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CONTENTS

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Building an Energy Secure Future for India

Climate change has been the flavour for the last two months and energy security has taken a back seat both in terms of high level discussions on implementation of policy and schemes that enhances security, as well as media coverage.

This issue seeks to revive interest in energy security issues both at a broad based international level as well as specific sectors in India where energy savings could be high which, in turn, will enhance energy security.

The first article on *India's energy security: imperatives for change* covers the current status in the energy sector and projects energy demand in a business-as-usual scenario, which clearly establishes that our energy demand in the medium to long term will be unsustainable. Import dependence for fossil fuels will increase considerably and in the case of coal there will not be enough global availability to meet India's projected demand, let alone that of other countries. Therefore, several steps need to be taken, both by way of policy changes and technology improvements, to bring down India's demand to more manageable numbers, while at the same time providing clean commercial energy to those who currently do not get it or cannot afford it.

The second article on *Energy efficiency in the small scale sector: focus on bricks and glass sectors* takes a close look at two industries, bricks and glass, which are in the small scale sector. These two industries have a very low profile and not many people within the industrial sector are aware that they consume a large amount of energy and do so very inefficiently. They lack technical and financial assistance by which they can achieve substantial energy savings. TERI has done some work in the glass industry to raise the efficiency bar. ESCOs (energy savings companies) could provide financial and technical assistance to the brick industry to be compensated with a share of the savings achieved, and thus find fortune at the bottom of the brick pyramid.

New buildings too, offer considerable scope for energy savings which are very well documented in the third article. TERI, in its own way, has helped establish GRIHA (Green Rating for Integrated Habitat Assessment) as a national rating system and has also been tasked to examine 100 government-owned buildings in Delhi to see how they can be retrofitted for greater energy savings.

The last article on *Secure routes and the supply of energy to India* looks at securing routes for the supply of imported energy to India. Unfortunately India has not been able to achieve any success in importing gas by pipeline due to the geopolitics of the region and issues related to the security of such supplies. Currently, imports are therefore only by sea. A concern, though not an immediate one, relates to three chokepoints, that is, the straits of Hormuz, Malacca and Bab-al Mandab, which could seriously impact imports by India arising from international disputes, inter state conflicts, terrorism, piracy, and so on. Some suggestions have been made as to how importing nations in the region could, by way of joint patrolling, address the issues of piracy. Other measures suggested are swap arrangements and joining the Energy Charter Treaty. Though not covered in this article, China, in contrast, has taken very positive steps in enhancing its energy supplies and finding alternative routes by laying long distance gas pipelines from Central Asia, oil and gas pipelines through Myanmar to avoid the Straits of Malacca, securing oil from Russia by another long distance pipeline and establishing a large port on the southern tip of Sri Lanka which will add to 'the string of pearls' that it is developing across the Indian ocean and the South China seas. China's strategy is clear cut, far-sighted and under active implementation. It may not be possible for India, for geographical and logistical reasons, to duplicate what China has done, but it clearly needs to come up with a well-defined strategy for securing its energy imports through actual physical infrastructure to complement the steps described earlier.

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India's energy security: imperatives for change

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Energy security has traditionally been viewed from a supply-centric perspective with a focus on energy import dependence. However, more recently, views on energy security have widened to encompass not only availability and affordability of energy, but also the environmental implications of energy consumption.

India's energy security: current status

Though India accounts for 17% of the world's population, it consumes just 5% of global energy consumed. However, with an expanding economy and rapidly growing population, India is witnessing an unprecedented increase in its energy demand. This growth in energy demand presents several challenges, particularly in the context of India's energy sector and its primary features; some of which are as follows.

- Dominance of coal in electricity generation (Figure 1)
- Persistently high dependence on imported oil – imports currently stand at 75%, of which nearly 74% is sourced from West Asia (Figure 2); recent developments include import of natural gas and coal as well
- Persistently high dependence on traditional biomass (used in inefficient smoky cook stoves) for cooking in 100 million households

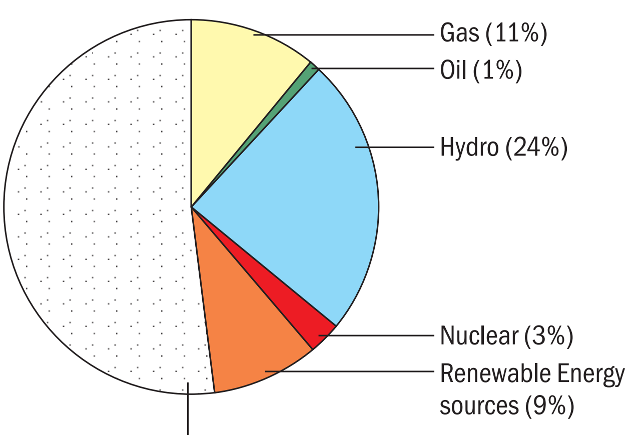

Figure 1 Power g eneration by fuel
Source Ministry of Power 2009

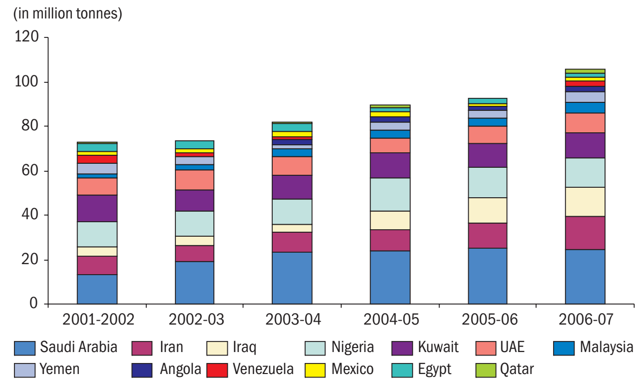

Figure 2 Share of various countries in India's oil imports
Source Online oil and gas database of Infraline Energy and Research and Information Services (2008) as cited in TERI (2009)

- Poor electricity access with 56% of households unelectrified and average per capita electricity consumption (700 kWh) just about one-third world average per capita level (2429 kWh) (TERI 2010 *forthcoming*)

India's energy future: critical concerns

Though the future is uncertain, some indications of what India may be faced with in a BAU (business-as-usual) scenario will give some sense of how energy secure or insecure India is expected to be. Assuming that population and GDP (Gross Domestic Product) growth would progress as per Government of India estimates (1.45 billion people by 2031 and a doubling of GDP every decade), the following may be expected in a BAU scenario (TERI 2010 *forthcoming*).

- *Energy growth* Primary energy requirement to grow over 7.5 times from the 2001 levels and this is met by an eight-fold increase in coal and oil consumption and a near quadrupling of gas consumption.
- *Energy mix* Coal continues to be the most important source of energy accounting for just over half the share in total commercial energy in 2031, followed by oil. Natural gas, hydro power, nuclear power and renewable sources of energy make up less than one-tenth of total commercial energy.

- *Import dependence* Nearly three-fourths of energy supply may need to be imported in 2031.

Thus, prima facie India's energy security concerns are manifested in its high energy import dependence which presents concerns about the outflow of foreign exchange reserves and questions about whether port infrastructure is adequate not only in India but also in the exporting countries. The physical availability of coal in particular seems doubtful, based on current projections of the size of the global coal export potential. There are also concerns that there may be spurts of resource nationalism or other pressures such as from environmental lobbies that may impose limits on accessing fossil fuels from certain countries.

Additionally, persistently high dependence on fossil fuels presents challenges in terms of global and local environmental concerns. An estimated 100 million households that continue to depend on traditional biomass fuels are also no less a threat given the potential adverse environmental, health and welfare effects as well as possible impacts on the state of the forests.

Given these challenges, transitions in the Indian energy sector are therefore an imperative. These transitions can be effected not only on the supply side but also the demand side.

Changes in the supply side: focus on electricity mix

On the supply side, a large concern for India stems from the electricity sector, which will need to expand rapidly to meet the country's targets for continued economic growth and human development. A number of factors will constrain fuel choices in expanding electricity capacity. Coal, has been the mainstay of the Indian power sector thus far. However, in the future there will be growing concerns about the availability of coal, both domestic and imported. Also, given the carbon intensive nature of coal, trade in coal in the future may become uncertain, as the climate change negotiations unfold and the multilateral framework to mitigate climate change strengthen. Technologies aimed at more efficient and low-carbon applications of coal, in various stages of development and/or commercialization (for example, supercritical and gasification), are promising. CCS (Carbon capture and storage), seen by some as a potential boon to coal users globally, is a technology that has several uncertainties attached to it, not least regarding the costs and whether it will work or not. Other uncertainties pertain to efficiency, environmental and safety implications of CCS and the feeling in some quarters that CCS will take away precious policy interest and investments away from energy efficiency and renewables. These uncertainties will have to be addressed if CCS is to find a future in India.

Natural gas has the potential to emerge as a transition fuel for low-carbon power generation, while renewable and nuclear energy take off in the coming decades. Though recent domestic finds have been promising, important gaps remain in terms of policy on gas pricing and utilization and an understanding of the relative economics of gas use in alternative sectors (particularly power vis-à-vis fertilizers).

India's nuclear strategy is remarkably innovative in its farsightedness that will eventually rule out import dependence through conversion to technologies that use domestically available thorium. However, uranium imports will have to be secured in the interim. The Indo-US civil nuclear agreement and the Nuclear Suppliers Group waiver are positive developments. However, how much uranium India will be able to tap from the international market remains uncertain. Within the country, public perceptions about the safety of nuclear energy (for example accidents and leakages) remain sceptical given past experiences such as the Bhopal gas tragedy. Therefore, much will be dependent on the transparency with which the nuclear sector moves forward. There have been mixed reactions to the recently announced civil liability regime.

Uncertainties about fossil fuels and rising climate change and energy security concerns provide an impetus for the development of RETs (renewable energy technologies). While several of the RETs offer much hope, several factors hinder their development. These will have to be looked into in the immediate term. The recent CERC (Central Electricity Regulatory Commission) notification on tariffs seeks to address many of the gaps in pricing policy. Over a longer time-frame, attitudinal issues (for instance, apprehension relating to the intermittent nature of wind energy) will need to be addressed as will institutional aspects, specifically the multiplicity of agencies involved. Uncertainties about costs and technology availability persist. For instance, though the Jawarharlal Nehru National Solar Mission is full of hope, it also recognizes the challenges in procuring technologies and resources internationally.

Demand side responses: an imperative

Given the uncertainties that cloud various supply side options, some tightening on the consumption side is inevitable. Not only will energy consumption have to be reduced, but the ecological and social implications will also have to be managed. On the positive side, reduction in consumption of energy need not imply a decline in the quality of life.

