Mitigation options for India

The role of the international community








teri The Energy and Resources Institute

Mitigation options for India – the role of the international community

The Energy and Resources Institute
New Delhi

TERI Project Team

Dr R K Pachauri
Dr Leena Srivastava
Dr Ritu Mathur
Dr Atul Kumar
Dr Pradeep K Dadhich
Ms Ila Gupta
Ms Amrita Goldar
Mr Nishant Mehra
Ms Ruchika Chawla

Acknowledgements

The project team would like to acknowledge the support and inputs received from several research professionals and sector experts from the various divisions across TERI. We also thank TERI Press for undertaking printing and publishing work.

Mitigation options for India – the role of the international community

We are energy secure when we can supply lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy to satisfy their various needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected
–Integrated Energy Policy (2006)

Background

The energy scenario in India today looks quite challenging. With an installed generating capacity of less than 150 000 MW and a per capita consumption of a mere 650 units of electricity, India is suffering from huge shortages—nearly 10% in energy terms and almost 17% in peak energy (2007/08). Energy shortages and peak shortages in 2003/04 were 7.1% and 11.2%, respectively. These shortages in the system are increasing rapidly because of our inability to meet more than 40%–50% of the targeted capacity addition requirements in the last three Five-year plan periods. And, this is the situation when over 50% of India's rural population does not even have access to electricity!

Apart from facing electricity shortages, the country has been facing challanges in establishing new oil reserves. Although it has witnessed considerably higher success in natural gas finds, the lack of a delivery infrastructure has significantly limited the expansion and spread of benefits from this source. Therefore, gas consumption has increased at a meagre growth rate of 2% during 1999/2000 to 2006/2007, while India's oil import dependence has increased to over 75% in 2006/07. Also, less than 30% of India's population is able to use LPG (liquefied petroleum gas) for meeting its cooking energy needs, with over 50% dependent on firewood and chips.

India's coal resources, which till recently, at the current reserves to production ratio, were estimated to last for another 200 years, have been depleted to provide us secure access for just about 40 years or so – and that too at a peak production level of about 700 MT. The coal sector has been plagued by inadequate investment in resource development, inefficiencies in production, and inadequate resource allocation for technology development. It has also proven to be one of the most difficult sectors to get the private sector interested in.

Several innovative measures have been tried in recent years to overcome the major bottlenecks being faced by the energy sector, albeit with limited success. The NELP (New Exploration and Licensing Policy) rounds for oil exploration and development, the

invitations to the private sector to participate in the development of the power sector, the efforts to pry open the coal sector and move it along more market-driven lines, and the partnership-based rural electrification programmes have all met with lower than expected results. On the other hand, climate change considerations are putting the country under more immediate and intense pressure to improve efficiencies (higher fuel prices, costlier equipment/ appliances), reduce dependence on coal or move to clean coal technologies (increase in costs), use more renewable energy forms (again, higher cost of energy provision), and adopt more efficient transport options (huge public investments needed). All these measures would make the task of providing universal access to clean and convenient energy much more challenging for the government. Reconciling the energy pathway to be followed for sustainable development with what might be needed for climate change will require extreme innovation – both in technology use and in policies – and international partnerships at unprecedented scales.

What does the future hold?

India hopes to achieve a fairly high rate of growth over the next several decades – notwithstanding the current global financial crisis. Energy availability – in adequate quantities and good quality – would be a prerequisite to sustain these levels of economic growth and the desired social development. However, the quantum of energy demand would obviously be a function of the energy pathways that India can choose to adopt or design to follow. An attempt has been made here to define four alternative energy development pathways, which could lead to significantly different outcomes in terms of the fuel mix, technologies deployed and, therefore, total conventional energy demand. All four scenarios assume an average annual economic growth rate of about 8% up to the 15th Five-year Plan ending in 2031/32, consistent population growth and affluence, and the same economic and social structures. While the progress with regard to electrification has been slow in comparison to the targets for providing universal access to electricity by 2012, it is assumed that all households would have electricity by 2016 (a delay of four years). Moreover, households are assumed to make a transition towards cleaner cooking fuels, such as LPG and kerosene, with a rise in incomes.

A summary description of the four scenarios is provided in Table 1.

Commercial energy demand projections

Total commercial energy consumption in the Reference scenario is projected to increase from 283 MTOE (million tonnes of oil equivalent) in 2001/02 to around 2150 MTOE in 2031/32 (Figure 1).

