GJ/t in 2006. Similarly in the case of the fertilizer industry, the decreased has been impressive. A recent study[68] from the Fertilizer Association of India estimates that the weighted average energy consumption of all ammonia and urea plants in 2007-08 was reduced by about 30% from the level of 1987-88. Improvement has occurred because of (3) government macro policy for instance the shifting of fertilizer production towards increased use of natural gas[69], (2) stricter environmental regulations as in the case of chlor-alkali production,[70] and/or (3) economic considerations. 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)[71] and the second best energy efficient cement plant[72] in the world today

67 USAID 2008. Financing Agriculture Demand Side Management (Ag DSM) Projects Revised Edition August 2008

68 Nand S. and Goswami Manish, 2008. "Recent Efforts in Energy Conservation in Ammonia and Urea Plants", the Fertilizer Association of India, Indian Journal of Fertilizers, December 2008, Vol. 4 (12), pp. 17-20 (4 pages),

69 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

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

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

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

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.[73]

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.[74] 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. Inclusion of labor and material cost savings during the operation of an efficient iron and steel plant, however, increases the potential to 3.8 GJ/tonne of output at the same cost. More importantly, the ranking of technologies changes dramatically; an oxy-fuel burner ranked # 41 when only energy cost savings are factored in becomes the # 1 technology to implement when cost savings of other factors are included. Inclusion of all resource benefits thus is crucial to understanding the full cost impacts of a technology. This may be particularly relevant to end-use energy efficiency technologies whose main goal often is not providing or saving energy but providing some other form of service or the production of an industrial good.

The utilization of waste heat[75] in all types of commercial and industrial establishments can provide a significant benefit. Waste heat is generated in a process by fuel combustion or chemical reaction, and is "dumped" into the environment even though it could still be used for some useful and economic purpose. The essential quality of heat is not the amount but its heat value. How to recover it depends on the temperature of waste gases and the economics involved. A large quantity of hot gases is generated in boilers, kilns, ovens and furnaces. If some of this waste could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered. However, much of the heat could be recovered and loss minimized by adopting various measures. Waste heat of low temperature range (0-120°C) could be used for the production of biofuel by growing of algae farms or could be used in greenhouses. Waste heat of medium (120-650°C) and high (>650°C) temperature could be used for the generation of electricity via different capturing processes. Units or devices that could recover the waste heat and transform it into electricity can use an organic Rankine cycle with an organic fluid as the working fluid. The fluid has a lower boiling point than water to allow it to boil at low temperature, converting it to a superheated gas that could drive

73 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

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

75 http://www.bee-india.nic.in/GuideBooks/2Ch8.pdf

the blade of a turbine and thus a generator. Another unit like the thermoelectric can transform the change of heat between two plates directly into a small DC Power which could be amplified to produce usable electric power. The potential for CHP (Combined Heat and Power) in India based on a survey by TERI of 300 industries as reported by IEA is estimated to be about 7.5 GW with a high end of 10 GW.[76]

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.[77]

4 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.[78] These programs are being designed and implemented by governments at all levels, industries and industry associations, public-private partnerships, and non-governmental organizations. In India, the central government, designated state agencies, 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 and utility demand-side management (DSM) programs. In both sectors, we report on programs at the state and local (city) level and those at the federal or central government level. We review programs in 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.

4.1 Central government programs:

Electricity use in the residential and commercial sector increased to 33% of the total consumption in 2007-08 from 24% in 1994-95.[79] 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:

76 http://localpower.org/documents/IEA_India.pdf

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

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

79 Govt. of India (2006) Economic Survey, 2006, New Delhi, India. and Central Electricity Authority (2009) All India Electricity Statistics: General Review 2009. New Delhi, India

- Evolve minimum energy consumption standards for notified equipment and appliances
- Prohibit manufacture, sale and import of equipment and appliances not confirming to standards
- Introduce energy performance 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 3.2, refrigerators and distribution transformers appear to be the ones that provide the largest percentage savings.

Market research conducted for BEE recently as a part of the refrigerator and air-conditioner labeling program shows an exponential growth in the number of consumer electrical/electronic appliances in Indian households. The issue of standby power used by these products is of increasing importance. An effective labeling program has the potential to significantly reduce energy use and GHG emissions.[80] Some of the consumer electronics /electrical products, such as TVs, computers, monitors, and ceiling fans, are included in the list of priority products for labeling in the BEE's Action Plan.

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.[81]

BEE with support from USAID ECO-II Project and a Committee of Experts developed Energy Conservation Building Code (ECBC) with an overall purpose to provide minimum requirements for energy efficient design and construction of buildings. In May 2007, Ministry of Power (MOP) launched ECBC for its voluntary adoption in the country. Since then BEE has been promoting and facilitating its adoption through several activities. USAID ECO-III Project has been assisting BEE in these capacity building efforts. As per the EC Act 2001, the State Government has the power to amend the provisions of ECBC to suit regional and local climatic conditions, in consultation with BEE and MOP

Base-lining and Benchmarking of Existing Buildings

Under a joint initiative taken by BEE in partnership with the USAID-ECO-III project (http://www.eco3.org), end-use energy consumption data has been collected for the first time using standardized forms at the building level. Preliminary results from the study are shown in Table 3.3.