Three-fourths of the energy efficiency potential in the country lies in energy end use sectors (TERI 2010, *forthcoming*). Industry, transport, households, agriculture and the commercial sector all have the potential to benefit from energy efficiency. Structural changes in the economy (for example, emphasis on less energy-intensive sectors) and sectoral planning (for example, encouraging tele-commuting, improved land use planning to reduce the need for transportation, improved building design) – albeit more difficult to do than technology adoption – can further reduce the demand for energy services without compromising on well-being or standards of living. While energy efficiency improvements are applicable largely to 'islands' of relatively high energy intensity such as industry, transport and high-income households, energy poverty representing unmet energy demand also offers opportunities to seek newer ways to meet energy demand – ways that are greener and more efficient. For instance, replacing traditional biomass with LPG (liquefied petroleum gas) does address the issue of energy access, but it does not address the issue of dependence on 'brown' energy. Locally available biomass could be used in cleaner forms (gaseous or liquid) to potentially address issues of access, import dependence and carbon emissions simultaneously. Similarly, small scale industries that have not been a part of industrial efficiency improvements in the country, offer huge potential for improvement in energy efficiency and environmental performance but will need some specific measures (as highlighted in a subsequent article). Another promising area, given the rapid growth in construction in the country, is Green Building Design, described in some detail in another article in this volume.

Managing energy import dependence

Despite efforts on the end-use efficiency and supply fronts, India's reliance on imported oil, coal and gas is expected to rise and this renders the country's energy import strategy a vital element of its energy security strategy. Choosing energy partners for trade and acquiring overseas equity investments judiciously, pipelines diplomacy and securing sea routes as well as strategizing technology transfer will all have to be a part of India's energy security initiatives. In diversifying its import sources, India will have to broad-base its criteria for choosing countries – looking beyond distance and exportable surplus to focus also on countries where India could have a special geopolitical advantage due to historical or socio-economic reasons.

Going forward: catalysing change

It is evident that transitions are imperative and therefore imminent in the Indian energy system. These transitions call for changes not only in terms of technology and fuel choices but also in the larger policy and institutional domains. Specific sectors that require attention on a priority basis include:

- Biomass strategy – Biomass has thus far been seen as compartmentalized – a cooking fuel in poor households; a blend fuel with oil in the transport sector; a renewable source of electricity. However, what is missing is a holistic assessment of biomass as a resource and a usage pattern driven by relative economics.
- Gas pricing and utilization policy – Gas has the potential to reduce the carbon content of the Indian energy sector with relative ease. However, domestic policy gaps will have to be addressed at the earliest.
- Transport sector – The urgency for evolving a coherent over-arching transport strategy stems from the high dependence on imported oil as also from its implications for mobility, an important aspect in access to basic services and connectivity.
- Solar energy for power generation – The recently launched Jawaharlal Nehru National Solar Mission has acknowledged the potential of solar energy in the country and has drawn up a roadmap. Action on this will require a detailed examination on several aspects, particularly on securing and developing appropriate technologies and market creation.

In terms of the larger context, several points are important. Beliefs and perceptions must change; there has to be recognition that energy is scarce, and it needs to be consumed judiciously. There has to be a longer term view of energy. In an era of low price for oil (and a damp carbon market too), renewable energy options are sometimes seen as being priced out. However, it is important to see these indigenously available environment-friendly sources for the energy security benefits that they bring in. Investments in renewable energy technologies cannot, therefore, be based on financial cost considerations but will have to factor in the associated longer term and less tangible benefits (Krishnan 2009).

Technology change is imperative. A proactive strategy for technology transfer will have to be devised focusing on specific technologies (such as clean coal and renewable energy). Given India's large pool of scientists and technocrats, the country will also benefit from spurring domestic energy innovation by making its current system of energy research and development more dynamic.

The policy and institutional context must adapt itself to the changing roles of markets and regulation, particularly with the advent of a large number of private players. Larger roles of state and local governments and for civil society will have to be planned. Given the multi-sectoral links of energy, water-tight ministries and agencies will have to open up and would need to work in a dynamic and coordinated manner.

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Energy efficiency in the small-scale sector: focus on bricks and glass sectors

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Introduction

Small-scale industries are an important segment of the industrial sector. There are over 500 small-scale industrial clusters in India that produce a wide range of products. Its share of the industrial value is about 40% and is a huge source of employment. Majority of the small-scale enterprises are located in clusters, and follow similar production processes. As per Ministry of Micro, Small and Medium Enterprises (MSME), there are 1223 clusters (in 26 states) engaged in manufacturing activities in registered small-scale industries (SSI) sector. The number of small scale industries in India is as follows: registered (2 031 910) and unregistered (10 811 864).

Very little information is available on the technologies used and the potential for reducing energy consumption in these industrial units. A large number of sub-sectors in the small enterprises are energy intensive and are a significant source of greenhouse gas (GHG) emissions. Due to low level of awareness and in-house capacities, a large number of small enterprises continue to use obsolete technologies and operating practices, thus resulting in specific higher energy consumption levels. The small-scale sector therefore offers opportunities for reducing the overall energy consumption by adoption of energy efficient technologies at the enterprise level. This paper identifies two sub-sectors – brick and glass – for in-depth study and analysis.

'Greening' bricks: energy and carbon saving potential

Brick making is a highly energy-intensive process and consumes about 8 MTOE (as coal) and a huge quantum of biomass per year. The basic raw material required is clay. The large production of fired bricks has an impact on the environment in the form of carbon dioxide (CO_2) emissions, air pollution, topsoil erosion, deforestation and so on.

About 140 billion bricks are produced every year in 100 000 brick kiln units with an annual turnover of Rs 100 billion. These units are located in peri-urban and rural areas in a number of clusters that can be categorized into two major zones based on the nature of soil availability: (1) Indo–Gangetic Plains, consisting of North and Northeastern part of India, which caters to about 65% of total, demand (Zone–1) and (2) Peninsular India – consisting mostly of south-central and Southern part of India and which meets about 35% of total demand (Zone–2).

It appears that there is potential for large brick kilns to switch over to better firing technologies, which can improve the yield of high quality bricks from about 80%–85% to about 95%. Along with technology adoption, better operating practices (BOP) in existing and new kilns is critical and could help reduce fuel consumption by 5%–10%.

Products and production process

Mainly, two types of bricks are produced in India – (i) clay-based bricks — solid bricks, perforated bricks, hollow blocks – and (ii) fly ash bricks. The production process followed for clay-based and fly ash bricks are different from one another. Solid bricks are predominantly used in India, whereas perforated/hollow bricks are used in Kerala and Karnataka. Solid brick production process followed in India is generally manual. The hand-moulded bricks are sun-dried and fired in kilns. In Kerala, Karnataka and Tamil Nadu, a small quantity of green bricks are moulded using machinery, that is, extruders, soft mud moulding machine with the predominant production being tiles. Use of fly ash for brick making in India is at a nascent stage. For fly ash brick making instead of firing, curing process is followed.

The type of brick kiln used for firing green bricks generally depends on production capacities. For small production capacities (5000 to 50000 bricks per firing), intermittent kilns such as clamps and downdraught kilns are used.[1] The use of these kilns are generally seen in Peninsular India. For large production capacities (30 000 to 50 000 bricks per day), BTKs (bull's trench kilns) are used, which generally operate in Indo-Gangetic Plains. Few VSBKs (vertical shaft brick kiln), Hoffmann kilns and tunnel kilns are also used for firing bricks and tiles. The brick kilns in North India generally use- coal as fuel, whereas, biomass fuels are widely used in kilns operating in southern states.

Agricultural top soil is the most commonly used raw material in brick making in India. Soil upto about 3 feet is dugout and used for brick making. Ministry of Environment and Forests (MoEF) has issued notification for partial blending of fly ash with soil in brick kilns which are located within a radius of 100 kilometres of coal-based TPPs (thermal power plants). However, this level of mixing is dependent on the quality of soil and its clay content. Through 'Fly Ash Mission', the Government of India is promoting 'fly ash bricks'. There is very low level of perception on the use of fly ash bricks by different end-users, which is also evident by its level of production in the country. Under a study carried out by TERI for MoEF, it has been found that there are benefits from fly ash based brick making techniques such as reduced energy use, cost savings on account of lesser mortar requirement on part of consumers, prevention of top soil erosion and even CDM benefits, and so on (TERI 2006).[2] However, in spite of these benefits, barriers on account of high costs associated with initial investment, fixed costs, high raw material costs, lack of level playing field, mindsets, lack of awareness, broad policies, and so on, poses significant barriers in tapping the potential of brick making as a gainful use of fly ash.

Technology review

This section briefly describes the brick production process, technologies used, energy consumption and potential alternative technologies that are available in the manufacturing process. It also outlines the barriers that inhibit the technology upgradation process.

Clay-brick production

Manual moulding methods are used for green brick making and sun-drying is practiced for drying of green bricks. No electrical energy is required for the production of solid clay bricks through manual process. The sun-dried green bricks are fired in kilns such as clamps, BTKs, VSBKs and tunnel kilns.[3] The specific energy consumption for clamp kilns, which are of intermittent type, is the highest. Table 1 shows

[1] Clamps are traditional, intermittent kilns which are generally used in Peninsular India.

[2] Policy, institutional and legal barriers to economic utilization of fly ash (TERI Report No. 2006RD25)

[3] BTKs are used generally for large and continuous production processes and account for about 65% of total brick production in India; VSBKs is a technology of Chinese origin, introduced in India under a project supported by SDC (Swiss Agency for Development and Cooperation). Tunnel kiln is largely used in European countries for brick production.

the specific energy consumption levels of different types of brick kilns.

Table 1 Specific energy consumption of brick kilns (clay and coal-based)

Type of kiln	*Specific energy consumption* (MJ/kg brick)
Clamp	1.5–2.5
BTK	1.1–1.3
VSBK	0.8–1.0

In South India, especially in Kerala and Karnataka, mechanical green brick making process is adopted for producing brick and tiles. Generally, extruders are used for the production of solid bricks, hollow blocks and perforated bricks.

Fly ash bricks

In the manufacture of bricks, fly ash is an alternative material to clay. Fly ash may be used either as clay as part replacement or in combination with other materials like sand, lime, gypsum, and so on, to produce a substitute to conventional clay bricks. Fly ash bricks/blocks can be of following types:

- Clay fly ash bricks
- Fly ash, lime, gypsum (Fal-G) bricks
- Cellular lightweight blocks
- Fly ash, lime, sand autoclaved bricks

Fly ash bricks are produced in very small quantities in India.

Alternative technologies, products and energy saving potential

Discussions with the All India Bricks and Tiles Manufacturers Federation (AIBTMF) and one of the most active state level associations 'Int Nirmata Parishad' (INP) of Uttar Pradesh, revealed that most of the technological interventions in the brick sector take place in South India. As a result, Karnataka and Kerala were identified for further study. A visit to prominent bricks and tiles clusters was undertaken in July–August 2008 to ascertain field conditions related to brick production processes. The brick making clusters/locations visited included (1) Kundapur, (2) Mangalore, (3) Kannur and (4) Trissur. These clusters were chosen based on (i) availability of improved green brick moulding processes; (ii) use of better firing technologies in brick production, and (iii) production of resource efficient bricks. The team also interacted with equipment/machinery suppliers and contractors.