Table 1 Four alternative energy development scenarios

Scenario name	*Storyline*
Reference	Life continues pretty much as we know it, with autonomous efficiency improvements taking place where feasible; the renewable energy being used at the same pace; and defined policy priorities being implemented with no real sense of urgency.
Evolution	A determined effort is provided here for efficiency improvements both on the supply side and demand side; an accelerated push for renewable energy, nuclear energy, and new technologies such as CTL (coal-to-liquid) and GTL (gas-to-liquid). Energy security concerns are paramount in this scenario.
Resolution	This scenario honours the prime minister of India's commitment that India's per capita carbon emissions would never exceed those of the developed world, and it is optimistically assumed here that the developed world would be able to bring down its emissions to a level of 2 tonnes/capita.[a] To fulfil this commitment, carbon emissions for India in this case would be around 38% of the reference levels in 2031.
Ambition	This scenario considers that India sets aside its legitimate arguments on 'common but differentiated responsibilities' and equitable per capita rights, and takes on even more stringent emission reduction targets (reaching 1.3 tonnes/capita in 2031[b]) towards influencing global response to the challenge of climate change.

[a]Based on the IPCC (Intergovernmental Panel on Climate Change) projections in AR4; with 80% reduction of 2000 levels in 2030, the OECD (Organisation for Economic Co-operation and Development) CO_2 emissions would be ~ 2 tonnes/capita.
[b]Assuming 60% reduction of 2005 Non Annex I energy-related per capita CO_2 emissions by 2030.

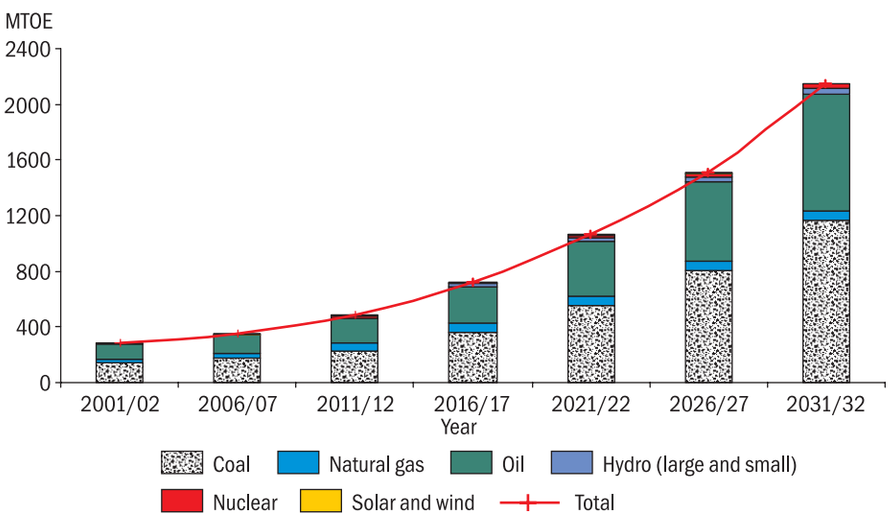


Figure 1 Commercial energy requirements in the Reference scenario

As is obvious, coal remains the dominant fuel even in 2031/32, with its consumption increasing from 147 MTOE in 2001/02 to 1167 MTOE in 2031/32. Petroleum consumption also increases rapidly by over eight times over the period 2001/02–2031/32, mainly on account of the transport sector.

Figure 2 presents the total commercial energy requirements across the alternative scenarios. As can be seen from the figure, the policy and technology interventions, as also the investments required for the alternative scenarios, only yield results with a time lag, and significant effects, in terms of reduced overall demand, are seen only from the 13th Five-year Plan period (2016/17–2021/22). By 2031/32, the difference in energy consumption in the Evolution scenario and the Reference scenario is of the order of 806 MTOE (which is about 2.8 times the energy consumption in 2001/02).

