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Energy Security Insights

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Energy efficiency and renewable energy: key routes to energy security

Energy is an essential ingredient for social development and economic growth. Achieving the goals of poverty eradication, improved living standards, and increased economic output imply increasing energy requirements. It has been estimated that by 2031, India's energy needs would be about seven times that of 2001 levels. The current trends in oil and gas production, and the level of coal reserves clearly indicate that the country will face constraints in indigenous availability of conventional energy resources. This coupled with the widening of gap between energy demand and supply means increasing and higher levels of energy imports. It is estimated that India's fossil fuel import dependence will reach about 80% by 2031. Such a trend obviously militates against energy security apart from adversely affecting the overall economy.

Fortunately, India has abundant renewable energy resources, which can contribute towards reducing dependence on imported fossil fuels. Renewable energy sources assume special significance in India when viewed in the context of the geographic diversity and size of the country, not to mention the size of its rural economy. Essentially, renewable energy technologies can complement conventional energy in meeting the basic needs of the rural population as well as the rapidly increasing requirements of energy associated with high economic growth.

Considering the fact that maintaining a high growth rate is essential for enhancing quality of life and for reducing vulnerability to the impacts of climate change, India needs to chart a course of action that leads to these goals in a sustainable and environmentally benign manner. Not only are energy conservation/ enhanced energy efficiency and renewable energy the two main building blocks of such a pathway, they go hand-in-hand insofar as energy for sustainable development is concerned. The current practice of treating both of them in isolation, therefore, needs to be changed. What is required, instead, is the implemention of energy efficiency measures in processes, equipment, appliances, and devices, and the exploration of the possibility of utilizing renewable energy technologies to meet the balance of energy needs. This essentially calls for a paradigm shift from supply domination to an integrated approach—a judicious mix of improvements in operational and end-use efficiencies, and renewable energy technologies. Renewable energy technologies, such as solar water heating, could be a very good tool for demand side management. Similarly, by including passive solar and other efficiency features in the design and construction of buildings, overall energy requirements can be brought down considerably.

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The role of energy efficiency and renewable energy in enhancing energy security: challenges and opportunities for India

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Introduction

While debates about energy security issues have in the past, generally, tended to track global oil prices, it is now increasingly being recognized that energy security for many countries in the world is about much more than just oil security. This particularly applies to the Indian context where energy security has two interlinked but distinct aspects. The first is the need to achieve better distribution of energy for people (particularly in rural India) and better utilization so that a minimal, 'lifeline' amount of commercial energy is available to everyone. The second is the need to fulfill the growing need for energy, concomitant with at least 8% growth in GDP (gross domestic product).

Clearly, there is a need to make every effort to increase the availability of, and access to, energy to fuel the country's growing energy requirements. But this should be done in a sustainable manner that takes cognizance of the environmental implications of energy production and use, and attempts to reduce the country's energy import dependence. This paper focuses on the role that energy efficiency measures and use of renewables can play in addressing these concerns.

Estimates of India's energy requirements

The projected estimates of energy requirements indicate that by 2031, India's energy requirements would increase to about seven times the 2001 levels. The Integrated Energy Policy report prepared by the Planning Commission estimates that in an 8% GDP growth scenario, India's total commercial energy requirements would be in the range of 1514–1856 MTOE (million tonnes of oil equivalent) by 2031, under various alternative scenarios (Planning Commission 2006). A similar exercise carried out by TERI indicates that commercial energy requirements would increase to 2149 MTOE in 2031 (Figure 1).

Coal is the mainstay of the Indian economy, and under the BAU (business-as-usual) scenario, the dominance of coal is expected to continue. Coal consumption in the BAU scenario increases by 8 times from 147 MTOE to 1167 MTOE, during the period between 2001 and 2031. The electricity sector especially is heavily dependent on coal with 53% of the total electricity generation being coal-based. Petroleum consumption also increases rapidly by over 8.2 times between 2001–31, mainly on account of increasing use in the transport sector.

Increasing energy import dependence

Over the years, India's coal reserves have been believed to be significantly large, but they are now estimated to be adequate for only about 40 years at current production levels, and are likely to be depleted even faster if exploited more rapidly. The production of domestic crude oil has remained nearly stagnant for the last 15 years. The reserve-to-production ratio for oil and gas is 40 and 67 years, respectively. These trends indicate that, with existing technology and E&P (exploration and production) efforts, indigenous

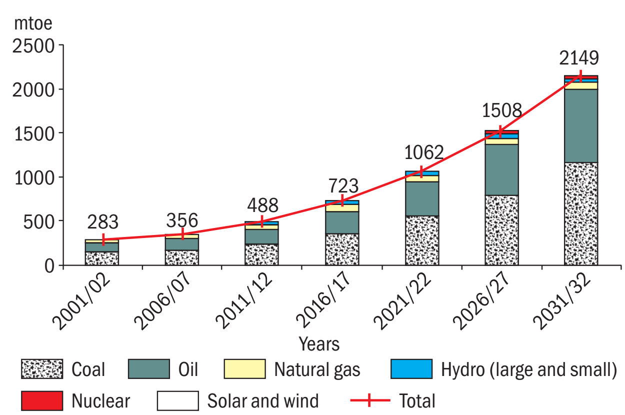

Figure 1 Commercial energy requirements in BAU scenario (MTOE)

conventional energy forms will reach maximum production limits soon. Based on the assumption that the maximum allowable indigenous production levels for all fuels would be achieved by 2016, results from TERI analysis of import dependence are indicated in Figure 2. The Integrated Energy Policy Report also corroborates the expectation of high levels of energy import dependence in the future.

Exceptionally high fuel prices in the international market and an almost stagnant domestic crude oil production have caused a drain on the country's foreign exchange reserves. The latest statistics published by the Department of Commerce of the Government of India indicate that during the financial year 2007/08, spending on fuel imports was equivalent to about 8% of GDP. Furthermore, port capacity in India is limited, especially for coal imports. These issues raise concerns with regard to the adequacy of energy infrastructure, the appropriateness of incurring such huge foreign exchange outflows on account of energy imports, and the sourcing of fuel supplies in the future.

Options for reducing fossil fuel needs

In the view of rising energy prices and geo-political considerations regarding energy imports, it is important to identify and adopt policies and measures that enhance energy security and help to reduce the final energy requirements of the economy. Accordingly, various scenarios reflecting enhanced penetration of alternative energy forms, energy-efficient technologies, and DSM (demand side management) measures have been envisioned across various studies in recent years.

It is estimated that a reduction of about 751 MTOE (more than twice the total commercial energy requirements in 2001) can be achieved by exploiting successive energy-saving options on the energy demand and supply sides (Figure 3), bringing the level of commercial energy down from 2149 MTOE in the BAU scenario to 1398 MTOE in 2031. Possible interventions are detailed below based on an analysis undertaken at TERI using the MARKAL model.[1]

Intervention I-1 Intervention 1 corresponds to energy efficiency measures in the transport sector, in the form of policy interventions by the government, such as increased share of rail vis-à-vis road in passenger and freight movement, promotion of public transport, efficiency improvement in transport vehicles, and introduction of hybrid vehicles.

Intervention I-2 This intervention includes efficiency improvements across the various end-use sectors, for example, increased use of efficient electrical appliances for space conditioning, lighting and refrigeration, and efficiency improvements in industrial processes.