Switch over to alternative clay products

Solid bricks are the major building material in India. They are also used as 'load bearing' materials in buildings. However, with a switch over to RCC (reinforced cement concrete) structure and multi-storey buildings, it may not be necessary to use solid bricks for filling. Perforated bricks and hollow blocks can be effectively used as alternatives to solid bricks. This however would require a shift from manual moulding to machine moulding that is, use of extruders. This would further require electricity for the operation of extruders and substantial investments by individual brick kiln units.

For the same volume of brick production, perforated bricks/hollow blocks would require 30%–40% less clay and about 20% reduction in fuel consumption in the kilns.[4] Assuming 30% of BTKs opt for these resource-efficient brick products, the estimated energy saving potential is 1.320 million tonnes of oil equivalent (MTOE). Apart from direct energy savings at production level, there are additional benefits associated with the use of resource efficient bricks. For example, they offer better insulation and help in saving heating and cooling loads in buildings.

Apart from perforated bricks/hollow blocks, fly ash brick is an alternative construction material. Fly ash production would require setting up different production processes. Fly ash from coal based thermal power stations may be utilized for this purpose. Fly ash brick production would completely eliminate the use of top soil in brick making.

However, the following barriers need to be addressed.

- Setting up of machinery required for production of resource efficient bricks in a brick kiln unit producing about 40 000 bricks per day would require an investment of Rs 10 million to Rs 20 million.
- Resource-efficient products are produced in limited quantities in few clusters and the productions have not been demonstrated for varying soil conditions in different regions.

[4] For producing perforated bricks, as per IS 2222:1989, the area of perforation shall be between 30 to 45 percent of the total area of the corresponding face of the brick and should be uniformly distributed over the surface.

Existing technology with manual moulding does not require electricity for the production process. However, switching over to the production of resource-efficient brick products would require substantial power connection and majority of the brick kilns are located in rural and remote areas.

- The present level of awareness about resource-efficient brick products, benefits in production as well as end-use, availability of manufacturers, and so on, is low among brick kiln entrepreneurs. The end-users generally select bricks based on colour and the ringing sound of bricks.
- Substantial investments would be required for technology upgradation in brick kilns and acquiring machinery for the production of resource efficient bricks. It may not be easy for a small scale brick maker to arrange for such huge investments. At present, there is no tailor-made financial instrument for financing modernization of the brick industry and very few brick makers are able to access loans from commercial banks.
- Poor markets for alternative brick products – due to limited production of resource efficient bricks, the market for them remains underdeveloped. There is a need to enhance market requirements that would match the supply of resource-efficient bricks.

Given these barriers, there are certain suggested strategies that can be put in place. In order to facilitate technology upgradation in the brick sector, it is necessary to demonstrate identified technologies at the cluster/regional level. A programmatic approach would help in this purpose. Along with technology demonstration, it is essential to develop financial linkages between banks and brick kiln units that would enable individual brick kiln units to avail bank loans for technology upgradation. It may be required to create brick sector-specific financing schemes for this purpose.

The market for such resource-efficient brick products must be strengthened to bridge the supply and demand. It is necessary to address public procurement policies of the government such as PWD (Public Works Department) and MES (Military Engineering Services) that would directly impact on large consumption as well as production of resource-efficient bricks. There is need to build awareness among various end-users on the use of resource-efficient brick products.

Creation of brick sector-specific programmes with a long-term commitment from government/bilateral/multilateral agencies is essential for technology upgradation in the brick sector. As an example, a project supported by UNDP–GEF (United Nations Development Programme–Gloabal Environment Facility) has been endorsed by the MoEF, which will focus on supporting technology upgradation, financial linkage and market development in five selected clusters (Delhi, Punjab, Pune, Varanasi and Bangaluru) over a period of four years. However, similar programmes need to be initiated in other clusters as well with an objective to develop local capacities for accelerating the adoption of technology upgradation in the brick sector.

Brick firing kilns

Brick firing in the kilns is generally done by untrained firemen. Improvement of their skills in brick firing such as use of proper coal sizing, coal feeding practices, maintaining adequate draught and adhering to firing temperature requirements would help in saving about 5% of fuel in BTKs. Assuming about 50% of BTKs adopt BOP (best operating practices), it would lead to an energy saving of 0.550 MTOE in BTKs.

However, it is difficult to estimate at this stage the investments requirements for building/strengthening institutions and carrying out formal training process. The barrier to training the firemen is mainly institutional. There is no formal training system/mechanism/institution existing in the country to train firemen on best operating practices. Also, comprehensive programmes of the government are absent.

There are some suggested strategies pertaining to the training of the 150 000 firemen who work in brick kilns and still do not have formal training. Institutionalizing the training process is hence essential. Training would help firemen in adoption of best operating practices in brick kilns and help in fuel savings. It may be worthwhile to look at options such as 'training of trainers' along with establishing networking with regional-level training institutions that would help in sustaining the training process.

VSBK as an option for clamp

Clamps are used for smaller production capacities. The bricks produced from clamps are generally inferior in quality. VSBK (vertical shaft brick kiln) has been identified as an alternative technology to clamps, which would help in reducing the specific energy consumption (SEC) by about 50% (From 2 MJ/kg-fired brick to about 1 MJ/kg-fired brick). Possibilities of switchover are more in the states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, which account for 50% of clamps. The total energy saving potential is estimated at 3.230 MTOE.

The investment requirement for setting up of a 2–shaft VSBK along with its accessories producing about 10 000 bricks per day is Rs 2 million. However, the major barrier for adoption of VSBK technology by small brick makers is the investment requirements.

VSBK has been identified as an alternative technology for large clamp kilns that would help in energy saving, pollution reduction and improve yield and quality. VSBK technology has also been identified as one of the options by the MSME for which subsidy schemes are available. The Ministry has identified a few thrust states such as Madhya Pradesh, Chhattisgarh and Orissa. Efforts must be made to cover all states in Peninsular India.

Various subsidy schemes of the Government of India must be utilized effectively for promotion of VSBK. Here too a programmatic approach needs to be followed while utilizing government schemes and obtaining support from bilateral/multilateral agencies for establishing self-sustainable service delivery model.

A summary of the technology options and the energy saving potential is given in Table 2.

It is evident therefore that with partial adoption of energy saving practices and technologies in the Indian bricks sector, the country could save about 3 MTOE each year.

Table 2 Technology options and energy saving potential in brick sector

Existing technology	*Option for improvement*	*Assumption*	*Energy saving potential (MTOE)*
BTK	• Best operating practices	• 5% fuel saving	0.24
		• 50% BTKs adopted BOP	
Solid bricks	Switch over to perforated bricks/hollow blocks	• 20% fuel saving	0.58
		• 30% BTKs produce resource efficient bricks	
	Fly ash bricks	10% of solid brick production is replaced with fly ash bricks	0.67
Clamps	Shift to VSBK	Clamps in the states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, which is about 50% of total clamp kilns in the country adopt VSBK	1.57
Total energy saving potential in brick sector			3.06

MTOE – million tonnes of oil equivalent

Towards a more energy efficient glass sector

The Indian glass industry represents one of the largest markets with the largest manufacturing capacity for glass products in the Asian region. Indian glass industry is dependent on other sectors such as construction, automotives, food and beverages, which together account for 80% of the output of the glass industry.

There are about 100 large scale glass units in India involved in the production of different types of glass. Majority of these units are located in Ahmedabad, Mumbai, Kolkata, Bangaluru and Hyderabad. Container glass segment represents the largest in the glass sector, representing about 60% of total glass production, followed by flat glass (20%). There are 44 glass units involved in the production of glass container and hollow wares with an installed capacity of 1.5 million tonnes per year.

Apart from these large units, there are more than 300 medium, small scale and cottage units involved in glass making in the country; meeting the requirements of domestic segment as well as other types of glass. Majority of the small scale units are located as a cluster in Firozabad (Uttar Pradesh), which meets about 70% of glass demand from the small scale sector. While large and medium industries have the technical capacities to upgrade their production process and improve upon energy efficiency, the small-scale industries do not have the required capacity to upgrade the units. Therefore, this report focuses mainly on the small scale glass industries located in the Firozabad cluster. [5]

Technology review in the glass sector

The production process in a glass industry includes batch preparation, melting, shaping/forming, annealing (heat treatment) and finishing. The production profile shows that float glass industry accounts for majority of the glass production in the sector. The glass manufacturing processes followed in different product segments are generally common with minor variations in the downstream operations of the furnace. The melting process, which uses thermal energy, is the most energy intensive operation in a glass unit. Many of the larger units use tank furnaces built of refractory blocks.

The small-scale glass industries in Firozabad use tank furnaces and pot furnaces for melting glass.[6] The production capacity of tank furnaces is higher than pot furnaces and is about 20 to 40 tonnes per day. The production capacity of pot furnaces is about 4 to 5 tonnes per day. The melting process accounts for about 60% to 70% of energy consumption. Other than these, the cluster also operates muffle furnaces for heat treatment of bangles and polishing with synthetic colour.[7]

The majority of tank and pot furnace units have switched over from coal/oil to NG (natural gas) firing system following a 1996 Supreme Court verdict to use NG due to environmental pollution. The muffle furnace units, which are small in size, still use coal as NG supply is not available to these units. Glass making is an energy intensive process, accounting for about 30%–40% of total production cost in a glass unit.

The theoretical energy consumption for melting glass includes the following important components.

- Heat required to raise the temperature of raw materials from ambient to reaction temperature to form glass
- Heat of reaction to complete the reaction forming glass from the raw materials
- Heat required or enthalpy to raise the glass temperature to 1500 °C
- Heat content of flue gases released during melting

The theoretical energy requirement for melting one tonne of soda lime glass with 50% cullet (glass wastes) in the batch material is about 2.32 GJ and it would be around 2.7 GJ in case there is no cullet in the batch. The actual specific energy consumption (SEC) by glass melting units varies widely. In case of tank furnace, it varies in the range of 5.86 to 8.79 GJ per tonne of glass melt. On the other hand, the SEC of pot furnaces is in the range of 10.67 to 21 GJ per tonne of glass melt production depending upon batch composition of the individual unit. The estimated annual fuel consumption of Firozabad glass cluster is 320 100 TOE (tonnes of oil equivalent), as shown in Table 3.

Table 3 Estimated fuel consumption in Firozabad glass cluster

Type of unit	*Number of units*	*Fuel used*	*Average fuel consumption per unit*
Pot furnace	100	NG	4000 SCMD (standard cubic metres per day)
Tank furnace	41	NG	13,000 SCMD
Muffle furnace	500	Coal/wood	0.500 tonne/day
Total annual fuel consumption in the cluster			320,100 TOE

It was observed that the factors affecting performance of furnaces in terms of energy efficiency include furnace capacity, furnace throughput, the age of the furnace, which can be as high as 20% higher than the design value, and ratio of cullets, which can significantly reduce the energy consumption as the heat of the reactions required for glass forming reduces to a great extent.