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80 BEE has requested technical assistance from international partners including USEPA and USAID for labeling for consumer electronics (CE) products.

81 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.

BEE has recently has taken an initiative to establish energy base-lining and benchmarking of commercial buildings in India, with an aim to assist building owners and other stakeholders to evaluate and track energy efficiency performance of buildings, and also give recognition to the top performers. In addition, BEE has also started a Star Rating and Labeling Program to rate both air-conditioned and non- air-conditioned office buildings on a 1-5 Star scale, with 5 Star labeled building being the most efficient. Energy Performance Index (EPI) in kWh/sqm./year is being used for rating the buildings. Buildings having a connected load of 500 kW and above are being considered for the Program. The Program is targeting buildings initially in three climatic zones - Warm and Humid, Composite, and Hot and Dry. It is envisaged that the Star Rating Program for buildings would create a demand for energy efficient buildings in the market.

Table 3.3: Benchmarking of Buildings, India

No. of Buildings	**Type of workplace**	**Floor Area, m^2**	**Annual consumption, kWh**	**Annual consumption, kWh/m^2**
74	Office buildings - one shift	15,100	23,77,208	173
34	Office building - 3 shifts	12,729	38,20,288	374
40	Hotel	23,219	51,62,460	251
9	Multi Specialty Hospitals	22,010	49,61,344	232
15	Secondary Government Hospitals	20,385	10,46,972	54

Indian Green Building Council established at Confederation of Indian Industry with partial support from USAID, has been promoting LEED Green Building Rating Program which takes into account both environmental and energy efficiency aspects. Green buildings population is increasing rapidly. At present, there are 39 green buildings in India which are certified under LEED green building rating program. India’s green building footprint has reached 265 million square feet area with 397 buildings registered for LEED rating. These projects are mainly coming-up in sectors like IT offices, Data Centers, airports, schools and colleges, Indian corporate and public sector office buildings, factory buildings, hotels, residential housing, etc.

Ministry of New and Renewable Energy (MNRE) has also initiated a program ‘Green Rating for Integrated Habitat Assessment (GRIHA)’ for rating of buildings focusing on the utilization of renewable energy sources in buildings. In view agro-climatic conditions in India and promotion of non-AC buildings, GRIHA has been developed for all kinds of buildings (commercial, institutional, and residential) in different climatic zones of the country. The system was initially developed by The Energy and Resource Institute (TERI) as TERI GRIHA but later modified and renamed as GRIHA by MNRE after incorporating various modifications suggested by a group of architects and experts. GRIHA rating system takes into account the provisions of the National Building Code 2005, the Energy Conservation Building Code 2007 and other IS codes. MNRE also provides incentives to Architects for designing GRIHA rated buildings.

4.2 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 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 and DSM programs that are mostly though not always managed by the utility companies.

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 Maharashtra, Delhi, Madhya Pradesh, Uttar Pradesh, and Karnataka.[82] 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.[83] In another example, BESCOM in Karnataka initiated a program to promote the use of CFLs.[84] Other State Electricity Regulatory Commissions (SERCs) such as those in Chhattisgarh, Gujarat, Madhya Pradesh, and West Bengal are considering starting similar programs.

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.

82 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

83 MERC (op. cit.)

84 BESCOM (op. cit.)

The Maharashtra Public Works Department (MPWD) has identified energy savings opportunities in government buildings. [85] 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. [86] 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.[87]

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 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 utility companies.

Best Practices: Table 3.4 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.

85 With support from US EPA and US AID, LBNL has assisted the Maharashtra government in identifying opportunities to reduce electricity consumption in the public sector.

86 MPWD presentation at PEPS-India Workshop in Mumbai, September 2005

87 Ibid

Table 3.4: Energy Efficiency Policies and Programs – Summary of Best Practices for Policies and Programs in the Buildings Sector

Program Design and/or Development	Program Adoption and/or Implementation	Program Monitoring and Evaluation
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 EERS 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 additionally 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 analysis of codes. 12. Provide budget and staff for the program, and train staff	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

Source: Adapted from information on best practices in US EPA (2006). *Clean Energy-Environment Guide to Action: Policies, Best Practices, and Action Steps for States*. http://www.epa.gov/cleanenergy/energy-programs/state-and-local/state-best-practices.html..

5 Policies and programs for the promotion of energy efficiency: Industry Sector

More than 40% of the primary commercial energy consumed in India 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.

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 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.[88]

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.[89]

BEE has recently initiated conduct of Energy Use and Technology Audit and preparation of Detailed Project Report for 25 SMEs clusters in India. The preliminary findings on energy consumption and production data has been collected for various clusters. Further work is continuing.

One of the focus areas of USAID's ECO-III Project has been on the improvement of energy efficiency in SMEs. The Project has observed that implementation of energy

88 IGEEP, n.d.

89 www.undpgefsteel.net.

efficiency projects require due diligence for packaging the right mix of short and long term measures. Often, the management is eager to adopt 'no and low cost measures' but normally need more outside help for better understanding of energy efficient technologies and technical information on the implementation of energy efficiency opportunities. Regarding financing of energy conservation projects, Indian banks so far have not moved in the direction of cash flow lending to SMEs. Higher transaction cost for the projects is a deterrent. Synergic relationship among energy auditors, equipment vendors, concerned institutions, and management specialists could help in developing appropriate solutions to share costs, risks and benefits of energy efficiency program in SMEs.