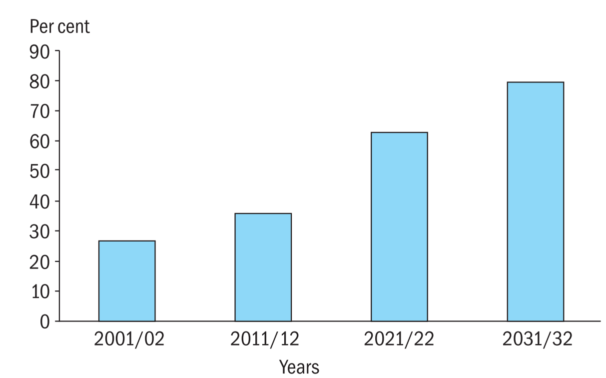

Figure 2 Fossil fuel import dependence

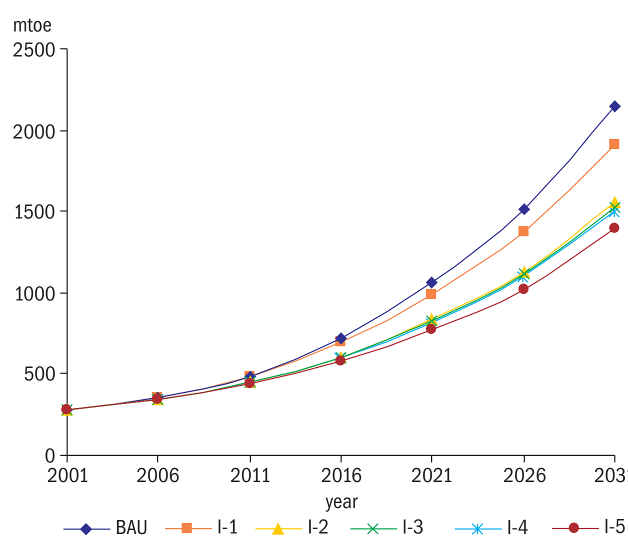

Figure 3 Scope of reducing commercial energy requirements

[1] The MARKAL model is a representation of the entire energy system for a geographic entity. The database (version 2008) for the India MARKAL model has been developed by Ritu Mathur, Pradeep Dadhich, Atul Kumar, Nishant Mehra, Amrita Goldar, Ila Gupta, and Leena Srivastava.

Intervention I-3 This intervention considers the adoption of advanced coal-based power generation technologies such as ultra-supercritical and IGCC (integrated gasification combined cycle), at a commercial scale.

Intervention I-4 This intervention includes aggressive deployment of nuclear energy for power generation driven by the assumption that the country is able to import nuclear fuel.

Intervention I-5 Intervention 5 includes enhancement of the exploitation of renewable energy sources.

The scope for energy reduction is the maximum from introducing end-use efficiencies in the demand sectors as represented by the area between BAU and I-3. It is estimated that efficiency improvement interventions in the transport sector could reduce commercial energy requirement in the year 2031 by 236 MTOE, which accounts for about 11% reduction in the total commercial energy use. Interventions in other end-use sectors together could reduce about 352 MTOE of commercial energy use in the same year, which is about 16% of the total commercial energy reduction in the country.

While there is significant scope for saving energy in the transport sector, with limited options for fuel switching, options in the transport sector are largely focused on increasing the share of public transport, and enhancing the share of rail-based movement. Accordingly, fiscal and policy interventions are important for inducing efficiency in this sector. While recognizing the relevance of alternative fuel options such as CNG, ethanol, and bio-diesel, studies have thus far indicated a rather limited role that these alternatives can play in the next couple of decades.

In the industry sector, while several large industrial units are already doing well and the country has some of the BATs (best available technologies) to demonstrate, there is a need to up-scale efforts, and tap energy efficiency potential across the board. Particularly difficult is the task of bringing about efficiency improvements in the small industries spread across various industrial activities. The SMEs (small and medium enterprises) are constrained by the non-availability of adequate capital due to their small size. Furthermore, low degree of creditworthiness of these enterprises makes it difficult for them to raise funds in the financial markets. They are, therefore, not willing to invest in energy-efficient technologies because of their initial high upfront cost. Also, most of these enterprises come under the domain of the unorganized industrial sector. Their fragmented nature, and lack of expertise and technical know-how, act as barriers to the uptake of energy-efficient technological options.

In the residential and commercial sectors too, significant opportunities exist with regard to efficiency improvements in appliances for lighting and space conditioning. Again, while technological alternatives do exist, these savings are spread across diverse sectors and end-users, such that the nature of barriers differs widely. This makes it impractical to undertake any single policy or technology approach to make a significant impact.

The possibility of commercial energy savings with adoption of advanced coal-based technologies is estimated to be about 35 MTOE in the year 2031. Aggressive penetration of nuclear energy for power generation as indicated by the area between I-3 and I-4 in Figure 3, is estimated to reduce the total commercial energy requirement by 18 MTOE. Higher deployment of renewable energy sources is estimated to reduce 109 MTOE of commercial energy demand in 2031.

While renewables are also seen to have a role to play especially in terms of decentralized applications, these have thus far been examined in a rather limited context, and are expected to be able to displace only up to 5%–6% of the total energy requirement. However, given the large potential of renewables in India, this is an area that needs to be re-evaluated in terms of its possible contribution to decreasing the use of fossil fuels, and enhancing energy security, while taking into consideration environmental concerns.

Additionally, promotion of nuclear energy through enhancing nuclear capacity and adopting fast breeder and thorium-based thermal reactor technology in nuclear power generation, would bring significant benefits in terms of energy and environment security, including GHG mitigation.

Achieving sustainable development and energy security: key opportunities for India

Clearly, energy efficiency measures and mainstreaming of renewable sources into the country's energy mix are indispensable if the country has to achieve its developmental objectives whilst simultaneously addressing its environmental and energy security concerns.

Role of energy efficiency measures

Adoption of demand side management at the consumer end can help in reducing incremental energy requirement. Transport, industrial, commercial, and residential sectors have substantial potential for decrease in energy demand, through energy efficiency interventions. Energy efficiency efforts are able to address energy security concerns in two ways: (a) by decreasing demand itself and (b) by deferring the need to add additional capacity to meet incremental energy requirements. The industrial sector has taken initiatives to promote energy efficiency as it directly increases profitability in business. However, penetration of demand-side measures at the consumers' end in the residential and commercial sectors has been comparatively insignificant thus far.

Demand-side management is a win-win proposition for all concerned stakeholders—government (decrease in subsidy burden), utilities (shaving off of peak requirements), and consumers (reduction in expenditure on energy). Hence, both the government and the utilities, in association with the regulators, need to create awareness about the merits of using energy-efficient appliances and adopting other demand-side measures.

Mainstreaming renewables into the energy mix

While advanced coal-based power generation technologies are associated with higher efficiencies as compared to the sub-critical coal-fired plants, and can contribute to energy security by achieving fuel saving to some extent, renewables-based power generation technologies need to be tapped and integrated into the country's generation mix. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. The average solar radiation incident over India is about 5.5 kWh/m^2 per day. It is estimated that only 1% of India's land area, given currently available solar PV and thermal power technologies, can fully provide for its estimated power generation till 2030.

Similarly, given present yields and transesterification technologies, bio-diesel plantations over 25% of the wasteland can displace 21% of current petroleum-based transportation fuels. Surplus crop residues, estimated at 139 MT (million tonnes) per year, almost the same in coal-equivalent, comprise another significant renewable energy source at the village level. (The total yield of crop residues each year is 546 MT, a significant part of which plays an important role in maintaining the rural economy and in ensuring agricultural sustainability. Hence, only the estimated surplus may be used for renewable energy.) Other biomass sources include fuelwood plantations on wasteland and degraded forestland. Wind turbines and hydropower, which are now established commercially, are other significant sources of renewable power.

Efforts need to be made by all concerned stakeholders in order to mainstream renewables into India's energy mix. There is a need to push technology development. On the policy front, it is important to provide an enabling environment for growth of renewable energy, by providing adequate incentives to developers to invest in the sector.

The way forward

It is clear that the country is facing an energy challenge, and that energy efficiency and renewable energy have a significant role to play in reducing energy requirements on the one hand, and making available clean and renewable indigenous sources of energy on the other. However, there are several barriers (technological, financial, and social) that exist in exploiting this potential, and appropriate policy interventions and targeted efforts are required to bring about a major transformation in the sector.