Alternative technologies and energy saving potential

The higher level of energy consumption by the glass manufacturing units (in Firozabad cluster) and the

[5] The team reviewed the project reports prepared under the on-going initiative being supported by SDC (Swiss Agency for Development and Cooperation) since 1994. The project team collected information related to energy consumption through field visits and interactions with entrepreneurs from different process segments. The data obtained through field survey were analyzed to conclude the existing energy consumption scenario in Firozabad glass cluster. The team also verified field data with the information provided by the local glass association, the Glass Industry Syndicate during its different interactions.

[6] Tank furnaces are used for large capacity. A glass furnace is a large, covered furnace or tank for melting large batches of glass, in which heat is supplied by a flame playing over the glass surface, and regenerative heating of combustion air and gas is usually employed. It is also known as a glass tank. A pot furnace is used for smaller capacities and is a furnace containing several pots in which glass is melted.

[7] A muffle furnace is a furnace with an externally heated chamber, the walls of which radiantly heat the contents of the chamber.

significant variations from the theoretical energy consumption indicates large scope for reducing energy consumption. Significant energy savings can be realized by the adoption of energy efficient technologies or technology upgradation of individual units. An analysis of diagnostic survey for closed pot furnace in the cluster reveals similar conclusions.

There are 25 closed pot furnace units generally producing soda lime container glass of about 150 tpd. The estimated specific energy consumption of the existing units vary widely in the range of 15–28 GJ/tonne. A performance study of large glass units shows that the specific energy consumption varies between 3.9 to 7.9 GJ/tonne glass melt, indicating a large energy saving potential in the small-scale glass sector.

In case of pot furnace, TERI has initiated promotion of energy-efficient NG-fired pot furnaces using waste heat recovery system, which has been adopted by about 50% of pot furnace units in Firozabad glass cluster, under a programme supported by SDC (Swiss Agency for Development and Cooperation) since 1994. Various pot furnace units that have adopted the TERI-design have realized significant and consistent energy savings of about 30%–35%.

In the muffle furnace segment, NG was generally not available directly to individual muffle furnace units, which were using coal and wood as fuels. TERI, under the SDC supported-project, demonstrated NG-fired pot furnaces and provided technical backup support for adoption of gas firing in about 100 muffle furnace units. An energy saving of about 15% was realized by the muffle furnace units with fuel switch over. However, majority of these muffle furnace units were shutdown due to non-availability of NG to these smaller furnace units.

Apart from these furnaces, there are a number of auxiliary furnaces in pot furnace units such as reheating furnaces, colour melting furnaces, bangle making furnaces and pot preheating furnaces, which are traditional systems used in the cluster and have large potential for energy saving through technology upgradation.

Apart from the furnaces, all pot furnaces use pots (open and close types) for melting glass. These pots, which are produced locally in the cluster, are inferior in quality and generally last between 2 and 20 days, resulting in production and energy losses apart from causing hard labour to workers while replacing the broken hot pots at about 1400 °C.

Apart from pot furnace units, the tank furnaces which are used in the cluster are smaller in capacity as compared to the furnaces used in large glass units. The SECs of tank furnaces indicate significant energy saving potential (about 15%). Apart from tank furnaces, there are other auxiliary furnaces such as annealing lehr which are used for heat treatment of the glass products.[8] Design modifications in crown, optimizing waste heat recovery, preheating of feed material using waste heat from flue gases, improvements of insulation, reduced heat losses in furnaces and annealing lehr are some of the options available for tank furnace units in reducing their energy consumption levels.

Table 4 Potential energy savings from Indian glass sector

Furnace segment	Energy consumption (TOE/year)	Energy saving (TOE/year)
Pot furnace (melting furnace, auxiliary furnaces and improved pots)	120 300	38 000
Tank furnace	160 400	24 000
Muffle furnace	39 400	7 000
Total energy saving potential	320 100	69 000

Barriers

Technology changes in different furnace segments in Firozabad glass cluster would entail substantial investments in order to realize energy savings.[9]

Table 5 Investments required for energy savings

Type of unit	Investments per unit (Rs million)	Simple payback period (yr)
Pot furnace	6	2
Tank furnace	25	5
Muffle furnace	0.1	Less than 1

[8] An annealing lehr is used for heat treatment of finished products. It is a long, flat oven, which first reheats the bottles to 550 degrees Celsius and then gradually cools them until they emerge at the cold end, between 30 minutes and one hour later.

[9] For payback period: with 350 days of operation; NG price of Rs 6.50 per Sm3 and GCV of NG 8500 kcal/Sm3)

Apart from investments, there are other barriers that stand in the way to greater energy efficiency in the glass sector in India. Majority of the glass manufacturing units for example are not aware of technological developments taking place in large glass industries and the benefits of technology upgradation. It is also very difficult for an entrepreneur of a small-scale unit to have easy access to the technical know-how. Furthermore, like other MSME clusters, technology options are not readily available for different furnace segments in Firozabad glass cluster. Technologies need to be developed and demonstrated to suit the local conditions. Also, the operators/workers in small scale glass making units are not formally trained and there is no mechanism that exists in providing training. Although technology upgradation brings in benefits such as energy savings in a glass unit, substantial investments would be required for such changes. Tailor-made/attractive financial instruments are not available for glass cluster that would interest the entrepreneurs to adopt changes.

Suggested strategies

There is great scope to reduce energy consumption, generally 5%–10% by adopting best operating practices. Although large energy savings can be realized from the Firozabad glass cluster, it is essential to address the above-mentioned barriers. Cluster-specific programmes must be promoted with support from the government, bilateral and multilateral agencies to address energy, environment and other related issues. It is necessary to involve all stakeholders in different stages of the implementation of the programme to assess the needs and challenges. Technology experts must be involved for development of specific technologies meeting the cluster requirements and must be demonstrated at field level. It may also be necessary to develop a set of technology solutions to meet the bandwidth of industry units.

Close involvement of government and financial institutions would greatly help in fine-tuning government policies and financial instruments respectively. For example, for energy-efficient technology adoption, government may provide incentives to individual industry units. Soft loans may be made available to the units for adopting energy-efficient technologies.

It is also necessary to strengthen/develop local service system at cluster-level to provide regular technical backup services in terms of best operating practices and troubleshooting. Therefore, it is suggested to evolve cluster-specific programmes in order to accelerate the adoption of technology upgradation in the Firozabad glass cluster.

Conclusion

In general, MSMEs are driven more by immediate livelihood considerations with the result that longer term and less visible issues like energy efficiency or environmental impacts are generally not accorded priority. Higher productivity or lower resource costs would kindle more interest. Also, radically different technologies such as the vertical shaft brick kiln, will need greater push and demonstration of benefits to be able to elicit active sector participation, even if they offer significant gains for energy efficiency. This is essential for successful technology development and adaptation. Also, while the growing demand for end-products (as is the case for both bricks and glass) is important to maintain commercial viability of the units, it may breed complacency and/or inertia vis-a-vis change. Addressing these issues will have to take cognizance of the institutional milieu in which SMEs operate.

Energy efficient building design: contribution to energy security

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Introduction

Buildings are responsible for at least 40% of energy use in most countries. As construction booms, especially in countries like China and India, so will energy consumption. The construction sector in India is witnessing a fast growth due to several factors. Some of the key growth drivers are increased demand for housing, strong demographic impetus, expansion of organized retail, increased demand for commercial office spaces by multinationals and IT (Information Technology) hubs; setting up of special economic zones (SEZs); easy availability of finance and increase in per capita income and standard of living.

The gross built-up area added to commercial and residential spaces was about 40.8 million square metres in 2004–05 (Construction Industry Development Council 2005–06), which is about 1% of annual average constructed floor area around the world. Since 1970s, the annual energy consumption of the residential and commercial sectors has grown at a near consistent 8%. However, the share of building sector in this total energy has increased from a low 14% in 1970 to a nearly 33% in 2004–05 (RICS 2007). Energy consumption would continue to rise unless suitable actions to improve energy efficiency are taken urgently.

As per TERI estimates (Table 1), there is an increased demand of about 5.4 billion units (kWh) of electricity annually for meeting end-use energy requirement in residential and commercial buildings. This is in addition to energy requirements for manufacturing of building materials/equipment and energy used during construction (comprising the embodied energy of materials and machinery). Simultaneously, while there is a construction boom with 10% increase in net built up area in the residential and commercial sector annually, there is also a significant number of existing building stock that needs tune-up and upgradation, particularly from an energy efficiency point of view.

This article addresses the critical role energy efficiency can play in the building sector. This is important especially because the growth in the construction sector offers great potential for energy savings through green buildings. Also, green buildings are an integral component of India's transition to a sustainable and energy-secure future. The paper highlights ways and means to achieve energy efficiency in the existing and new residential and commercial sector buildings, as a means to enhance India's energy security.

Energy demand in the residential and commercial building sectors

The Indian energy sector has witnessed an unprecedented growth in energy generation capacity (TERI 2006). Even though the industrial, domestic and agricultural sectors are the major consumers of

Table 1 Annual energy saving potential in new constructions

Gross built-up area (thousand square metres)			Energy saving potential		
Sector	New construction in 2004–2005	Projected constructed built up area in 2005–06 assuming a 10% growth rate in the sector	Energy consumption (kWh) at Business as usual scenario: 80kWh/sq m/annum for residential buildings and 160 kWh/sq m/annum for commercial buildings	Energy consumption (kWh) at energy efficient scenario: assumption of 30% savings in residential and 40% savings in new commercial buildings	Annual energy saving potential (kWh) over current consumption patterns
Residential	19 250	21 175	1 694 000 000	1 185 800 000	508 200 000
Commercial	21 550	23 705	3 792 800 000	2 275 680 000	1 517 120 000
			5 486 800 000	3 461 480 000	2 025 320 000

Source Majumdar (2006)

electricity, the ongoing construction and real estate boom has resulted in an annual electricity sale growth rate of 11.35% in public lighting, followed by the 10.87% rise in the commercial and 7.65% rise in the residential sector.

Energy services constitute a significant proportion of total household and commercial expenditure. The household and commercial establishments consume energy for meeting their needs for cooking, lighting, space-heating/conditioning, water heating and for operating many appliances such as refrigerators, stoves and televisions. The residential sector in India is responsible for 13.3% of total commercial energy use (PSA 2006). Energy sources utilized by the residential sector in India mainly include electricity, kerosene, LPG (liquefied petroleum gas), firewood, crop residue, dung and other renewable resources such as solar energy.

Energy saving potential in the building sector

Energy efficient building design, technologies for efficient lighting and space conditioning and renewable energy technologies offer 40–50% energy saving potential in new buildings. Retrofit options in energy efficiency offer a 20%–30% saving potential. The following section elaborates the present technology options for energy (electricity) savings potential in new residential and commercial buildings.