6 Key barriers to market penetration in India

As stated in the introduction, most energy efficiency technologies are cost effective when compared with the cost but not necessarily the price of energy supply. Electricity tariffs in India range from less than Rs. 0.5/kWh for subsidized agricultural customers to Rs. 10/kWh or more for commercial customers. Energy efficiency is thus not cost effective when compared with the low tariff price since its cost ranges upwards from Rs. 1/kWh. The market penetration of energy-efficient technologies is often hampered by barriers[90] 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.[91]

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 market impediments and failures that both must work together to overcome. Some of the most significant market barriers and steps to address them include:

- Higher first cost of efficient technologies. Most EE technologies are cost effective from a life-cycle cost perspective but typically have higher first cost. Because consumer discount rates are many times higher than societal discounts rates the higher first cost serves as a major disincentive to customers.
- In case of buildings, a related barrier to the higher first cost is the split incentive between builders and buyers of buildings and landlord and tenants who are not individually metered. Because of the first cost barrier, builders have a tendency to install cheaper less efficient equipment that has higher life cycle cost. Split-incentive between landlords and tenants results from lack of metering of individual rental property thus discouraging tenants from using the installed equipment more efficiently and from purchasing efficient equipment.
- Absence of better information about efficient technology and EE products. This barrier may result from inadequate or hyped up information that a product may be

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

91 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

labeled with by the manufacturer or supplier of the equipment. It may also result from lack of a consumer's ability to decipher the available information.

- Uncertainty about the performance of a new product is common cause of reluctance to purchase a product. Often EE products that are new on the market suffer from lack of trust, limited product warranty or lack of credibility about a warranty. This issue is particularly acute where suppliers are unwilling to take the product back after its performance has been demonstrated to be poor.
- For less energy-intensive industrial processes, energy costs tend to be a small fraction of the total cost of production, which serves as a disincentive for manufacturers to focus on efficiency options.
- Efficiency programs and policies may lack adequate legal backing to be pursued by utility companies or other entities. In India, the BEE was established as mandated by the Energy Conservation Act, but state-level electricity efficiency programs that could be pursued by utility companies faced with massive electricity shortages are challenging to initiate.
- Subsidized tariffs for agricultural and residential customers serve as a disincentive to energy efficiency programs. These are particularly a problem in the agricultural sector, where bulk of the customers are not metered and do not have a separate feeder making it difficult to promote efficient pumpsets and motors since the reduced consumption does not result in reduced electricity costs to the customer.
- 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.
- 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.
- Lack of EE service providers is a critical issue. Most of the attention in the energy sector has traditionally focused on energy supply, which is also evident in the enormous interest expressed in solar power over the past few months. EE experts particularly those with evaluation, monitoring and verification skills are lacking in the country.
- Standardized documents such as protocols, templates, contracts, etc. – One of the hurdles cited by various stakeholders in the energy efficiency sector is lack of standardized documents and templates that can be quickly adapted with minimal revisions for implementation. Examples of such documents include but are not limited to – demand-side management (DSM) program designs, load research survey questionnaires, ESCO performance contracts, and measurement and verification protocols. Such documents are being developed in both the U.S. and India and collaboration between the two could leverage experience in the two nations for better products.

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.[92] 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.[93]

Economic Gains – Who benefits from increased penetration of efficient products and efficiency services? 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. An 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.[94] It would thus be to MSEB's benefit to promote a program on agricultural efficiency.

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

A recent study of the macro-economic benefits of demand-side electricity efficiency improvements in India illustrates that energy efficiency costs are only a fraction of those for supply, and offer a way to eliminate the electricity deficit without increasing direct investment in capacity addition (Sathaye and Gupta, 2009)[95]. This study shows that energy efficiency offers a way to alleviate the deficit while potentially increasing India's

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92 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.

93 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

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

95 Sathaye J. and Gupta (2009) Reducing electricity deficit through energy efficiency in India: An evaluation of macro-economic benefits. LBNL Report Draft.

economic output by US $320 to 500 billion and employment opportunities by over 11-33 million person-years over the next eight years by the end of the Twelfth Five Year Plan (2012-2017). However, these impacts vary by the exact nature of the deficit, the rate of energy efficiency technology penetration and other variables. In addition to output and employment, removing the deficit also reduces the fiscal deficit by reducing subsidies and government capital outlay. An important conclusion from this study is that the low-voltage (LV) industrial sector and the commercial sector, which along-with the domestic sector usually experience electricity cuts during times of shortage, are actually more productive per unit of electricity consumption than the high-voltage industrial sector, which rarely experiences electricity cuts. Thus, the Indian economy would greatly benefit if the removal of electricity shortages in the more productive LV industrial and commercial sectors were given the highest priority. These results are robust even under conservative assumptions.

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.

7 Gap analysis and recommendations:

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 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 local environmental and global warming 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. Many of these were discussed in the 2006 and 2009 background papers[96] and those that are already being implemented are noted below.