There is a pressing need to undertake appropriate interventions within the domestic energy supply sectors, in terms of moving towards market-based/full-cost pricing of energy products such that the scarcity value of fuels is adequately represented and there is no waste of energy resources. For instance, electricity is provided to agricultural consumers at very low prices or for free in select states, encouraging wastage of electricity as well as wasteful use of water. Wherever required, targeted subsidies should be put in place such that they directly benefit the sections of population they are meant to assist. Smart cards can be used to appropriately target energy subsidies. Recent initiatives by the BEE (Bureau of Energy Efficiency)[2] are steps in the right direction but need to be further stepped up. Efforts are required in the transport sector to make available a good public transport system and encourage rail-based movement, apart from policy interventions to step up efficiency in motorized road transport vehicles. The NAPCC (National Action Plan on Climate Change)[3], through its eight missions that are geared towards reducing energy demand and GHG emissions, is likely to play an integral role in providing an impetus to energy conservation efforts while bringing about radical transformations in the energy mix of the country.

References

Planning Commission. 2006
Integrated Energy Policy, Report of the Expert Committee
New Delhi: Government of India

[2] BEE is a statutory body under the Ministry of Power. Details available at <http://www.bee-india.nic.in/index.php>

[3] The NAPCC has been prepared by the Prime Minister's Council on Climate Change. Details available at <http://pmindia.nic.in/Pg01-52.pay>

Renewables-based power generation: regulatory framework and future directions

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The development of renewable sources of energy started in India in the mid-1980s with a range of policy initiatives by the government. These programmes included development of renewable energy technologies for diverse applications including power generation from renewable energy sources like wind, solar, and small hydro. This article reviews the policy and regulatory environment for power generation from renewables in India, and the impact it has had on the development of the sector.

Policy support

In 1993, the MNRE (Ministry of New and Renewable Energy), earlier known as the MNES (Ministry of Non-Conventional Energy Sources), issued guidelines for purchase of power from renewable energy sources by state utilities. These guidelines marked a power purchase tariff of Rs 2.25 per unit, with an annual escalation of 5%. The guidelines also prescribed other promotional measures like wheeling[1] and banking of power generated from different renewable energy sources. The guidelines were adopted by various state utilities, and provided the initial policy support for renewables-based power generation in India. Besides a fixed power procurement rate, the government provided other incentives like accelerated depreciation, and exemption in customs duty for imports of components/ machinery for renewable energy systems/projects.

The regulatory framework

Subsequent to the enactment of the ERCA (Electricity Regulatory Commissions Act) in 1998, SERCs (state electricity regulatory commissions) became key players in determining power tariffs.

[1] Wheeling refers to transportation of electric power over transmission lines.

The SERCs were constituted to bring transparency and competition into the sector.

The Electricity Act 2003 repealed the earlier acts—The Indian Electricity Act, 1910; The Electricity (Supply) Act, 1948; and The Electricity Regulatory Commission Act, 1998. The Electricity Act 2003 further strengthened the role of regulatory bodies in pricing, and in the promotion of competition and transparency. The Act has specific provisions for promotion of power generation from renewable energy sources:

Section 61 (h) The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the promotion of co-generation and generation of electricity from renewable sources of energy.

Section 86 (1) (e) To promote co–generation and generation of electricity through renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any persons, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee.

The National Electricity Policy, formulated by the Ministry of Power, in pursuance of the provisions of the Act, also stresses the need for promotion of non-conventional energy sources:

5.12 Cogeneration and Non-Conventional Energy Sources

5.12.1 Non-conventional sources of energy being the most environment friendly, there is an urgent need to promote generation of electricity based on such sources of energy. For this purpose, efforts need to be made to reduce the capital cost of projects based on non-conventional and renewable sources of energy. Cost of energy can also be reduced by promoting competition within such projects. At the same time, adequate promotional measures would also have to be taken for development of technologies and a sustained growth of these sources.

In terms of specifying a percentage of total consumption, which should come from renewable energy sources, the policy specifies that

5.12.2 Progressively the share of electricity from non-conventional sources would need to be increased as prescribed by State Electricity Regulatory Commissions. Such purchase by distribution companies shall be through competitive bidding process. Considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the Commission may determine an appropriate differential in prices to promote these technologies.

The National Tariff Policy, formulated by the Ministry of Power, has specific guidance on purchase tariff for power generated from renewables.

Section 6.4 It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

Such procurement by Distribution Licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act within suppliers offering energy from same type of non-conventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs.

The Electricity Act 2003, and subsequent policies, provide for three important promotional measures for renewables.

- The Act provides a framework for tariff determination in Sec 61(h), and the tariff policy further elaborates it, providing a long-term policy for pricing of power from renewable sources of energy, and prescribing a gradual step-by-step introduction of competition.
- In addition to provisions on tariff determination, which boost investor confidence, Sec 86 (1) e of the Act creates demand for power generated from renewable energy sources by mandating SERCs to specify a percentage of consumption which should be procured from renewables.
- Power evacuation infrastructure is a critical requirement for promotion of renewables-based generation, since sources like wind and small hydro are geographically unevenly distributed,

and often located in remote areas. The Electricity Act addresses this by mandating SERCs to take suitable measures to ensure connectivity with the grid. Providing the infrastructure for evacuation of power is the responsibility of the STU (state transmission utility), and it is expected that the STUs would prepare grid expansion/augmentation plans in light of the renewable energy potential of the state.

The provisions regarding tariff determination and percentage specification have been implemented by many SERCs. Table 1 gives the percentages specified by different SERCs for procurement of power from renewable energy sources.

These SERCs have also issued tariff orders for purchase of power from different renewable energy sources, which is a technology-specific tariff. This implementation of the provisions of the Electricity Act has boosted power generation from renewable energy sources as shown in Figure 1.

Emerging regulatory issues

It is clear from Table 1 that despite the provisions of the Electricity Act and subsequent policies, some states have not yet specified percentage for procurement of power from renewables. Some states have not complied with the requirement of specifying percentage for power procurement from renewable energy sources, since there is minimal renewable energy potential available. (Currently,

Table 1 Renewable energy procurement percentage specified by respective SERCs, by state

State	*Percentage to be procured from renewables*
Tamil Nadu	10%
Maharashtra	3%–6%
Karnataka	10%
Andhra Pradesh	5%
Gujarat	2%
Rajasthan	7.5%
Madhya Pradesh	10%
Kerala	3%
West Bengal	3%–8%
Delhi	1%
Punjab	1%–4%
Himachal Pradesh	20%
Uttar Pradesh	7.5%
Uttarakhand	5%–10%
Haryana	3%–10%

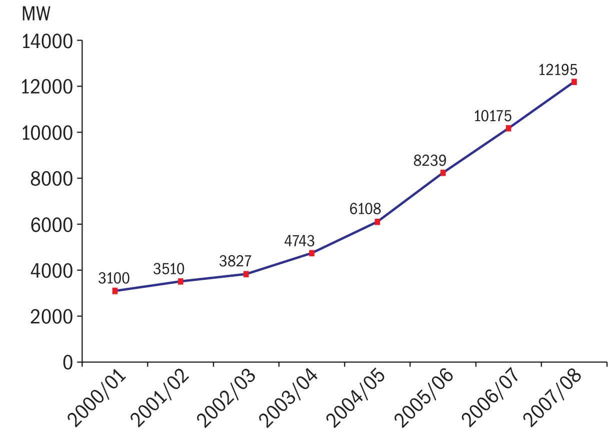

Figure 1 Installed power generation capacity from renewable energy sources

all regulations/orders by SERCs require renewables-based power to be purchased from plants located within the state.) Some states, in spite of good resource potential, have specified very modest percentages. In states with adequate renewable energy resources, the development of renewable power is limited to the capability of the state to purchase power from renewable projects, to the extent that it does not substantially affect consumer tariffs. Renewable energy resources therefore remain under-utilized in these states. On the other hand, states which do not have/or have very limited renewable resources cannot procure power from renewable energy sources. One possible solution, to optimally utilize renewable energy resources, is to specify a national minimum RPO (Renewable Procurement Obligation). The NAPCC (National Action Plan on Climate Change) published by the Government of India in 2008, indicates the necessity of such a national minimum percentage.