Energy savings potential in new buildings

As per TERI studies, assuming the average energy consumption for a residential property is 80 kWh/m^2/annum and for a commercial building is 160 kWh/m^2/annum in the business as usual scenario and there is a 10% annual increase in built up area for residential and commercial buildings, the projected annual increase in energy demand in commercial and residential buildings would be 5.4 billion kWh (Majumdar 2006).

Application of energy efficient building design concepts, techniques and technologies (as discussed above) in new constructions can result in energy savings of 2 billion kWh annually (Table 1). Assuming 50% aggregate technical and commercial (AT&C) losses and a plant load factor of 72%, the estimated savings in total generation capacity requirement per annum would be 600MW (Rs 30 billion).

If energy efficient measures are applied to all new constructions, approximately 3400 MW of plant capacity reduction could be achieved during the Eleventh Five-year plan by 2011–2012. Although energy savings would amount to incremental costs of Rs 450 billion towards application of energy efficient measures, however, it would result in Rs 400 billion in savings towards O&M (operation and maintenance) and coal and plant requirements for infrastructure.

The incremental cost due to implementation of energy efficient measures (with respect to overall cost of project) vary between 3% and 5% for residential buildings and 10%–15% for commercial buildings. The life cycle cost analysis of the initial investment and operation cost indicates that the payback period for all efficiency measures is less than 5 years since energy efficient buildings and systems reduce energy consumption in buildings.

Energy efficiency measures can help achieve a 30% energy savings in new residential buildings and 40% energy savings in new commercial buildings. Savings in new buildings can be effected through a combination of passive solar architectural measures and energy efficient systems, equipment, appliances and renewable energy systems such as solar water heating systems or solar photovoltaic systems. Use of control devices for lighting and space conditioning can make further savings.

Of 30%–40% achievable savings in residential and commercial buildings, about 10%–15% is achievable through proper passive design interventions, for example bio-climatic architectural interventions such as proper orientation, appropriate window and shading systems, insulation, high performance glazing and so on.[1] Energy efficient lighting can save

[1] Passive systems provide thermal and visual comfort by using natural energy sources and sinks, e.g., solar radiation, outside air, sky, wet surfaces, vegetation, and internal gains. Energy flows in these systems are by natural means such as radiation, conduction, and convection with minimal or no use of mechanical means. The solar passive systems vary from one climate to the other. For example, in a cold climate, an architect's aim would be to design a building in such a way that solar gains are maximized, but in a hot climate, the architect's primary aim would be to reduce solar gains, and maximize natural ventilation. India has a rich legacy of architecture wherein we find use of traditional low/no energy techniques to ensure thermal and visual comfort. The old forts and havelis (traditional, joint-family houses often built around a courtyard) had deployed several innovative techniques of natural lighting, ventilation, natural cooling to achieve desired comfort levels. Passive architectural concepts can save up to 15% energy consumption in lighting and space conditioning. Appropriate integration of passive concepts can significantly offset need for energy intensive lighting and space conditioning.

5%–15% in energy consumption in residential and commercial buildings respectively. Energy efficient space conditioning that has larger application, particularly in commercial buildings, can further provide savings of 15%–20%. Solar water heating systems have the potential of nearly 10% energy savings in residential applications. The CESE (Centre for Environmental Sciences and Engineering) building for example is a research facility at the IIT (Indian Institute of Technology) Kanpur, on a plot area of 175 000 sq m (approximately 4.5 acres). The facility houses laboratories, seminar rooms, and discussion rooms for various disciplines of environmental sciences, and a built up area of 4250 sq. m. Greater than 50% reduction in energy consumption over conventional buildings has been achieved here through envelope optimization and because it has been designed on energy efficient principles, for example, orientation to predominantly face north-south, wall and roof with 50 mm expanded polystyrene insulation, daylight friendly window design with shading and high performance double glazing, lighting optimization (light power density less than 10W/sqm and day linked controls) and HVAC (heating ventilation and air conditioning) optimization (high efficiency chillers with thermal energy storage system and integration of earth air tunnel with air handling units). The incremental cost was 25% over conventional design with the increased cost paid back in a little over 5 years, through cost of energy saved in operation.

Energy saving potential in existing buildings

Existing residential and commercial buildings offer energy saving potential through suitable retrofit options. The energy saving potential for existing buildings in the residential sector is approximately 20% and that for commercial buildings is 30%.

Residential buildings

Energy in urban residential buildings is used primarily as electricity in heating/cooling, lighting, appliances and as cooking gas. Captive diesel generating sets that run on fossil fuels also supplement grid electricity in some cases. The potential technologies for energy saving in existing residential buildings are tabulated as follows.

Energy efficient lighting

- Replacement of incandescent lamps with compact fluorescent lamps (CFL): replacement of 60W GLS lamp (incandescent lamp) by 15W CFL gives a savings of about 60%–70% over the life of a CFL with a payback period of less than a year.
- Replacement of existing 40 W fluorescent lamps with T-5 lamps (14/28W tube lights): replacement of 40 W tube lights with conventional copper choke by T5, 28W tube light can save more than 20% energy over the life of a T5 lamp. Payback period varies between 2–5 years depending on cost of electricity and operating hours.
- Replacement of electromagnetic chokes in 40/36 W fluorescent lamps with electronic chokes: replacement of conventional copper choke by electronic choke can yield 30%–40% saving with payback period varying between 3–8 years (varies with tariff and operating hours).

Space cooling

- Replacement of conventional ceiling fans with energy efficient ceiling fans: energy efficient ceiling fans (50 W) consume less energy than conventional ceiling fans (70 W). These fans are approximately 10% more expensive than conventional ceiling fans with payback of 5–6 years.
- Use of BEE (Bureau of Energy Efficiency) labelled air conditioners: a 4-star rated air conditioner saves 30% energy with incremental cost being paid back in less than 6 months time.

Commercial buildings

In commercial buildings, use of air conditioning is predominant and accounts for maximum energy consumption, followed by lighting, equipment and other electrical systems. Energy saving opportunities are, therefore, maximum in retrofit of HVAC systems. Some of the options that offer energy saving opportunity in HVAC system are: replacement of conventional ceiling fans with energy efficient ceiling fans, replacement of single skinned by double skinned air handling units, replacement of inefficient chilled water and condenser water pumps by efficient ones, conversion of constant chilled water flow to variable flow, installation of wet bulb operated frequency drive at cooling tower fans, regulation of fresh air to the design value and so on.

Potential for solar thermal systems to conserve energy

Renewable energy, particularly solar energy, has a large potential for energy savings in the building sector. Water heating needs in residential and commercial buildings is large. It constitutes the second largest energy use in residential complexes after space conditioning (cooling/heating). Depending on the season, solar hot water systems can reduce the operating expenses on fuel for water heating from 70% to 100%. Typically, a solar hot water system is sized to provide 80%–100% of required hot water during sunny winter days. Replacement of electric geysers with solar hot water system for domestic water heating gives up to 60% energy saving, with a payback period of approximately four years.

Potential for energy efficient appliances to conserve energy

Energy efficient appliances (such as refrigerators, tubular fluorescent lamps, air conditioners, ceiling fans and CFLs) have a large potential to save energy. The BEE has recently introduced energy labelling for air conditioners and refrigerators. There is possibility of nearly 17% energy saving just by moving up one star (that is, a 4-star vis-à-vis a 3-star refrigerator has a 17% annual energy saving potential). With the current annual growth rate (of 8%) in the production of refrigerators which is likely to continue till 2020, the projected energy savings that can be achieved according to BEE would be 17602 million kWh/year.

Similarly, BEE labelled air conditioners also have a large energy saving potential. A shift from EER 7 (unlabelled) to 10 (5 star) can save up to 30% in annual energy consumption. Projected savings that can be achieved by using energy efficient air conditioners according to the BEE is 8682 million kWh/year by 2020.

Likewise, use of energy efficient ceiling fans can contribute to an energy saving of 48 408 million kWh/year by 2020 and use of CFLs can contribute to an energy saving of 13 081 million kWh/year by 2020. The energy savings that can be achieved by using energy efficient appliances by 2020 form an important part of energy saving in the building sector.

Policies for enabling energy efficient buildings

Energy Conservation Building Code 2007

The ECBC (Energy Conservation Building Code) covers minimum requirements for building envelope, mechanical systems and equipment, including HVAC system, interior and exterior lighting system, service hot water, electrical power and motors in order to achieve energy efficiency in different climate zones of India. The objective of the ECBC is to reduce the baseline energy consumption by supporting adoption and implementation of efficiency measures in buildings. To encourage adherence to ECBC code, BEE has supported several activities in Government/ Public Sector buildings, for example the Ministry of Health and Family Welfare is developing six AIIMS-like institutions under the 'Pradhan Mantri Swasthiya Yojana' (PMSSY) scheme at Bhopal, Jodhpur, Rishikesh, Patna, Bhubanshewar and Raipur. These are being developed as ECBC-compliant buildings. BEE is providing assistance to them through their empanelled ECBC expert architects. The Government of Delhi has approved mandatory implementation of ECBC in government buildings/ building complexes (new construction) including buildings/building complexes of municipalities/local bodies, boards, corporations, government aided institutions and other autonomous bodies of the city government.

National building code 2005

The National Building Code (NBC) has been developed by the Bureau of Indian Standards as a guiding code to be followed by municipalities and development authorities for formulating and adopting building byelaws. Some aspects of energy conservation and sustainable development have been addressed in the latest version (2005) of the document. Aspects of appropriate design, usage and practices with regard to building materials, construction technologies, and building and plumbing services have been addressed. However, so far the NBC is not integrated with the ECBC.

Energy labelling of appliances

The BEE has several programmes that target high energy end use equipment and appliances to lay down minimum energy performance standards. Energy labelling on a voluntary basis for refrigerators and tubular fluorescent lighting was launched in 2006. Labelled products (refrigerators, air conditioners, motors and other appliances) have been in the market since 2006. Each appliance is ranked on a scale of five stars, with more stars indicating higher efficiency and more power savings – thus the programme motto of 'More Stars, More Savings!'.

The labels provide information about the energy consumption of an appliance, and thus enable consumers to make informed decisions. Almost all fluorescent tube lights sold in India, and about two-thirds of the refrigerators and air conditioners, are now covered by the labelling programme (MoEF and MoP, GoI 2007). To widen the scope for energy savings, BEE has included several widely used equipment and appliances such as Distribution Transformers, Motors, Colour TVs, Ceiling Fans, Geysers, LPG Stove and Agricultural Pumps under 'Standards and Labelling' programme in 2008–09.