96 Sathaye et al. (2006). Implementing End-use Efficiency Improvements in India: Drawing from Experience in the US and Other Countries. LBNL – 60035, and Sathaye et al. (2009). Energy Efficiency and Sustainable Development –Potential for US-India Collaboration in Buildings, Industry and the Smart Grid, LBNL-xx

The key feature that US-India collaboration may to focus on is how best to scale up existing or past pilot energy efficiency programs that have either perished or are expanding slowly. As noted in the description of programs in India the Indian government has experimented with many energy efficiency projects and programs in the past but nor all have continued or expanded. In addition to the barriers listed in Section 6, several factors have played a role including lack of private sector involvement and legal backing for programs, frequent movement of champions, start-up inertia, market structure, etc. The NMEEE described in Section 3 offers several policy options that can support the scaling up effort. Additional government and industry policies can help overcome these barriers and US support can accelerate these improvements.

7.1 US-India cooperation

Peer-to-peer exchanges between US and Indian governments, industry, financial and academic institutions, and other entities that have similar energy efficiency goals and activities will help maximize benefits of US-India cooperation. At the federal level, the US DOE and EPA have 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 and city governments, utility companies and commissions, industry associations and several foundations have similar magnitude of expertise for promotion of energy efficiency. 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 expanding collaboration with the US. In the last three years since the 2006 USAID-DOE Delhi Conference, several MOUs have been signed between counterpart US and Indian organizations. These offer a core set of activities for similar cooperation among other institutions. Examples of these MOUs are noted below.

State-State:

LBNL has signed MOUs with Maharashtra and Delhi Electricity Regulatory Commissions (ERCs) and with the Forum of Regulators (FOR) in 2007 and 2008. California Energy Commission and the Public Utilities Commission are partners in this effort. The MOUs form the basis for providing technical support to the participating state ERCs. In addition to Maharashtra and Delhi, these include Chhattisgarh, Gujarat, Madhya Pradesh, and West Bengal. Maharashtra and Delhi have already approved funds as part of their Annual Revenue Requirement (ARR) process for DSM programs in their states totaling about $25 million and other states are considering doing similar budget allocations for initiating load research and DSM programs.

City-City:

Brookhaven National Laboratory (BNL) and DOE's Office of Energy Efficiency & Renewable Energy (EERE) recently facilitated a memorandum of understanding between the cities of Atlanta, GA, and Ahmedabad in India, initiating a first-ever US-India cities partnership to share best practices in sustainable development, energy and environment.[97] Under this program, other Indian cities such as Delhi, Mumbai, Chennai, Bangalore,

97 http://www.bnl.gov/today/story.asp?ITEM_NO=655

Bhubaneswar and Vadodara will partner with U.S. cities including Chicago, Denver, Columbus, Los Angeles, and San Francisco.

US-India Clean Energy Deployment Center (CEDC):

As the USG moves forward in addressing global climate change (GCC) issues through the Asia Pacific Partnership and other bilateral programs, assistance to clean energy development efforts in India assumes major significance. Success in mitigating GHG emissions through technical assistance and capacity building in India will set the pace and direction for international efforts that have a global impact. Clean energy technology innovation, GCC research centers, trade, investment and harnessing India's IT prowess in addressing GCC issues will be a vital and necessary part of the solution.

The proposed US-India CEDC program aims to advance the rapid application of energy efficiency in key growth sectors in India, scale-up commercially viable renewable energy technologies and accelerate the movement of low carbon commercial technologies into the market place. *The envisaged program will foster institutional and commercial alliances between key US and Indian stakeholders – regulatory and policy bodies, financial institutions, equity investors, national labs, energy utilities, public & private enterprises at state-to-state and city-to-city levels aimed at moving clean energy technologies into the Indian market place.* Specifically CEDC would focus in creating technology transfer, trading and investment partnerships that increase jobs in India and the US in areas of mutual interest including renewable energy (solar and biofuels), clean coal and energy efficiency. Based on the meetings with Indian experts during the January 2010 team visit, the energy efficiency focus areas may comprise of:

1) Industry – particular focus on energy intensive industrial processes, viz. steel, non-ferrous metals, chlor-alkali, etc. Other areas to be targeted include:
    a) Small and Medium Enterprises (SMEs): assistance in developing energy management capability of energy intensive industries through the development and maintenance of EM tools, training, certification and quality assurance
    b) Waste heat utilization
    c) Create green industry organizations such as Green Plumbers India that has five chapters and trained 1500 green plumbers in India.
2) Sustainable buildings -- including technology and applications leading to net-zero and positive energy buildings and creation of district cooling systems for multiple malls. Focus on
    a) Water and carbon positive buildings and enterprises
3) Smart grids – support the transition to a smart electric grid system in India that is cleaner, more efficient, reliable, resilient and responsive
4) Mass market technologies -- Lighting and appliances – particularly focused on national or multi-state incentive programs that are targeted at manufacturers of white goods

5) Banks -- Setting up a revolving fund financing mechanism at banks (e.g., ICICI and State Bank) to initiate pilot projects that can be replicated through continued bank financing.

   a) Work with Reserve Bank to target their buildings and also set up financing mechanisms based on this model.