Another related issue is that of difficulty of physical transfer of electricity generated from renewable energy based power plants from one state to another, because of the variable nature of power generation as well as smaller individual project capacities. The REC (Renewable Energy Certificate) mechanism, if implemented in India, could overcome this barrier of geographical mismatch of resources, and help meet the demand created by a national minimum obligation. Sec 86 (1) e of the Electricity Act mandates SERCs to specify a 'percentage of the total consumption of electricity in the area of a distribution licensee' to be procured from renewables. It is thus applicable to open-access consumers who are procuring power from sources other than the distribution licensee. With the requirement for energy increasing and the Electricity Act promoting open access, the quantum of electricity procurement through open access would increase and hence a compliance mechanism will be needed for enforcing an RPO. RECs would be a convenient tool for enforcing such compliance.

Finally, an important emerging issue is that of pricing of power from renewable energy sources. The most effective available mechanism is that of feed-in tariffs[2], which is similar to the present tariff mechanisms followed by the SERCs. However, in India, the long-term strategy seems to be in the favour of market prices. As per the tariff policy, renewable power needs preferential tariffs followed by step-by-step introduction of competition in the sector. Competition, through bidding, among same and different renewable sources, is an option envisaged for pricing of power from renewable energy sources. RECs could also be employed to promote competition, since the price of RECs would automatically be governed by the market scenario. International experience in the areas of competitive bidding and RECs shows that the REC mechanism has been more successful as compared to bidding, in increasing the share of renewables with market-based pricing.

Given the energy security and climate imperatives, renewable sources of energy are slated to play an important role in meeting the country's energy demand. Power generation, being one of the most important applications of renewable energy, needs to be governed by an informed regulatory framework that facilitates its growth and improvement.

[2] The feed-in tariffs model is an incentive mechanism whereby the state/national utilities are obligated to buy renewables-based electricity from producers at (higher) rates set by the government.

Innovation systems for solar photovoltaics in India

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Growing concern for energy security and the environmental consequences of current energy systems have renewed focus on the renewable energy sector.[1] Innovation in renewable energy sources, such as SPV (solar photovoltaics)[2], can offer solutions to ensure energy security, allow movement towards non-carbon or lean-carbon energy futures, and spur economic development through provision of energy services and creation of employment opportunities.

The framework of sectoral innovation system[3] is a useful tool for the analysis of emerging

[1] The renewable energy sector includes solar, wind (offshore and onshore), hydro, marine (wave and tidal), biomass, and hydrogen among others.

[2] Photovoltaics is the field of technology and research related to application of solar cells for energy by converting sunlight directly into electricity.

[3] The notion of sectoral system of innovation, drawing mainly from basic concepts of evolutionary theory and from key aspects of the innovation systems approach, lays emphasis on non-market as well as market interactions, and focuses on the processes of transformation of the system. It places emphasis on the structure of the system in terms of products, knowledge, and technologies and on its dynamics and transformation. The main building blocks of a sectoral system of innovation and production are: knowledge base and learning processes; basic technologies, inputs and demand, with key links and dynamic complementarities; type and structure of interactions among firms and other organizations; institutions; processes of generation of variety and of selection (Malerba 2002).

industries that are characterized by uncertainty, innovation, and high dependence on firms and government organizations, policies, and institutions. PV is a relatively new industry in terms of development of technology and its diffusion. Adopting a sectoral innovation system framework, this article attempts to map and discuss the knowledge and technology base for PV, relevant technological and institutional actors and their interactions, and the role of institutions in shaping the energy technology innovation process[4] of PV in India. This would help in understanding the barriers that influence the emergence of low-carbon technologies, and provide insights on how to overcome the situation of carbon 'lock-in' in the energy sector.

Solar power constitutes about 2.1 MW (megawatt) of the total 10 250 MW of grid-interactive renewable power[5] in India, sourced by a total of 32 grid-interactive SPV plants installed with financial assistance from the central government. Decentralized solar energy systems form a large share of India's solar power with the application of SPV for off-grid lighting, water pumping for irrigation, and drinking water applications.[6] Table 1 gives the present status of installed capacity of solar power in India. It can be seen that rural applications of PV have increased to 69 549 streetlighting systems, 363 399 home-lighting systems, 585 001 solar lanterns, and 7068 SPV pumps.

Knowledge and technology base

R&D (research and development) in SPV has been carried out for more than three decades. The focus of the innovation system for PV in India has been on development of polysilicon and other materials, device fabrication processes, and thin-film solar technology (based on amorphous silicon films, cadmium telluride films, copper indium diselenide thin films, and organic, dye-sensitized and carbon nanotubes), along with improvement in crystalline silicon solar cell/module technology. These technologies are at various stages of R&D or commercialization. At present the entire production capacity in Indian PV Industry is based on crystalline silicon. To make solar cells and modules cost effective, the focus of R&D during the Eleventh plan period (2007–12) is proposed to be development of: 1) polysilicon and other materials; 2) efficient silicon solar cells; 3) thin-film materials and solar cell modules; 4) concentrating PV systems; and 5) PV system design (MNRE 2008b). The R&D in SPV technology in the country encompasses several areas, including high-efficiency solar cells and organic PV.

Actors and networks

R&D and technology development is carried out in central/state government research organizations, IITs (Indian Institutes of Technology), engineering colleges, universities, CSIR (Council of Scientific and Industrial Research) labs, non-government organizations, and industries, which have suitable infrastructure for undertaking R&D in PV. Also, a specialized R&D institute, the SEC (Solar Energy Centre), was established in 1982 at Gurgaon, Haryana under the MNRE (Ministry of New and Renewable Energy), for development of solar energy systems and devices.

Although the manufacturing base of PV has been gradually strengthened so as to become self-sufficient in PV production, manufacture of solar cells and PV modules has not kept pace with global trends. During 2006/07, it was estimated that about 45-MW capacity solar cells and 80-MW capacity PV modules were being produced in the country. The overall growth in PV production and deployment of PV modules by sector in India is shown in Figures 1 and 2. The production during 2007/08 (till December 2007) was estimated to be over 40 MWp

[4] Energy technology innovation is the process of improving or developing energy technologies and their widespread diffusion. This encompasses activities ranging from R&D (research and development) to demonstration and deployment.

[5] The installed capacity of grid-interactive power from renewable energy sources in the country reached 10 250 MW (megawatt) at the end of the Tenth Plan, that is, by 31 March 2007. A capacity addition of 14 000 MW from renewable energy sources is proposed during the Eleventh Plan. These sources are wind, biomass, solar, and small hydro system (MNRE 2008a).

[6] In India, PV offers many applications especially in rural areas, such as usage of PV in the telecom industry to power relay systems and telephone exchanges. In the railways, PV has been used for remote applications, signalling, and for operating unmanned gates.

Table 1 Installed capacity renewables (solar power): present status (1 January 2008)

Grid-interactive renewable power	Installed capacity
Solar power	2.12 MW
Decentralized energy systems	
Solar photovoltaic programme	110 MWp
Solar streetlighting units	69 549 nos.
Home lighting units	363 399 nos.
Solar lantern	585 001 nos.
Solar power plants	2180 kWp
Solar photovoltaic pumps	7068 nos.
Other programmes	
Energy parks	504 nos.
Akshay Urja shops	269 nos.
Battery operated vehicles	270 nos.
Research, design, and development	600 projects

MW – megawatt; kWp – kilowatt peak
Source MNRE (2008b)

(megawatt peak) of solar cells and 60 MWp of PV modules.

India serves as an excellent low-cost production base for SPV cells. More than 60% of the total SPV cells produced in the country are exported. The major players in SPV, given in Table 2, come from both the public and the private sector. Private sector involvement in investment in solar energy is a new trend.[7] During 2007, about 9 companies were engaged in manufacture of solar cells and 19 companies were involved in the manufacture of PV modules. In addition, about 50 companies were actively engaged in the manufacture of a variety of PV systems (MNRE 2008b). However, there are no major players involved in the manufacture of the inverter (essential for grid-connected systems and required for most off-grid systems), the storage battery and charge controllers (for off-grid systems).