The Ministry of New and Renewable Energy (MNRE)

MNRE has initiated several programmes focusing on the utilization of renewable energy sources in buildings. The MNRE has a solar buildings programme that provides financial support for the design and construction of energy efficient and solar passive buildings. Emphasis during the Tenth Five-year Plan (2002–07) was to provide central financial assistance for the development of efficient building guidelines to be implemented by community housing development organizations or corporations and to encourage the adoption of BIPV (building integrated photovoltaics).

In particular, MNRE provides CFA (Central Financial Assistance) at 50% of the cost of DPR (Detailed Project Reports) for public or private institutional buildings to a maximum of Rs 200 000, 50% released on completion of DPR and rest at beginning of construction. MNRE also covers 10% of the cost of construction of public, governmental, or State Nodal Agencies' buildings to a maximum of Rs 5 million, with 25% released on commencement of construction and rest dependent on progress. The goal was to construct 10 solar buildings in 8 states in 2006–07 alone (Singhal 2006).

MNRE also provides financial support for workshops, seminars, and orientation courses related to solar buildings for engineers, planners, builders, architects, housing financing organizations, and potential house owners up to Rs 200 000. MNRE funds publications of documents on solar building including popular literature, technical books and manuals, promotional material in different languages, and award competitions, for up to Rs 200 000 per activity.

MNRE has partnered with the Centre for Innovation, Incubation and Entrepreneurship to implement the Solar Innovation Programme, which incorporates research and development of technologies related to solar thermal, photovoltaics, and passive solar building design (Centre for Innovation, Incubation and Entrepreneurship 2010). The Solar Innovation Programme is essentially a competition open to teams of entrepreneurs, researchers, and students to design new applications for solar for rural or urban areas within India.

In addition to states such as Haryana, West Bengal, Karnataka, Rajasthan, Uttaranchal, and Andhra Pradesh, cities such as Bangalore, Thane, Nagpur and Rajkot, solar water heating is mandatory/incentivised for certain types of buildings.

The MNRE has also launched and incentivised GRIHA (Green Rating for Integrated Habitat Assessment) as a national rating system.

Building rating systems

Environmental clearance for large construction projects

The Ministry of Environment and Forests (MoEF) has established mandatory norms and standards for environmental clearance of large construction projects. All new construction projects are appraised on the basis of the norms and standards by both the EACs (Expert Appraisal Committees) at MoEF and SEACs (State Expert Appraisal Committees) at the State/UT level. The EACs/SEACs grade the projects as Platinum (90–100 points), Gold (80–89 points), Silver (60–79 points) and Bronze (40–59 points). Buildings receiving lower than 40 points would not receive environmental clearance.

The State Pollution Control Board is responsible for verifying that the Environmental Management Plan is complied with during construction and post-construction and that all proposals that resulted in the given rating are also followed through appropriately.

For buildings and construction projects larger than built up area of 20 000 sq metres, compliance with the ECBC is mandatory, thereby contributing to energy savings (MoEF and MoP, GoI 2007).

Green Rating for Integrated Habitat Assessment (GRIHA)

Endorsed by the MNRE, GRIHA is a five-star rating system for green buildings that emphasises on passive solar techniques for optimizing indoor visual and thermal comfort. In order to address energy efficiency, GRIHA encourages optimization of building design to reduce conventional energy demand and further optimise energy performance of the building within specified comfort limits. A building is assessed on its predicted performance over its entire life cycle from inception through operation.

GRIHA was developed as an indigenous building rating system, particularly to address and assess non-air conditioned or partially air conditioned buildings. GRIHA has been developed to rate commercial, institutional and residential buildings in India emphasizing national environmental concerns, regional climatic conditions, and indigenous solutions.

GRIHA stresses passive solar techniques for optimizing visual and thermal comfort indoors, and encourages the use of refrigeration-based and energy-demanding air conditioning systems only in cases of extreme thermal discomfort (GRIHA 2010). The rating integrates all relevant Indian codes and standards for buildings (as mentioned above) and acts as a tool to facilitate implementation of the same. The Central Public Works Department (CPWD) has issued an office memorandum for all future CPWD buildings (March 2009 onwards) to be GRIHA compliant and certified.[2]

National Action Plan on Climate Change: mission on sustainable habitats

As a response to combat the impacts of climate change, the Prime Minister's Council on Climate Change has released India's NAPCC (National Action Plan on Climate Change) on 30 June 2008. The NAPCC serves as the first country-wide framework on climate change with the approval and support of the Government of India. One of the key missions of the NAPCC is on Sustainable Habitat, which comprises three components, namely:

- Promoting energy efficiency in the residential and commercial sector
- Management of municipal solid waste, and
- Promotion of urban public transport

In an attempt to promote energy efficiency in the residential and commercial sectors, the mission emphasizes the extension of the ECBC, use of energy efficient appliances and creation of mechanisms that would help finance demand side management. In essence, the NAPCC gives a further boost to exiting initiatives on green and energy efficient buildings and construction in India.

Government initiatives for existing buildings

Energy Auditing

In March 2007, the conduct of energy audits was made mandatory in large energy consuming units in nine industrial sectors. These units, notified as 'designated consumers' are also required to employ 'certified energy managers', and report energy consumption and energy conservation data annually.

BEE and the CPWD have also partnered to train a team of energy audit consultants to perform audits of several important government buildings and to contract the implementation of the recommendations. They expect annual savings of more than 30 GWh per year with payback of less than two years. BEE has continued the training and accreditation of new energy auditors and has proposed to expand energy audits beyond governmental buildings and to commercial and even residential buildings.

Scheme for star rating office buildings

In order to accelerate energy efficiency activities in commercial buildings, the BEE has developed the scheme for star rating the buildings. The programme is based on actual performance of the building, in terms of specific energy usage (in kWh/sq m/year) with the following highlights.

- The programme would rate office buildings on a 1–5 star scale, with 5-Star labelled buildings being the most energy efficient.
- Initially, the programme shall target the following 3 climatic zones for air-conditioned and non- air-conditioned office buildings;[3]
  - Warm and Humid
  - Composite
  - Hot and Dry
- EPI (Energy Performance Index) in kWh/sq/m/year is considered for rating the building.[4]

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[2] CPWD is the premier construction agency of the Government of India (established under the Ministry of Urban Development) and plays a pivotal role in the construction programme of government projects. Its activities are spread throughout the length and breadth of the country. It also undertakes the projects of Autonomous Bodies and Public Sector Undertakings as Deposit Works. Besides being the construction agency of the government, it performs a regulatory function in setting the pace and programmes for the building industry in the country.

[3] However, this shall be subsequently extended to other climatic zones and building types.

[4] EPI is kWh/sq.m/year in terms of purchased and generated electricity divided by built up area in sq.m. However, total electricity does not include electricity generated from on-site renewable sources such as solar photovoltaic.

Bandwidths for EPI for different climatic zones have been developed based on percentage air-conditioned space. For example, buildings in composite climate zones like New Delhi with air conditioned area greater than 50% of the built up area, the bandwidths of EPI range is 190–90 kWh/sq m/year. Thus, a building would get a 5-Star rating if the EPI falls below 90kWh/sq m/year and 1 Star if it is between 165–190 kWh/sq m/year.

- Similarly for buildings in warm and humid climatic zones like Chennai, the bandwidths of EPI range between 200–100 kWh/sq m/year. The building shall get a 5-Star rating if its EPI is below 100 kWh/sq m/year and 1-Star if it is between 200–175 kWh/sq m/year.
- For buildings with air conditioned area less than 50% of their built up area, in a composite climatic zone, the bandwidths of EPI range between 80–40 kWh/sq m/year. Similarly for buildings in warm and humid climatic zones like Chennai, bandwidths of EPI range between 85–45 kWh/sq m/year.
- The Star Rating Programme provides public recognition to energy efficient buildings, and creates a 'demand side' pull for such buildings. Buildings with a connected load of 500 kW are considered for the BEE star rating scheme.

Implementation barriers and way forward

While there is huge potential to achieve energy efficiency by incorporating passive design, efficient envelope and systems, the current trend in mainstream architecture is not able to capture the same. The existing building sector needs to be addressed in a more holistic manner, so that energy efficiency retrofits can be implemented routinely and with ease. By way of conclusion, discussed below are some prime implementation barriers and steps that may be taken to remove them.

Knowledge gap (amongst builders, designers, architects, politicians, investors and consumers)

The construction industry remains unaware of the environmental impacts of its operations and the economic, environmental and health benefits of using green and efficient products and appliances. Lack of sustainable building solutions needs the promotion of knowledge among architects, system providers and other professionals.

A general apprehension of high initial cost and lack of life cycle cost approach to carry out cost benefit analysis are major barriers. With an increasing number of green, efficient buildings coming up in the country, there is a need to have collective information on incremental costs and benefits. This would help in tiding over the myth that exists about efficient buildings being expensive. All consultants that provide services to help design efficient buildings should follow a life cycle analysis approach to motivate stakeholder 'buy in'.

Additionally, larger usage of a voluntary building rating system is crucial. While GRIHA has become the national building rating system, further outreach and education on GRIHA should be undertaken immediately. This is important as it takes time for developers to familiarize themselves with the ratings and for the market to demand higher rated buildings.

There is need for effective and large-scale capacity building and awareness generation programmes at all stakeholder levels. It may be mentioned that energy efficiency in buildings is not taught as part of the curriculum in any school of architecture. Select architectural/engineering schools, colleges should introduce relevant courses in their curriculum as there is a lack of knowledge among architects and system providers to incorporate energy efficiency mechanisms.

Most consumers are currently unaware about the availability of green products and BEE-labelled products. They are also unaware about the economic, environmental and health benefits of using green and efficient products or appliances. Since there is a lack of awareness about the life cycle cost benefits of efficient products, the higher upfront cost prevents purchase. Awareness programmes should also focus on marketing and increasing highlighting of life cycle costs and cost saving potential in efficient products. The economic benefits of BEE-labelled products should be marketed further.

Enforcement and implementation of strategies

In order to encourage adoption of energy efficiency in buildings, products and services are required. Lack of programmes for monitoring and verification, policy mandates and incentives (both financial and symbolic) should be addressed to encourage greater participation of the corporate sector.

The residential sector, which is dominated by apartments and high-rise buildings developed by builders and developers, do not provide any direct benefits by incorporating energy efficient features in new developments. Due to lack of incentives for builders, the penetration of energy efficient techniques and technologies is very limited in the residential sector. However, with the growing CDM (Clean Development Mechanism) market in India, there is a scope for earning CDM benefits, which would in turn provide direct benefits to developers for incorporating energy efficiency into their developments.

Mandatory environmental clearance requirements from the central/state environmental appraisal committees for large construction projects, to some extent, also mandate the incorporation of efficiency measures such as solar water heating systems and efficient lighting systems into residential developments. However, enforcement and monitoring protocol should be in place to ensure effective implementation.

An initial boost to promote energy efficient products and services is required, and could take the form of reduced excise taxes or reduced VAT (value added tax) for efficient products.

Financial incentives such as tax breaks could be linked to rated buildings. This would provide motivation for users to demand energy efficient buildings and for developers to provide the same.