6) Agricultural energy and water use – Scale up energy efficiency programs to reduce pumping electricity load, and as a co-benefit extracted ground water, in the sector

7) Power Sector – Scale up energy efficiency programs in power plants and through demand-side management (DSM)

8) Educational and training institutions – Provide support for capacity building through universities and industry associations

9) Government and utility companies -- Load research and analysis to inform electricity suppliers of the key end-uses that are driving load by the hour and season, and establishment of periodic surveys of energy use in the residential, commercial, and industrial sectors.

10) Technical assistance to BEE, FOR, state and local institutions and energy consumers to assist in the implementation of NMEEE

11) Need to set up a reliable entity perhaps like the CDM Designated Operating Entities to undertake credible M&V.

12) Engage universities and IITs in seeking training of energy efficiency experts and for development and deployment of new technologies

13) Multiple entities need to participate in promoting energy efficiency across India including national, state and local governments, industry, and financial and academic institutions.

Both countries may pursue joint research in the above energy efficiency areas of mutual interest based on the availability of resources and institutional capacity. The proposed partnership would advance the objectives of the Energy and Climate Change pillar by focusing on supporting commercial, market driven clean energy components, associated with greenhouse gas mitigation. The CEDC, thus would be a key step in harnessing and helping implement the inherent synergies between discussions of climate change and clean energy. *It is envisaged that the CEDC would be guided by the strategic intent and direction of the GoI's National Action Plan on Climate Change, July 2008 and subsequent policy documents such as the National Mission on Enhanced Energy Efficiency***.**

Table 3.5 provides a summary description of the various activities and policies that would help in promoting the deployment of energy efficiency technologies and practices. The first column in the table lists examples of activities/programs that are of interest to Indian institutions that were visited by the national labs assessment team in January 2010. The remaining columns show the policies that are being pursued or of interest to these institutions. The policies include pilot demonstrations of technologies and/or processes, DSM programs, voluntary standards, codes, and labels, financial incentives that include fiscal incentives, revolving funds, and risk guarantees, industry and/or government procurement initiatives, minimum energy performance standards, collection of data on a multi-year basis such as the US RECS, CBECS and MECS programs, the perform, achieve and trade (PAT) program proposed under NMEEE, and the clean technology access and information and capacity building programs. The last two programs are noted in all the rows since the two form the core support for all the listed activities/programs. Data collection and analysis and load research are not directly tied to technology deployment but are important elements that constitute core activities of energy efficiency programs. The need for monitoring and verification (M&V) varies depending on where in the market penetration curve the policies are being implemented. All the policies prior to the peak of the penetration curve would benefit with monitoring by the user/implementer combined with verification by a third party. Later in the curve the monitoring may be done by a government agency to ensure that the manufacturer meets the standards for example.

Many of the policies noted in Table 3.5 are already in place for accelerating the market penetration of efficient products. However, their use depends on the level of market penetration of a product (Figure 3.5). Pilot demonstration programs would clearly be the first policy to demonstrate the viability and energy and other benefits of a technology. Once the technology is demonstrated it is important to let consumers know about its performance through labeling schemes such as the 5-star labels that are already in place for many products in India or through codes such as the Energy Conservation Building Code (ECBC). Depending on the type of product (not all products are suited for 5-star labeling) its penetration can be accelerated by providing different types of financial incentives, procurement of products, and/or DSM programs either after the labeling is completed or without the labeling. A mature technology does not require further incentives and once the product penetration reaches the peak in Figure 3.5, minimum energy performance standards (MEPS) may be put in place to ensure that products below this level are not sold in the market. (The lowest level of a mandatory 5-star label constitutes the same value as the MEPS.) Capacity building and information and access to clean technologies are programs that will be useful throughout the cycle but particularly so before the penetration reaches the peak value.

Table 3.6 is an extension of the previous table. It shows the roles of various government and other agencies that are already operational in India for each of the policy categories. In addition, it also shows the roles that US agencies could play in providing support for deployment of technologies and programs in the country. US assistance could take the form of capacity building and provision of clean tech technology identification and information and also as a means to transfer pilot program technologies and for assisting in the implementation of PAT programs.

8 Summary

Energy efficiency offers a cost-effective solution to overcoming many environmental and economic concerns that is almost entirely within the control of the Indian government and private sector. It has the potential to eliminate India’s electricity shortage, reduce environmental pollution in urban areas and rural households, and decrease India’s contribution to emissions of greenhouse gases while increasing the country’s economic output by as much as $350 billion between 2009 and 2017. Efficiency improvements will also lower India's vulnerability to potential oil and gas supply disruptions, and the volatility of petroleum crude prices. As part of its National Action Plan on Climate Change the Indian government has approved a singular National Mission on Enhanced Energy Efficiency that will help accomplish the aforementioned benefits.

A US-India strategic partnership aimed at building capacity to conduct research, developing new technology solutions, and designing and implementing energy efficiency programs will facilitate faster and cheaper acquisition of the energy efficiency resource for both countries. Improving the country's energy productivity will require a concerted effort by all sectors of the economy including government, private, educational/research institutions, and non-profit organizations.