Institutions and policies

Indian policies to promote renewable energy are mainly guided by concern for local air pollution, energy security, and socio-economic development imperatives. The MNRE (Ministry of New and Renewable Energy) has been supporting research, design, and development in new renewables for more than two decades. Currently, the areas of emphasis in solar energy are reduction in cost and increase in efficiency. To accelerate utilization and exploitation of solar energy, the MNRE has initiated innovative schemes and incentives like subsidy, soft loan concessional duty on raw materials import, and excise duty exemption on certain devices/systems. To make the sector market and consumer driven, the ministry has also

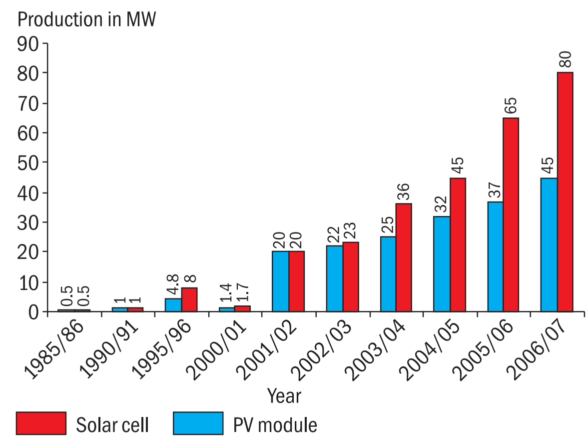

Figure 1 Growth in Indian PV production (December 2007)
Source MNRE (2008b)

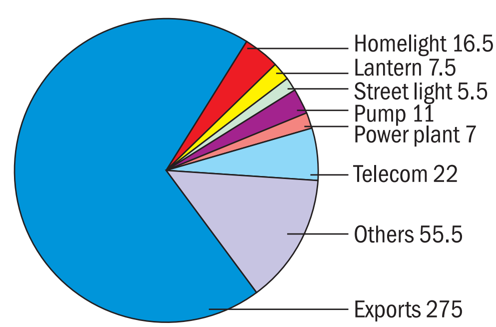

Figure 2 Use of PV modules (in MWp) by sector (December 2007)
Source MNRE (2008b)

[7] Moser Baer Photovoltaic Ltd, a wholly owned subsidiary of Moser Baer established in 2005, has planned to build a Rs 330 crore silicon PV manufacturing facility near Delhi. For technology transfer, the company has tied up with Applied Materials Inc. Signet Solar, a US-based company, is also planning to invest $2 billion to set up three PV production facilities in India. Solar Semiconductor has invested $40 million to set up two production facilities and has entered into supply agreements with two European companies (Sreekala and Reddem 2008).

Table 2 Major solar cell and module manufacturers in India

Solar cell manufacturers	*Cell technology*
Bharat Electronics Ltd	Monocrystalline silicon
Bharat Heavy Electrical Ltd	Monocrystalline silicon, crystalline silicon
Central Electronics Ltd	Monocrystalline silicon
Maharishi Solar Technology Pvt. Ltd	Multicrystalline silicon
Moser Baer Photovoltaic	Crystalline silicon

Source Details available at, http://www.solarbuzz.com/solarindex/CellManufacturers.htm, last accessed on 20 August 2008

devised a policy of R&D with close involvement of the industrial sector. Also, to make solar energy grid-interactive, which at present is largely concentrated on off-grid applications, the MNRE has announced a new initiative on development and demonstration of megawatt capacity grid-interactive solar energy potential. The ministry will support grid-interactive solar power generation projects up to a maximum capacity of 50 MW and will provide a generation-based incentive of up to Rs12 per kWh for SPV power fed to the grid by solar power project developers, after taking into account the tariff provided by the SERC (state electricity regulatory commissions) or the utility (MNRE 2008b).

Feed-in tariff of up to $0.30 per unit (kWh) for grid-connected SPV plants has been announced recently by the government. This is about 75% of the generation cost of SPV, which ranges between $0.38 and $0.75 per unit. With this, many state governments like those of Punjab, Rajasthan, and West Bengal, are initiating the process of formalizing solar tariffs. Based on these feed-in-tariffs, corporations are actively pursuing opportunities and are finalizing plans of setting up grid-connected solar farms (Kotwal 2008).

The CERC (Central Electricity Regulatory Commission) regulates the tariff for generating companies owned or controlled by the central government, including tariffs that state government bodies pay for renewable energy. SERCs take measures towards building an efficient electricity system in the state, safeguard interests of consumers, and provide advice to the government. Several organizations across different ministries, namely TDB (Technology Development Board), DST (Department of Science and Technology), NETCOF (Non-Conventional Energy Commercialization Fund); MNRE; PFC (Power Finance Corporation), MoP (Ministry of Power); and SNAs (state nodal agencies), support the commercialization of renewable energy. The public limited company – IREDA (Indian Renewable Energy Development Agency) – established in 1987 has been supporting the commercialization of SPV technology in India through appropriate financing mechanisms. It provides revolving funds to financing and leasing companies offering affordable credit for the purchase of PV systems. Also, various organizations have developed innovative funding schemes to tackle the constraint of high deployment prices of solar technologies, for instance, the solar loan programme in southern India.[8] Further, foreign direct investment is allowed in the renewable energy sector through the automatic route. Funding is also provided by MDBs (multilateral development banks) like the World Bank and the Asian Development Bank. However, when compared to other clean energy support in India, the funding from MDBs for promotion of solar energy is negligible.

Figure 3 presents an overview of the innovation system for PV in India, showing main actors involved and flows of influence, funding, and knowledge.

Conclusion

Despite having one of the largest and most wide-ranging renewable energy programmes in the world, the overall diffusion of the renewable energy

[8] The solar loan programme in the south of the country is one of the most successful examples of accelerating the market of finance for solar home systems. It was a four-year $7.6-million project, launched in April 2003 by UNEP in partnership with two of India's banking groups – Canara Bank and Syndicate Bank – and their sponsor Grameen Banks. Details available at, <http://www.treehugger.com/files/2007/09/solar_power_india.php>, last accessed on 28 August 2008