Government purchasing preference policy for energy efficient equipment should be done to increase market demand and guarantee investors a stable market for efficient products.

Lack of technological research and development activities

There is a need for technological research and development activities for lowering the costs attached to the use of energy efficient products and services. Thus, investments for innovative low cost technology options in developing sustainable habitats are required.

Mandatory adoption of ECBC, which is anticipated in the near future, shall help circumvent the problem posed by increased adoption of western architecture with glass dominant structures. The ECBC will restrict the gross wall area to window area ratio to a maximum of 60%; and higher stringency levels for glazing specifications for increased glazing areas.

Regulations and building byelaws

The state and central government building and construction projects follow age-old specifications, which need urgent revision to incorporate energy efficiency. Although there are regulations such as environmental clearances of large constructions by state/central environment department/ministry, the implementation and monitoring mechanism is totally absent. There should be a strong implementation and monitoring protocol and independent agencies set up for this purpose.

Building byelaws and urban planning byelaws do not address sustainable building solutions, for example, building energy codes are not included in the NBC or other building codes. At the national level, an attempt should be made to integrate provisions of energy efficiency into building byelaws.

The BEE has already made energy audits mandatory for many government buildings. It has planned to mandate energy audits for all commercial buildings above a certain threshold of connected load. However, it is important to develop mechanisms to ensure that the recommendations of the audit are implemented within a stipulated time. Auditing, combined with certification of energy performance, could work in tandem to ensure implementation of energy efficient systems. Further, there is no mandatory requirement for minimum energy performance.

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Secure routes and the supply of energy to India

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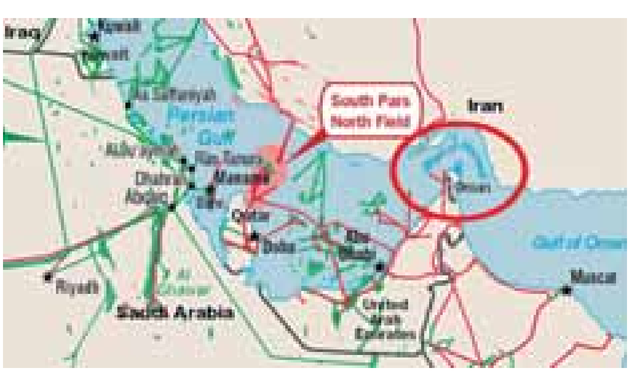
Introduction

India's energy security depends as much on diversifying its energy partners as it does on ensuring secure and reliable routes for the supply of its energy imports. Countries such as India that depend on the import of energy are particularly vulnerable to supply disruptions. Not only do energy importing countries require reliable sources of fuel, they also need reliable and secure routes for transporting fuel.

The securing of shipping routes (for oil, coal and LNG [liquefied natural gas]) or pipelines (for oil and natural gas) is as important as the security of equity investments and trade with energy-rich countries. In the case of bilateral energy trade and equity investments, it is the stability of the source countries which is of utmost importance. However, the security of key transportation routes and pipelines is under risk from multiple states and transnational non-state actors. It is for this reason that the security of transportation routes is an even more challenging task. Transportation routes are open to risks and threats from more than one country, given the transnational nature of shipping lanes and pipelines, as well as physical disruptions caused by natural disasters, accidents at sea and traffic constrictions at maritime chokepoints.



Map 1 Strait of Hormuz
Source EIA (2008a)

This article highlights some of the risks and vulnerabilities that India faces vis-à-vis the physical supply of energy from its key energy partners. Although the transportation infrastructure and vulnerabilities within India's borders is an equally important aspect of ensuring India's energy security, this article will focus on the external transportation routes. To this end, the article identifies the threats that make India's routes insecure and the response mechanisms India has already put in place to deal with some of these risks. It also highlights possible mechanisms that India should push for in order to circumvent some of the vulnerabilities that its energy routes face.

Types of risks to energy supply routes

Given that India has to meet a growing proportion of its demand for energy in the coming years through imports, the security of supply routes is an integral aspect of the country's energy security strategy. India's 'commercial' energy basket is dominated by coal (53%); oil (31%) and gas (8%). Given the limited domestic availability of coal, oil and gas, energy import dependency for India in the future is projected to rise to 70%, 94% and 24% in 2031, up from 14%, 74% and 21% for coal, oil and gas respectively in 2001 (TERI 2010 *forthcoming*). India has limited domestic reserves of uranium as well. According to the IEP (Integrated Energy Policy), India's reserves of uranium can only power about 10 000 MW of the expansion PHWR (pressurised heavy water reactors). Furthermore, given the low quality of uranium ore available in India, supplying nuclear energy from domestic resources is up to 2 to 3 times costlier than if it were sourced by international supplies (Planning Commission 2006: 35). India will therefore be dependent on uranium imports in the short-to medium term.[1]

Securing routes for imported energy for India, based on its projected need for imported energy, pertain mainly to maritime sea lanes, or what are referred to as Sea Lanes of Communication (SLOC). This is because, at least for the short-to-medium term, plans to pipe oil or gas will be unlikely to materialise given the geopolitics of the South Asian region as well as the relative costs (given that the distance from West Asia, from where India sources most of its oil and gas from, is not substantial). Although this article focuses on the threats and risks that can make sea lanes insecure, the same threats can also pose challenges to future pipelines for piping oil and gas to India (threats such as international disputes, insurgency and intra-state conflict and even natural disasters for example).

Transportation routes are vulnerable to several types of threats. These threats can be broadly grouped into three categories – (i) international disputes, (ii) intra-state conflicts and piracy, and (iii) natural disasters and natural chokepoints.

International disputes

Conflict between countries can be a source of instability for sea lanes that need to pass regions which would fall within the ambit of that conflict. For India, the route that is most vulnerable to being blocked due to deteriorating relations between countries at the international level is the route that passes through the Strait of Hormuz. The Strait is about 21 miles wide at its narrowest point and the daily flow of oil through it is about 6.5–17 million barrels (estimates up to June 2008), which is roughly 40% of all seaborne traded oil (or 20% of oil traded worldwide) (EIA 2008a).

Any blockage or threat to the security of the Strait of Hormuz is capable of blocking anywhere from 30% to 65% of India's oil imports from Iraq, Kuwait, Qatar, the UAE, Iran and Saudi Arabia, depending on whether the loadports are located on the Persian Gulf and have to pass the Strait of Hormuz or not.

To be sure, a blockade or blockage at the Strait of Hormuz is not only a challenge for India, but also for the rest of the oil importing world. Also, given that oil importing countries need markets, a blockade would also adversely affect oil exporting countries of West Asia. In this scenario therefore, how real is the threat of a blockade at the Strait of Hormuz?

While the possibility of an actual blockade is indeed slim, the vulnerability of the strait to a conflict between Iran and the West (particularly the US) is very real, as was evident in the recent past. In 2008 for instance, Iran's continued non-compliance with UN Security Council resolutions, to stop enriching uranium had lead to heightened tension in the region. While Iran threatened to respond to any military attack by either striking Israel or 'burning down' America's vital interests around the globe if the US or Israel launched a military strike on Iran's nuclear facilities, American, British and Bahraini ships were involved in a joint exercise – 'Stake Net' – to protect their oil and gas installations in the region. However, under President Obama's new policy to engage Iran and a deal brokered by the IAEA to persuade Iran to ship Iran's low-enriched uranium (LEU) for conversion 20% enriched uranium to fuel a medical research reactor in Tehran, have helped lessen the tension. Nonetheless, relations between the two remain difficult. Depending on deteriorating relations between the two, strategists warn that Iran could lay mines or increase its submarine activity—activities that are well within Iran's growing littoral warfare capabilities (Talmadge 2008). As the India–US strategic partnership becomes stronger, a possible eruption of hostilities between the US and Iran might impede discussions on the Iran–Pakistan–India (IPI) pipeline.[2]

Intra-state conflict, terrorism and piracy

Shipping routes as well as pipelines are also vulnerable to attack from not only international conflicts, but disputes within a country. That is, discord between central governments and secessionist groups, as well non-state actors such as terrorist

[1] India's three-stage nuclear programme envisages the use of natural uranium to fuel pressurised heavy water reactors (PHWRs) in Phase I, a Phase II that focuses on plutonium breeder reactors that would run on plutonium produced by the Phase I PHWRs and ultimately a Phase III that seeks to take advantage of India's ample supplies of thorium.

[2] Although India has long-term energy interests in both Iran as well as the US, India diluted its support for Iran in the recent past. In November 2009 for example, India voted for a resolution at the IAEA opposing Iran's decision to build a secret enrichment plant. However, given Iran's importance to India's energy security (as a source as well as a potential transit country), in the future, any full-blown conflict between the US and Iran might put pressure on India to not alienate both countries by choosing sides.

groups and pirates poses a very real threat to supply routes that need to traverse regions marked by intra-state conflict. The inter-linkages between crime, piracy and intra-state conflict make it difficult for states to individually deal with threats to SLOCs merely through reactive military means that do not address the root cause of the conflict.

India's energy imports that pass through the Malacca Straits and the Bab-al Mandab or round the Gulf of Aden are most vulnerable to pirate attacks. According to a report in the Time, in 2007 there were a reported 263 pirate attacks, particularly in unpatrolled waterways through which 90% of global trade flows (Altman 2008). Piracy attacks hit a high in 2009—the International Maritime Bureau's Piracy Reporting Centre in Malaysia reported that pirates attacked 42 oil-laden tankers around the world alone, a 40% rise from 2008 (Swartz 2010). In 2010 itself, there have been three successful piracy attacks—two around the Gulf of Aden and one in the Malacca Straits.

Over 200 ships and about half of the world's oil and two-thirds of the world's LNG pass through the Malacca Straits. Not only piracy, but terrorist outfits and disaffected insurgent groups operating in the region make the Straits a particularly insecure and risky SLOC for energy imports. For India, disruptions due to pirate attacks in the Malacca Straits would affect India's current imports of coal from Indonesia (non-coking coal from Kalimantan), and natural gas imports from Malaysia. As India seeks to diversify its energy imports, disruptions caused by pirate attacks in the Malacca Straits could also impact the country's energy imports from countries such as Vietnam (for coal), and Indonesia for natural gas as well as coal.[3] At its narrowest, the Strait is merely 1.7 miles – making passing tankers a ready target for thefts and hijackings, particularly because these tankers are slow-moving and difficult to manoeuvre. Given the inflammable nature of LNG, vessels carrying LNG are considered to be even more vulnerable to terrorist hijackings.