There is a reduction in overall energy consumption, and the fuel mix shifts (Figure 3) away from coal towards natural gas and

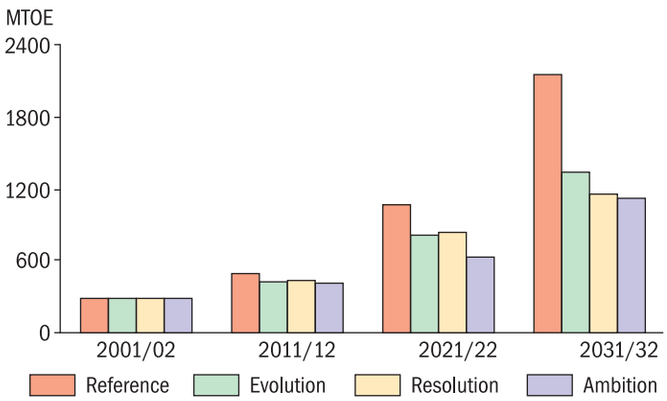


Figure 2 Comparison of commercial energy requirements across scenarios (MTOE)

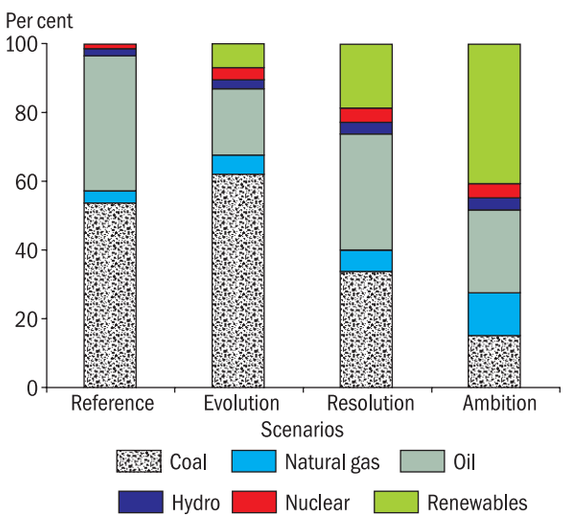


Figure 3 Percentage distribution of primary commercial energy in 2031/32 across various scenarios

renewables across the Resolution and Ambition scenarios due to the stringent emission reduction targets. In the Ambition scenario, nearly 41% of the commercial energy needs would need to be met by renewable energy sources. The higher share of coal in the Evolution scenario indicates that clean coal technologies and coal-to-liquid options are preferable for the country for energy security reasons but cannot be justified in the stringent CO_2 mitigation scenarios. Options such as coal-to-liquid, therefore, need to be looked at with caution, as in the long term, early investments in such options could lead to stranded capacities.

Import dependency

The shift in the fuel mix towards renewable energy and nuclear power would have obvious implications on the need to import fossil energy. While overall energy vulnerability of India in the future would be very high (Figure 4), based on the assumption that the maximum indigenous production levels for all fuels would be achieved by 2016/17, the import requirement for non-coking coal is projected to come down completely from nearly 80% in the Reference scenario to 0% in the Ambition scenario (Figure 5).

It is observed that the import dependency of gas in the Reference scenario is projected to increase from almost negligible levels in 2001/02 to 34% by 2021 (Figure 6). At higher prices of $20/mmBtu (million metric British thermal unit) of natural gas, it is not economical to import gas. Natural gas is not a preferred fuel at higher prices as compared with coal for power generation. However, it remains economical for fertilizer production and, to some extent, in the transport sector.

The impact on oil imports is less significant across various scenarios (Figure 7). While it is easier to bring down the import

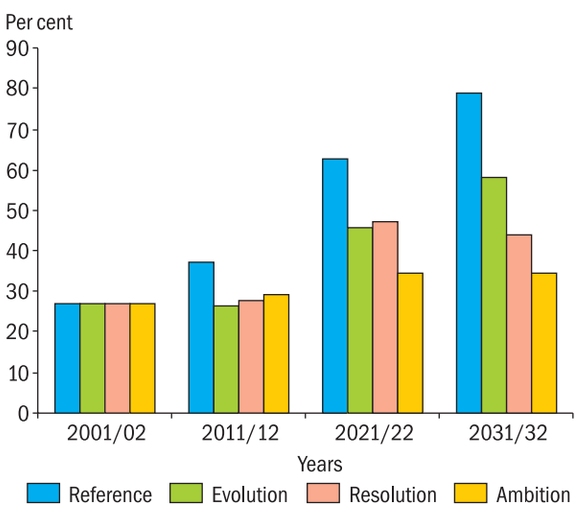


Figure 4 Import dependency of fossil fuels in total commercial energy requirements across various scenarios