This report was prepared to provide an assessment of the energy efficiency opportunities in India. It builds on the information provided in the EE background report for the 2006 and 2009 USAID-USDOE-MoP conferences and highlights energy efficiency technologies, barriers, and policies and deployment and market transformation strategies that could be pursued in India under the US-India Clean Energy Research and Development Initiative (CERDI). The paper discusses the lessons to be learned from these experiences, conditions that would accelerate and scale up energy efficiency penetration in India, and ways to foster cooperation between the two countries at the national, state and city level in the buildings, industrial and power sectors.

Several energy efficiency measures with considerable savings potential involve technologies that are either not available or not yet widely manufactured in India. Targeted efforts are needed to promote the widespread production, availability, and use of such products in appliances, buildings, industry, and smart grid sectors. In this report various technologies and policies/programs pertaining to energy efficiency that could assist India are discussed along with policies and programs to foster their penetration. Tables 3.5 and 3.6 and Figure 3.5 show the list of policies and programs and their relevance to various efficiency activities. Table 3.6 also shows the Indian institutions that are in a position to design and implement the various policies and the role that US could play in assisting these institutions.

1. Development of Codes, Standards, and Protocols - Data and analysis to support policies and joint US/India research on specific technologies for waste heat utilization, lighting and space conditioning would yield significant benefits.

a. Waste Heat Utilization -- The utilization of waste heat in all types of commercial and industrial establishments can provide a significant benefit. Waste heat is generated in a process by fuel combustion or chemical reaction, and is "dumped" into the environment even though it could still be used for some useful and economic purpose. A large quantity of hot gases is generated in boilers, kilns, ovens and furnaces. If some of this waste could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered. However, much of the heat could be recovered and loss minimized by adopting various measures.

b. Appliance labels and standards – India has released 5-star labels that provide equipment energy use information, while the US specifies minimum energy performance standards (MEPS) and Energy Star labels for appliances. Continued

US-India collaboration on developing labels and standards to cover other appliances relevant to India, while sharing latest technological breakthroughs about practical minimum energy use will be a valuable asset to both countries.

c. Building codes – Similar to labels and standards for appliances, codes for construction and commissioning of buildings can specify energy performance metrics for building systems (e.g. daylighting, glass-to-opaque ratio, white roofs, etc.). India is experiencing a 35% annual growth in air-conditioning equipment with only 2% of households featuring AC. This calls for a major national initiative to encourage the use of innovative HVAC technologies (e.g. radiant cooling, GSHP, direct-indirect evaporative cooling, etc.) that has the potential to reduce the energy use by HVAC systems by more than 50%. Since bulk of the buildings will continue to have no AC, adoption of thermal comfort standards that take into account people's adaptive behavior based on outdoor climate as prescribed by ASHRAE will help in improving occupant welfare. A US-India collaboration on developing thermal comfort codes to cover various building systems and at the same time keep updated with latest technological breakthroughs will be valuable.

d. Standardized documents such as protocols, templates, contracts, etc. – One of the important barriers cited by various stakeholders in the energy efficiency sector is lack of standardized documents and templates that can be quickly adapted with minimal revisions for implementation. Examples of such documents include but are not limited to – demand-side management (DSM) program designs, load research survey questionnaires, ESCO performance contracts, and measurement and verification protocols. Such documents are being developed in both the U.S. and India and collaboration between the two could leverage experience in the two nations for better products.

2. Demand-side Management (DSM) Programs and Delivery Mechanisms

a. Load research – A key element of electricity supply planning and operations is knowledge about the customer demand profile. Load research is designed to collect data and information about electricity use and power demand profiles. This research requires regular surveys of customers in all tariff classes. In India, this is knowledge is not available due to the absence of such surveys. US-India cooperation can help in institutionalizing such data collection within the Indian power system.

b. Appliance market transformation – The key barriers to rapid market penetration of energy efficient appliances include limited access to efficient appliances, high first-costs, low awareness levels, and lack of resources (e.g. economic, technical, organizational, etc.) to overcome these barriers. Implementation of DSM programs at state and national scales that would engage utility companies, state and central regulatory commissions and the Bureau of Energy Efficiency (BEE) would be an effective approach to promote market transformation. Within DSM, load research, program design, and monitoring and verification are key areas where collaborative efforts would be effective. A clear legal mandate, however, is essential but lacking for utility companies to participate in DSM programs.

Regional or even global programs such as the "Golden Carrot" program for the introduction and adaptation of superior energy efficient refrigerators and other appliances can facilitate rapid market transformation. Such opportunities could be realized through innovative financing mechanisms with costs and risks shared among vendors, state utilities and governments. An international scheme to promote such programs would also benefit US and India and lead to significant CO_2 reductions globally.

c. Retrofitting buildings through performance contracting mechanism – Unlike the appliance markets transformation programs, a useful mechanism for achieving energy savings in existing buildings is via performance contracting projects. Facilitation of the contracting process involving the building owner, Energy Service Company (ESCO), and financing entity (e.g. banks or utility companies) can allow the market for energy services to function more efficiently. Increased US-India collaboration in this arena can help educate and create awareness about this delivery mechanism among all relevant stakeholders.

d. Demand Response (DR) – In the U.S. there is a long history of utilities and independent systems operators (ISOs) providing programs and incentives to customers to reduce their energy consumption during short periods of time to address system reliability and cost concerns or high spot-market prices without having to build new supply capacity and for increased grid reliability. India faces peak period shortages that are currently resolved by implementing rolling blackouts. DR programs similar to those implemented in the U.S. have the potential of reducing the rolling blackouts by incentivizing at least the large customers to shift their load from peak to off-peak periods. Sharing of DR technologies, policies, and innovative tariff designs (e.g. dynamic pricing) between India and the U.S. would be very useful in reducing potential blackouts and also as a hedge against high spot-market prices.