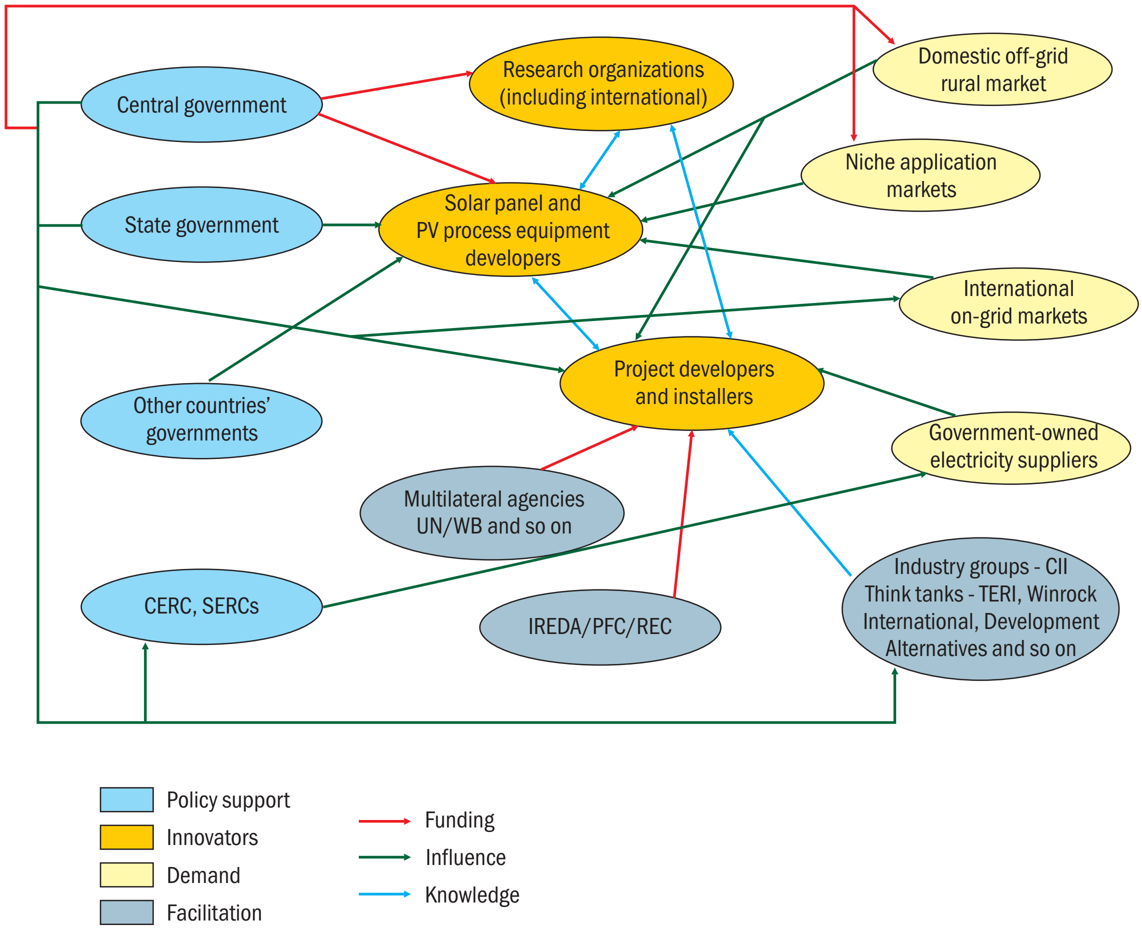

Figure 3 The innovation system for PV in India
Source Adapted from Foxon, Gross, Chase, *et al*. (2005)

sector in general, and PV in particular, is still relatively small in India. In this regard, there are several deficiencies in the PV sector in India resulting in an overall weak PV sectoral innovation system. Some measures that can improve this scenario are detailed here.

Need for greater R&D for cheaper photovoltaics High cost of PV is one of the major barriers to its deployment and diffusion. There is greater need for R&D focused on reducing cost and increasing efficiency in converting solar radiation to electricity at the commercial level, through harnessing next-generation technologies for SPV (thin film, nanotechnology, and so on).

Greater cohesiveness amongst actors At present, the R&D capabilities remain largely fragmented and there is a need to build greater cohesiveness among the academia, R&D labs, industry, and business. The important role played by coalitions that are formed around particular technologies (Jacobsson 2005) in making/influencing changes in the existing institutional framework and making the PV sector cost competitive cannot be overlooked in the process of PV technology development and diffusion. In India, such coalitions around the PV industry have been weak in influencing the policy agenda. From the experiences of developed economies like Germany, one could infer that the capacity of research groups in universities, PV manufacturing companies, and civil society organizations, in initiating changes in the existing institutional framework can go a long way in the socio-economic legitimization of PV technology.

Need for creating niche markets and moving beyond Generally, during the initial stages of development of a new technology, creation of niche markets operating under government subsidy schemes helps in improving the relationship between price and performance, and provides incentives to new firms to venture into the various stages of the innovation chain. India, having a substantial niche market for PV off-grid applications and having focused on decentralized applications of solar power for more than two decades, has been able to harness the vast potential of solar energy only to a limited extent. However, given the higher incidence of solar insolation and a dense population, there is a need to gear up the off-grid solar power systems as well as develop grid-interactive solar power generation. Most of the technological and market opportunities in PV have evolved around the fast growing on-grid markets.

Thus, for the PV sector in India to be innovative, the three building blocks of the sectoral innovation system – knowledge and technology, actors and networks, and institutions – need to develop together; and the strength of the sector should emerge from a favourable combination of all these factors. Despite a satisfactory knowledge and technology base and a growing manufacturing capacity in the Indian PV sector, the deployment and commercialization of this innovative technology has not achieved mass scale, and there is a need for interaction between different technological and institutional actors. Further, the role of the third building block – institutional set up and policy framework, and the ability to adjust the institutional set up in favour of an emerging PV technology – is a key determinant of the failure or success of the innovation system.

References

Foxon T J, Gross R, Chase A, Howes J, Arnall A, Anderson D. 2005
UK innovation systems for new and renewable energy technologies: drivers, barriers, and systems failures
Energy Policy **33**(16): 2123—2137 pp.

Jacobsson S and Johnson A. 2000
The diffusion of renewable energy: an analytical framework for research
Energy Policy **28**(9): 625–640 pp.

Kotwal A 2008
Solar Power: the new sunrise business in India
Details available on the website of Frost and Sullivan, <http://www.frost.com/prod/servlet/market-insight-top.pag?Src=RSS&docid=129223665>, last accessed on 30 August 2008

Malerba F. 2002
Sectoral systems of innovation and production
Research Policy Elsevier **31**(2) 247—264 pp.

MNRE (Ministry of New and Renewable Energy). 2008a
Grid-Interactive Power Installed Capacity from Renewable energy Sources Reaches 10,250 MW in the 10th Plan
Press Release issued by the Ministry of New and Renewable Energy on 1 April 2008. Details available at <http://mnes.nic.in/press-releases/press-release-01042008.pdf>, last accessed on 15 August 2008

MNRE (Ministry of New and Renewable Energy). 2008b
Annual Report 2007/08
New Delhi: MNRE Government of India

Sreekala G and Reddem A. 2007
India fast emerging as a solar hub
The Economic Times, 10 September 2007
Details available at <http://economictimes.indiatimes.com/News/News_By_Industry/Energy/Power/India_fast_emerging_as_a_solar_hub/articleshow/2353788.cms>, last accessed on 17 August 2008

Energy efficiency in buildings and appliances: key barriers and promotional initiatives

Binu Parthan* and Udo Bachhiesl#

Continued rise in global energy demand, coupled with the concentration of fossil fuel supply sources in a few countries, has important implications for world energy security. Energy prices have been increasing steadily. Clearly, besides increased investment in supply-side infrastructure, there is a need for efforts to curb demand in key energy-consuming sectors, in order to ensure adequate, reliable, and affordable energy supplies.

There are three key energy-use sectors where energy efficiency can curb demand and contribute to energy security—buildings and appliances, industry, and transportation. The buildings and appliances sector offers the greatest energy-saving potential among the three sectors. The IPCC Fourth Assessment Report (Figure 1) shows that energy efficiency in buildings (including appliances) offers the maximum potential, which lies in the range of 4.7–6.7 $GtCO_2$-eq/year (gigatonnes of carbon dioxide equivalent per year) (IPCC 2007). The McKinsey/Vattenfall study of global GHG (greenhouse gas) abatement opportunities also shows that several mitigation opportunities in the buildings and appliances sector such as insulation, air-conditioning, and lighting, constitute some of the most attractive options for emission reductions (Vattenfall 2007). These studies, as well as several political developments around energy and climate, have raised the political profile of the issues surrounding energy efficiency in buildings and appliances.