Map 2 Straits of Malacca
Source Wikipedia (2007)

The Bab-al Mandab poses another serious threat to energy imports, not only for India, but the world at large. Situated between Yemen, Djibouti and Eritrea, the Strait of Bab al-Mandab provides a strategic link between the Mediterranean Sea and Indian Ocean and connects the Red Sea and the Gulf of Aden and the Arabian Sea (EIA 2008b). The Bab-al Mandab is only 18 miles wide and tanker traffic is limited to a two-mile-wide channel. The chokepoint at the Bab-al Mandab has the potential of constricting/hampering India's energy imports from North Africa, although that is minimal as compared to India's imports from West Asia. However, as India casts its net wider in search of newer energy partners, particularly in Africa, the Bab-al Mandab may well pose a challenge to India's oil imports from Sudan, Algeria, Libya and Egypt and LNG imports from Europe (Belgium and Norway).

Piracy and the possibility of extremists/insurgents/terrorists joining hands in regions at the bridgehead of critical SLOCs is an ever-present danger. The Malacca Straits as well as the Bab-al Mandab are located in regions where there are several intra-state (as well as inter-state) conflicts raging, for example, in Mindanao in the Philippines, in Ache in Indonesia, Southern Thailand, Somalia, Eritrea and so on.

Piracy in the Gulf of Aden has been a persistent threat over the last decade or so. However, the threat has only recently gained serious attention, particularly for energy security. In 2008 for instance, a total of 135 attacks took place, resulting in 44 ships having been seized by pirates and more than 600 seafarers having been kidnapped and held for ransom (IMO 2008). Pirates functioning from the failed state of

[3] The Malacca Straits is located between Indonesia in the south and Malaysia and Thailand in the north, connecting the Andaman Sea and Indian Ocean to the South China Sea.

Map 3 The Bab-al Mandab
Source EIA (2008b)

Somalia were behind the hijacking of the supertanker MV Sirius Star about 450 nautical miles off the coast of Kenya in November 2008. The Saudi-owned (Aramco) ship, Sirius Star was loaded with 2 billion barrels of crude oil, worth about US $110 million.[4] The hijacking of the Sirius Star was the first most direct instance of the impact of piracy on the security of energy supplies in the world.

Intra-state conflict and insurgencies pose a challenge not only to maritime routes but also to possible plans to lay overland pipelines – such as the Iran–Pakistan–India natural gas pipeline, which must traverse Baluchistan, a region in Pakistan that has been simmering for decades. The obstacles facing TAPI (the Turkmenistan, Afghanistan, Pakistan, India) natural gas pipeline is similar, given the dismal security situation in Afghanistan.

Natural disasters and chokepoints

The supply of oil, coal and natural gas can also be disrupted by the occurrence of natural disasters, like hurricanes and tsunamis. The sudden nature of such transnational disasters makes all countries vulnerable to supply disruptions and sudden oil spikes due to disruptions. The 2005 Hurricane Katrina that struck the Gulf of Mexico, for instance, dealt a heavy blow to a major part of America's energy infrastructure; and as a consequence caused a surge in energy prices.

In the Indian Ocean too, there has been concern for studying the possible impact of natural disasters such as typhoons, cyclones and tsunamis on the energy security of the littoral countries. The Tsunami of 2004 caught all Asian countries unprepared. However, in its wake it raised the need for emergency preparedness and early warning systems. Since 2004 therefore, countries of the region have been working towards putting in place institutions that would make information sharing and coordination between the Indian Ocean countries transparent and seamless.

Way forward – possible response options

India's unique geo-strategic location at the head of the Indian Ocean and with an extensive EEZ (Exclusive Economic Zone) poses challenges as well as opportunities for the country. The asymmetric maritime challenges and threats facing India have already resulted in significant bilateral maritime relations between India and several Southeast Asian as well as extra-regional (US, Russia, Israel) powers.

Joint patrolling

The Indian navy has collaborated with other countries in what is called a 'sea-lane sanitising role'. Countries such as Indonesia, Singapore and Malaysia have looked to India as a 'reliable and non-controversial ally' in keeping SLOCs and chokepoints, such as the Malacca Straits, clear of piracy and its linkages with terrorism. India already has a series of joint patrolling exercises with Indonesia 'in a part of a 200 nautical mile-long energy feeder path' (Dikshit 2004). The Quadrilateral Naval exercises in the Bay of Bengal in September 2007 was a collaborative exercise geared to enhance maritime security in the Indian Ocean between countries such as India, the US, Australia, Japan and Singapore. In October 2009, India joined Indonesia and the Maldives to patrol the Indian Ocean waters to protect them against sea-based piracy.

A regional approach to securing SLOCs is, however, crucial. There is a need to pool resources, assets, efforts and intelligence in order to tackle threats to maritime security such as the identification of suspicious vessels on the high seas (Khurana 2004). There are several regional multilateral foras in Asia that seek to address issues related to maritime security, for example the EAS (East Asia Summit), ARF (ASEAN Regional Forum), IONS (Indian Ocean Naval Symposium), the CSCAP (Council for Security Cooperation in the Asia Pacific) and ReCAAP (Regional Cooperation Agreement on Combating Piracy and Armed Robbery against Ships in Asia) (Sakhuja 2009). The Indian Navy also holds an annual diplomatic initiative called MILAN that is a comprehensive Track I exercise for

[4] The ship was later released by the pirates for a ransom of US$ 3 million.

greater coordination on issues of ocean governance, sea piracy, terrorism and disorder at sea (Prabhakar 2007).

Patrolling is relevant not only to sea-based routes, but also for land-based pipelines. The security of transnational pipelines can be ensured, among other things, through patrolling of the entire length of the pipeline (Batra 2008). This can ensure that pipelines are not attacked by secessionist groups/terrorists working in the area.

Disaster management

The Tsunami in 2004 brought to the fore the possibility of natural disasters disrupting energy supplies in the region. Along with joint patrolling, countries are increasingly making disaster management and mitigation a crucial part of their maritime security, not least for securing their energy supplies. Early warning systems and easy flow of information can go a long way in alleviating the impact of natural disasters on energy supplies in the region.

Apart from natural disasters, countries need to come together to deal with accidents such as oil spills and accidents with LNG tankers, particularly in chokepoints and narrow channels.

Alternative routes

One way of circumventing threats to existing transport routes is by identifying and pushing for alternative routes and mechanisms that would allow India to import its energy from routes that are relatively safer. Several of these alternative routes and mechanisms have already been discussed, but have not become realities due to geopolitical reasons or due to the costs attached, for example the IPI and the TAPI. Some of the other alternative routes are discussed below.

Trans-Gulf Strategic Pipeline

To circumvent the Strait of Hormuz, six possible alternative routes for a trans-Gulf pipeline have been identified, which could bring oil from as far north as Iraq, passing through Kuwait, Saudi Arabia and the United Arab Emirates (UAE) to the Omani capital of Muscat on the Arabian Sea. Other possible routes could see the pipeline terminating in Yemen or Fujairah. One such route is the Dolphin project, which is a gas pipeline from Qatar to Fujairah. Another proposed pipeline would carry oil from the UAE's Habshan oil field, across a mountain range, to the Emirate of Fujairah, located outside the strait on the Gulf of Oman (See China Daily 2007). The most recent pipeline that is being discussed for India is the under-sea SAGE gas pipeline. The pipeline will stretch for 2000 kilometres from Oman to India's western coast. However, the technical feasibility of laying an under-sea pipeline and the estimated cost of the project are reasons cited for the project having stalled.[5]

Another pipeline that has been suggested to give access to India to Central Asian oil via Israel is the one proposed by Turkey. The pipeline would circumvent the Suez Canal and make it possible to get oil from Central Asia to Ceyhan in Turkey through pipelines, across the Mediterranean by tanker to Israel's port of Ashkelon and then onto India by pipeline and tankers.

Swap arrangements

Apart from alternative routes, other mechanisms to ensure security of energy supplies and to circumvent difficult shipping or pipeline routes are swap arrangements. Like laying pipelines and monitoring/patrolling SLOCs, swap arrangements too require a high degree of collaboration between countries. However, unlike the other more proactive measures, swap arrangements can be seen as reactive responses to the insecurity of sea lanes. Swap arrangements allow countries to leverage their comparative advantages – that is, proximity to an energy supplying country vis-à-vis overseas equity investments of another country. Recently, India discussed the possibility of swap arrangements with Japan. As per this proposal, Japan could import gas from Sakhalin where India has equity stakes, while India could gain access to Japan's gas supplies from West Asia (Sibal 2007). This arrangement would not only reduce transportation costs for both countries substantially, but would also help both Japan and India circumvent the Straits of Malacca. However, this arrangement has not materialised, primarily due to Japan's reservations regarding the reliability of supplies from Russia.

Treaties or agreements

Another mechanism to ensure reliability of energy supplies is by putting in place bilateral/multilateral agreements. The ECT (Energy Charter Treaty) is

[5] The total cost of the project would be anywhere between US $3 billion to US $7.5 billion (See Bhaskar 2009; Bhardawaj 2009).

a good example of ensuring the supply of energy by providing a set of binding rules that ‘protect long-term energy investments, particularly those on transport infrastructure. These in turn provide legal security for long-term supply agreements and protect the interests of energy-producing, transit and consuming states alike’ (Energy Charter Treaty 2008). The ECT model has been suggested for other countries faced with a similar challenge of ensuring the security of their energy supplies and countries such as India are considering joining up, at least as observers. This would make sense for India, particularly considering the fact that important countries of West and Central Asia are also observers of the ECT.

Conclusion

Secure routes for the sustained and dependable energy supplies (oil, coal, natural gas or uranium) are an important constituent of the energy securing strategies of countries. The above-mentioned strategies would have to be seen in conjunction with other efforts that are purely of a domestic nature, such as building port and shipping infrastructure and capabilities as well as building a strategic petroleum reserve.

Even though access to energy sources can and often is cast in zero-sum terms, the securing of routes, given their transnational nature, requires a collaborative approach. Countries cannot secure routes on their own, unless the distance between them is short and they are contiguous. Otherwise, for considering shipping routes for oil, coal or LNG or pipelines for oil and PNG (piped natural gas), there needs to be cooperation between countries to ensure routes are not attacked by pirates and terrorists, state and non-state actors, or impacted by environmental disasters and accidents.

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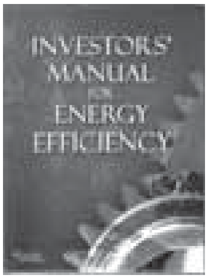
Books, CDs and Posters on Energy Efficiency



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Investors' Manual for Energy Efficiency
(Published by IREDA and marketed by TERI)

The industrial sector consumes a substantial share of energy in the country and presents considerable scope of improving energy efficiency, especially in the energy-intensive sectors. This information-rich *Investors' Manual for Energy Efficiency* covers topics like energy-saving potential for various industries, technologies available to improve energy efficiency; cost-benefit analysis, list of equipment suppliers, and government policy incentives available for the sector. This manual is intended to be a useful guide for consultants, energy service companies, industry, and other stakeholders working in the field of energy efficiency and conservation sectors. It would help in the promotion of energy efficiency and conservation and lead to saving in energy consumption through the judicious use of various technologies.

Contents

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