3. Pilot technology programs with financial and procurement incentives

   a. Financial institutions such as ICICI in India have worked over the years in providing revolving funds to set up pilot programs in various sectors. Most of these programs were successful but their scale up has been relatively weak. The pilot programs have large potential and assisting these and other institutions to scale up the successful programs would help speed up the deployment of efficiency technologies.

4. Analysis and Research, Development, and Demonstration (RD&D)

   a. Analysis – Conducting in-depth analysis such as estimation of energy efficiency potential, cost-effectiveness, efficiency of program and/or delivery mechanisms, etc. is an ongoing activity where US-India collaboration for sharing information about future technologies, tools/methods, and skills would be valuable.

   b. Benchmarking – Comprehensive databases of energy efficiency measures, building energy consumption, retrofit projects, case studies, best practices, etc. are very useful in developing the next set of policies, programs, and technologies. Benchmarking of building and industrial processes so that comparisons may be made with global energy efficiency performance would help in informing builders and industry of their potential for improvement.

c. Emerging technologies – RD&D with emphasis on technology commercialization and/or adaptation (to adapt foreign technologies to the Indian market) will accelerate the penetration of emerging technologies. Lighting technologies would be a critical item to focus on since lighting in all its applications is the largest cost-effective efficiency potential load in India and the US. Smart grid technologies would be invaluable to reduce distribution loss and to control peak load shortages and offer opportunities for collaboration between the information technology (IT) and control systems industries in the two countries.

5. US-India State and City Level Cooperation:

   a. State to state cooperation is important because both in the US and India the electricity sector is primarily governed by the state government. A state has its own independent regulatory commission(s) in both countries, and currently cooperative activities have been initiated in Maharashtra and Delhi with the support of US DOE and State Department. These are ripe for expansion to other states under MOUs signed by India's Forum of Regulators with counterpart commissions in California, and LBNL. Other US states and utility companies are also eager to share information about smart grid and demand response programs.

   b. City to city cooperation is also ongoing with DOE support and MOUs have been signed between cities in the two countries. DOE/Brookhaven National Laboratory (BNL) facilitated signing a memorandum of understanding (MOU) between the cities of Atlanta, GA, and Ahmedabad in India, initiating the first-ever U.S.-India cities partnership on energy, in March 2008. DOE/BNL will provide technical assistance for developing 1) new eight satellite towns on the concepts of 'zero energy', 2) energy efficient urban planning guidelines, and 3) green building guidelines in the future..

6. Education, awareness, and technical assistance

   a. Information sharing - Public sector buildings constitute a potential that is entirely within the government's jurisdiction to accomplish. White roofs, lighting and space conditioning constitute significant cost-effective potential in this sector. Sharing of knowledge and information about designing and implementing governmental procurement policies for energy efficient goods between the two countries would help in accelerating their penetration.

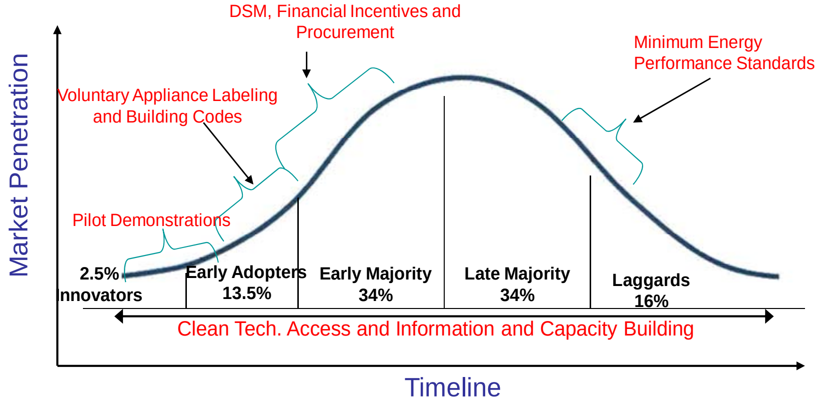
   b. Training and capacity building – Human resources for implementing energy efficiency activities need to be developed on a massive scale in India. Energy efficiency programs such as DSM are in their infancy in India and capacity for their design and implementation is lacking. The U.S. has broad and deep experience in most facets of energy efficiency activities. This experience – appropriately adapted to the Indian conditions – is currently being shared with Indian practitioners through training and capacity building workshops. Bringing these up to scale will benefit Indian practitioners from all stakeholder organizations – policymakers, regulators, utilities, manufacturers, evaluators, NGOs, etc.

c. Assistance organizations - Establishing test procedures that allow for regular testing and dissemination of results of such technologies would increase consumer confidence. Organizations that serve as technical resources – e.g. architects/designers, legal support, technical support, appliance awareness, demonstration of prototypes, etc. – can leverage the experiences that both India and the U.S. achieve

6. Energy efficiency centers that specialize in buildings, industrial furnaces, and appliances have been established in India with support from BEE/NEDO and USAID. These centers are intended to provide support for the development of cutting edge technologies and to foster their market penetration. The development of similar centers for other sectors and technologies would help accelerate their development and penetration in India.