Buildings and appliances sector

At the global level, the buildings and construction sector generates 5%–15% of GDP (gross domestic product) (UNEP 2007). Buildings need energy for space heating and cooling, appliances, lighting, building services equipment, water heating, cooking, and so on. Buildings and appliances used therein are responsible for almost 35% of energy use globally, which is close to the primary energy consumption of the US (REEEP 2008). Energy use in buildings and appliances rose by 11% in the last five years at the rate of 2% per year (REEEP 2008). There is a wide variation, however, in per capita energy use in buildings globally. The per

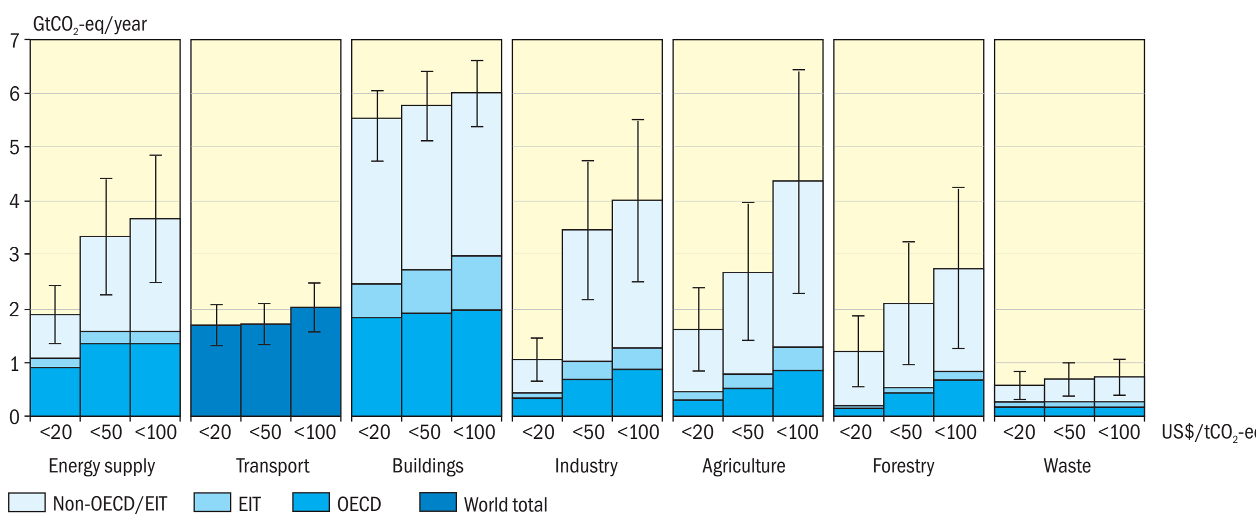

Figure 1 Economic mitigation potential by sector in 2030
Source IPCC (2007)

* REEEP (Renewable Energy and Energy Efficiency Partnership), International Secretariat, Vienna, Austria
# Graz University of Technology, Graz, Austria

capita use is high—in the range of 35–40 GJ (gigajoules) per capita/year, in North America, and in the range of 20–35 GJ per capita/year in Europe. The per capita energy use in buildings is considerably low in developing countries and is in the range of 4 to 10 GJ per capita/year (REEEP 2008).

The absolute figures of energy consumption in buildings and appliances are rising fast as the construction sector booms, especially in emerging countries such as China, India, and some West Asian countries. It is expected that between 2005 and 2050, residential building area will double, and the commercial building[1] area will triple. Buildings can last for decades and the economic lifetimes of building stocks are in the range of 40 to 120 years. Therefore, it is important, in light of these significant levels of increase in building area, that the projected built area is built to have good energy performance. A large number of technologies such as heat pumps, glazing systems with argon filling, special coatings in building shells, A-label cooling equipment, and LED lamps, are progressively entering the buildings and appliances market and are likely to help in curbing demand from this sector (REEEP 2008). Several recent technological developments such as high-performance windows, high-performance reversible heat pumps, and insulated panels, can be combined with integrated passive solar design to achieve 80% reduction in building energy consumption (IEA 2008).

Barriers

While the potential for savings in the buildings and appliances sector appears very high, the achievements have been rather modest. There are several barriers which prevent higher levels of energy efficiency in buildings and appliances. Some of these are as follows.

Investment barriers More energy-efficient buildings and appliances imply higher upfront investment costs, and the general objective of the construction companies and homeowners is to reduce the initial investment in a building/appliance. The effect of higher investment cost on decision-making is more pronounced in construction and design of residential buildings than commercial buildings.

Energy pricing Energy pricing, especially electricity pricing decisions, do not often reflect the true cost of electricity service. In many countries, especially developing countries and economies in transition, energy supply to households and for agricultural applications is highly subsidized. Low tariffs encourage inefficient use of energy.

Financial risk The incremental cost of implementing energy efficiency measures in residential buildings is in the range of 3%–5%, and 10%–15% for commercial buildings (Government of India 2008). Banking and financial institutions consider financial models for energy efficiency projects as risk-prone. This is because they are based on energy savings, without an additional revenue stream. A business model that is based on a shared savings contract (regular commercial contracts used by energy service companies) is considered to be more risk-prone than normal business models. Uncertainties with regard to the baseline, incremental cost of energy efficiency investments, and protocols for monitoring and verification, increase the risk perception of the financial sector. These risk perceptions result either in energy efficiency building projects not being financed or being financed at a high-risk premium. The latter increases the cost of funds thereby adversely affecting the financial profitability of the projects.

Structural issues There is a structural mis-alignment in the investment and returns of energy efficiency investments, in that the ones who make the decision about energy-efficient building envelopes and energy-consuming appliances are generally not the ones who pay the energy bills. Investments in the building, insulation, equipment, and electrical fixtures are made by the builder or the building owner, and the energy bills are paid by the tenant. As Figure 2 illustrates, more than 80% of energy consumption of buildings occurs during the operational phase of

[1] Banks, hotels, restaurants, shopping malls, supermarkets, offices and public buildings such as schools and hospitals

the buildings (WBCSD 2007). This implies that usually only price considerations go into building construction and purchase of appliances.

Absence of policy framework and regulatory instruments It is possible to regulate the thermal and electrical energy requirements of building components, service systems, and equipment. In most parts of the world, there are no policy frameworks and regulatory instruments to promote energy efficiency in buildings. Absence of a policy framework results in increasing number of inefficient buildings being constructed and appliances purchased, which then use excessive energy for a long period of time.

Awareness There is limited awareness of the opportunities available for energy efficiency in the buildings and appliances sector. Many households and commercial enterprises do not keep track of energy use and related expenditure. When appliances used in buildings are purchased, emphasis is placed on the features offered by the product and its purchase price, not on the operating costs.

Apart from end users, awareness about energy efficiency products, projects, and their economics, is limited in the finance and banking sector, and energy-efficient products and energy efficiency projects are considered to be risk-prone. Similarly, policy-makers are also unfamiliar with characteristics of the energy efficiency business, and policies and regulatory instruments are often designed with a limited appreciation of issues surrounding energy efficiency in general, specifically buildings and appliances.

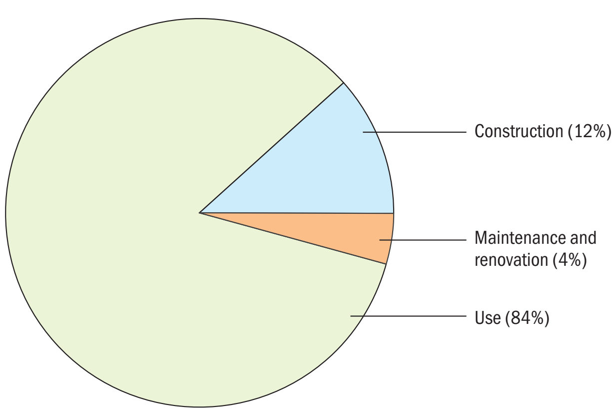

Figure 2 Life cycle energy use in buildings
Source WBCSD (2007)

Promotional policies

The buildings and appliances sector is a complex system involving a large number of stakeholders, long lifecycles, and a range of user preferences. A number of approaches and programmes involving policy, regulation, finance, institutional models, and technologies, are required to promote energy efficiency in the buildings sector. Some of the most effective approaches are listed below.

Building codes and performance standards Building codes and standards regulate the physical, thermal, and electrical requirements of building components, service systems, and equipment. Increasingly, building codes include energy performance standards which specifically limit the amount of energy that buildings can consume. One of the major challenges with regard to building codes is that they can easily be applied to new buildings but not to the existing stock of buildings.

The EU Energy Performance in Buildings Directive has resulted in significant savings already and the scope of this directive will be expanded substantially in 2009. In 2007, India launched the ECBC (Energy Conservation Building Code) which targets commercial buildings. Compliance with the building code has also been integrated into the EIA (Environmental Impact Assessment) requirements for large buildings. The ECBC requirements are currently voluntary and are expected to result in energy savings in the range of 30%–40% (Government of India 2008).

Appliance standards and labelling Energy efficiency labels, and standards for appliances and equipment, offer an opportunity to improve energy efficiency in residential and commercial buildings. Energy efficiency standards are specifications and regulations that prescribe the technical specifications or energy performance of manufactured products. Energy efficiency standards can transform markets by removing inefficient products and encouraging efficient energy services.

Energy-efficiency labels are informative labels affixed to manufactured products to describe the product's energy performance (usually in the form of energy consumption, efficiency, or energy cost). These labels give prospective consumers necessary data on their energy performance. Energy labels empower consumers to make an informed choice about the products they buy, and to manage their energy bills. In Japan, the 'Top Runner Programme' introduced in 1998, covers household and commercial appliances and automobiles, and uses the product with the highest energy efficiency as a basis for establishing standards. This standardization works in combination with an energy label.

Building rating systems Building rating systems are based on building performance standards and can be implemented either as mandatory or voluntary programmes. Mandatory programmes have been enforced in Japan, Taiwan, and Singapore, and one of the largest voluntary rating programmes is the LEED (Leadership in Energy & Environmental Design) programme of the World Green Building Council. LEED is a rating system for buildings based on building techniques and design wherein the buildings are classified as silver, gold, or platinum. TERI (The Energy and Resources Institute) has introduced a rating system for green buildings called GRIHA (Green Rating for Integrated Habitat Assessment) (REEEP 2008).

Rating systems provide an indication of the buildings' future energy performance and attendant energy costs to the prospective buyer/tenant of a property. Voluntary schemes like LEED are popular with commercial and corporate buildings in the US, Canada, and India.

Kyoto Protocol mechanisms The market-based mechanisms of the Kyoto Protocol, which allow for emissions trading between governments that are signatories to the Kyoto Protocol, are the CDM (Clean Development Mechanism) and JI (Joint Implementation). CDM and JI allow the energy efficiency gains from building energy efficiency projects and programmes to be quantified as avoided CO_2 emissions which can be traded. Since 2007, with the advent of the programmatic CDM (pCDM), it is possible to combine several housing units into a single CDM Programme of Activity to gain scale advantages. In June 2008, 9 projects were in the CDM pipeline with a potential to generate over 1.3 million CERs (certified emission reductions) by 2012. The possible revenues from trade in CERs provide an added incentive to energy efficiency projects and programmes.

Awareness and capacity building Information dissemination programmes and campaigns need to be conducted in local languages, and for specific target groups such as builders, architects, home owners, and tenants, using appropriate industry/trade media. Also, capacity-building exercises are required for financiers and policy-makers, in order to increase their awareness about features, opportunities, and economics of energy efficiency in buildings and appliances.

Key initiatives

While there are several institutions such as the UN (United Nations), IEA (International Energy Agency), the World Bank, and industries which conduct projects or release publications that promote energy efficiency in buildings and appliances, the following organizations have energy efficiency in buildings and appliances as a core area of operation.

Sustainable Buildings and Construction Initiative SBCI (Sustainable Buildings and Construction Initiative) was launched by the UNEP (UN Environment Programme) in 2006 and brings together a number of companies and initiatives from the fields of construction and metals, and consulting and rating organizations. The objective of SBCI is worldwide adoption of sustainable buildings and construction practices, and to provide a common platform for related issues.

Collaborative Labelling and Appliance Standards Programme CLASP (Collaborative Labelling and Appliance Standards Programme) was a partnership launched in 2002 at the Johannesburg Renewable Energy Summit and focuses on energy efficiency standards and labels for appliances, equipment, and lighting. CLASP originated from an initiative started in LBNL (Lawrence Berkeley National Labs) in 1996 and a subsequent project in 2000 by the UN on standards and labelling. CLASP is registered as a non-profit corporation and its headquarters are located in Washington

DC, US. CLASP works with governments, industry, inter-governmental organizations, NGOs, and technical support groups.

Renewable Energy and Energy Efficiency Partnership
REEEP (Renewable Energy and Energy Efficiency Partnership) was launched by the Government of the United Kingdom in 2002 at the WSSD (World Summit on Sustainable Development) in Johannesburg. REEEP currently consists of over 245 partners including 38 governments, and its projects are implemented in 50 countries. It supports renewable energy and energy efficiency projects in the priority countries of Brazil, China, India, Mexico, and South Africa as well as African and Pacific LDCs (least developed countries). The key REEEP donors are Australia, Austria, New Zealand, Norway, the Netherlands, Ireland, Italy, Spain, UK, and the US. REEEP has so far supported 84 projects with over €6 million, and has been able to leverage over €23 million in co-financing. Of these about €2.7 million of REEEP resources have supported energy efficiency projects. In 2007, REEEP launched the EEC (Energy Efficiency Coalition) consisting of a number of global stakeholders from industry, government, finance, and the non-governmental sector, who actively engage in promotion of energy efficiency. The initial focus of this coalition is buildings and appliances. REEEP was also mandated by the G-8 in its Gleneagles Plan of Action to target energy efficiency improvements in buildings. REEEP also accords priority funding to projects targeting energy efficiency in buildings and is currently supporting such projects in China, Poland, India, and Eastern Europe.

Conclusions

The conclusions that can be drawn from the brief overview of the buildings and appliances sector are as follows.

- Curbing energy demand is important for ensuring energy security and for mitigating climate change. The buildings and appliances sector offers the highest potential for energy efficiency measures to curb energy demand.
- There are several barriers preventing the realization of energy efficiency potential in buildings and appliances. The key barriers include investment, pricing, risk perception, structural issues, policy, regulation, capacity, and awareness.
- Some of the effective approaches to address these barriers and develop this market segment are establishment of building codes and performance standards, definition of standards and labelling of appliances, enforcement of building rating systems, highlighting possible financial gains through CDM/JI, and building capacity and creating awareness.
- Initiatives such as SBCI, CLASP, and REEEP, promote energy efficiency in buildings and appliances as a core area of activity. However, a great deal needs to be done and this will involve significant efforts from key stakeholders—home-owners, policy-makers, financiers, and other development and facilitating agencies.

References

IEA (International Energy Agency). 2007
China and India Insights
In World Energy Outlook 2007
Paris: IEA

IPCC. 2007
Summary for Policy Makers
In *Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental panel on Climate Change*, edited by B Metz, O R Davidson, P R Bosch, R Dave, L A Meyer
Cambridge, UK and New York, USA: Cambridge University Press

Vattenfall A B. 2007
Global mapping of Greenhouse Gas Abatement Opportunities
Details available at, http://www.vattenfall.com/www/ccc/ccc/577730downl/index.jsp, last accessed on 10 July 2008.

UNEP (United Nations Environment Programme). 2007
Buildings and Climate Change: status, challenges, and opportunities
Nairobi: UNEP

REEEP (Renewable Energy and Energy Efficiency Partnership). In Press
REEEP Global Status Report on Energy Efficiency 2008
Vienna: REEEP

IEA (International Energy Agency). 2008
Energy Technology Perspectives 2008: scenarios and strategies to 2050
Paris: IEA

GoI (Government of India). 2008
National Action Plan on Climate Change
New Delhi: Prime Minister's Council on Climate Change, GoI

WBCSD (World Business Council for Sustainable Development). 2007
Energy Efficiency in Buildings: business realities and opportunities
Geneva: WBCSD

Centre for Research on Energy Security

CeRES (Centre for Research on Energy Security) was set up on 31 May 2005. The objective of the Centre is to conduct research and provide analysis, information, and direction on issues related to energy security in India. It aims to track global energy demands, supply, prices, and technological research/breakthroughs – both in the present and for the future – and analyse their implications for global as well as India's energy security, and in relation to the energy needs of the poor. Its mission is also to engage in international, regional, and national dialogues on energy security issues, form strategic partnerships with various countries, and take initiatives that would be in India's and the region's long-term energy interest. *Energy Security Insights* is a quarterly bulletin of CeRES that seeks to establish a multistakeholder dialogue on these issues.

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