Many of the above activities could be designed and implemented through a joint US/India Clean Energy Deployment Center (CEDC) for with staff that is capable of conducting science, technology and policy essentials. A joint center would permit exchange of ideas and information across the policy and analysis, technology, and science elements and foster a more rapid development and penetration of energy efficient technologies.

Figure 3.5: Accelerating Market Penetration of Technologies



In conclusion, USAID/India's four decade long experience in India in the energy sector, specifically in the development and promotion of clean coal technologies, energy efficiency and renewable energy development provide it with a unique understanding and a partnership base for launching a credible program in India. DOC with the support of DOE, EXIM, TDA will establish long term sustainable exporting and investment relationships through a series of targeted trade missions in RE & EE aimed at matching US and Indian firms and advance understanding of the right policy and regulatory environments that will allow businesses to grow. As a next step a design team comprising USG agencies (AID, DOC, OES/State and DOE) may be constituted and authorized to prepare the design and implementation modalities of the CEDC program in collaboration with the GoI and other private and public stakeholders.

Table 3.5: Energy Efficiency Policies and Programs in India

Projects/Program Activity Examples	Pilot Demonstrations for New Technologies or Programs	Demand-Side Management (DSM)	Voluntary Labels and Standards incl. ECBC	Financial Incentives – Fiscal, Revolving Loans, Risk Guarantee	Government and/or Industry Volume Procurement	Minimum Energy Performance Standards	Periodic (Years) Data Collection and Analysis – National Scale	Perform, Achieve and Trade	Clean Tech. Access and Information	Capacity Building
Net-zero energy buildings	Y	Y		Y	Y		Y (All buildings)		Y	Y
Waste-heat utilization	Y	Y		Y					Y	Y
Energy-intensive industry						Y	Y (All industrial Sectors)	Y	Y	Y
Power Plants								Y	Y	Y
SMEs	Y	Y		Y					Y	Y
Smart Grids	Y	Y	Y (Common Performance Standards)	Y					Y	Y
Mass Market Products – Lighting and Appliances	Y (Program)	Y	Y	Y	Y	Y	Y (All residential end-uses)		Y	Y
Load Research		Y							Y	Y
Green-industry organizations (Green Plumbers)	Y (Program)				Y (with industry association support)				Y	Y (provided by industry)
Monitoring (Implementer/ user)	Y	Y	Y (industry compliance)	Y (industry compliance)	Y (industry compliance)	Y (industry compliance)		Y	Y	Y
Verification (Third party)	Y	Y	Y	Y				Y	Y	Y

Table 3.6: India and US Institutional Support for Policy and Program Implementation

Projects/Program Activity Examples	Pilot Demonstrations for New Technologies or Programs	Demand-Side Management (DSM)	Voluntary Labels and Standards incl. ECBC	Financial Incentives – Fiscal, Revolving Loans, Risk Guarantee	Government and/or Industry Volume Procurement	Minimum Energy Performance Standards	Periodic (Years) Data Collection and Analysis – National Scale	Perform, Achieve and Trade	Clean Tech. Access and Information	Capacity Building
Indian Institutions Examples	Many institutions would be candidates for initiating pilot programs.	Electricity Regulatory Commissions (ERCs), Utilities, BEE-EESL, Forum of Regulators (FOR), Builders, Architect-Engineers, White goods and Lighting Manufacturers	BEE, ESCOs, Builders, Architect-Engineers, White goods and Lighting Manufacturers	BEE, ICICI Bank, Reserve Bank, ESCOs, NMEEE, SDA, SNA, SEBs	Public Works Depts., BEE-EESL	BEE	BEE, Min. of Planning and Statistics, CEA	BEE, Industry, Utility Companies, NMEEE	BEE, ERCs, State Designated Agencies (SDAs), Industry Associations, Independent Organizations, Educational Institutions	BEE, ERCs, SDAs, Industry Associations, Independent Organizations, Educational Institutions, Consultants, PCA, NPC;
US Assistance – Candidate Activities	Transfer and organize installation of new/emerging technologies	Provide technical assistance and identify DSM technologies	Provide technical assistance	Provide similar backing for US industry, banks and other institutions for transfer of new technology	Transfer technologies as needed in India	Provide technical assistance	Provide technical assistance	Transfer technology to meet PAT goals	Y (for all the policies and programs listed in Table 3.4)	Y (for all the policies and programs listed in Table 3.4)
US AID Assistance to Date (Examples)	Y (PACER Program)	Y (Agriculture ESCO Programs)	Y (ECO Program)	Y (PACER Program)		Yet to be implemented	Yet to be implemented	Not yet initiated	Regular feature of USAID programs	Regular feature of USAID programs