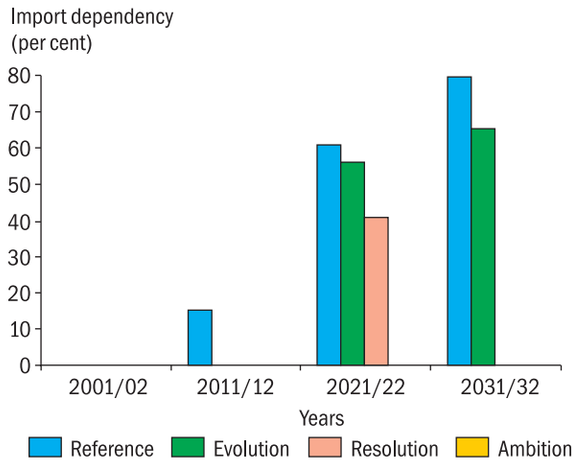


Figure 5 Non-coking coal import dependency across various scenarios

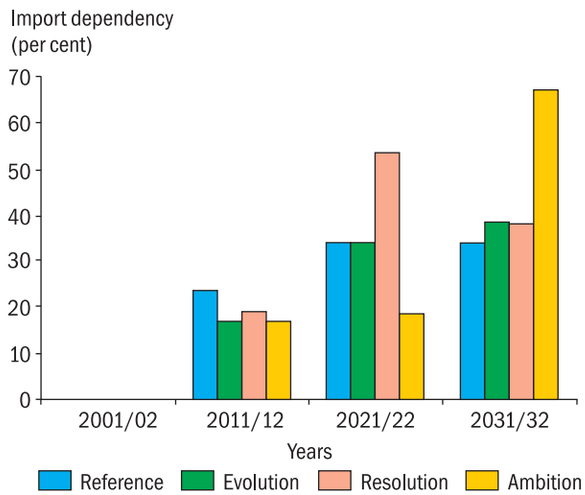


Figure 6 Import dependency for gas across various scenarios

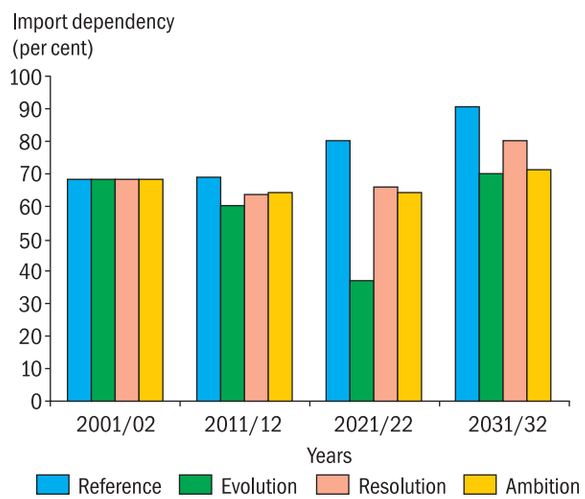


Figure 7 Import dependency for oil across various scenarios

dependency in coal and gas, to reduce import dependency in oil will require radical technological shifts in the transport sector. This will require providing mass transport systems running on electricity, adoption of hybrid vehicles, and advanced battery-operated vehicles. Also, aggressive investments in the development of bio-diesel and bio-ethanol technologies will help in the development of sustainable energy resources for the transport sector. A promising technological option that can provide a feasible solution is the production of cellulosic ethanol from forestry residue as well as agro-residue. A policy for biomass utilization will be required on the lines of the Gas Utilization Policy, which has prioritized the utilization of biomass on the basis of economic efficiency. Gas-to-liquid is not an economical option, with the assumed price trajectory for imported gas. Indigenous gas is economic for the fertilizer and transport sectors.

Technology deployment in the power sector

The reduction in import levels of energy is a function of both shifts in the fuel mix as also the adoption of more efficient technologies across the spectrum. One major contributor to reductions in fuel demand is the power sector, wherein serious technological options can be brought to the forefront (Figure 8).

The power generation capacity of fossil fuels consistently reduces as we move from the Reference scenario to the Ambition scenario, with a corresponding increase in the generation capacity from renewable energy. The additions required in the renewable-energy-based capacity are significantly higher than the reductions in fossil-based capacity due to the lower availability of renewables.

The model results indicate that the IGCC (Integrated Gasification Combined Cycle) technology is preferred, especially when India is importing large quantities of coal in the Evolution scenario, due to its better economics over supercritical and ultra-

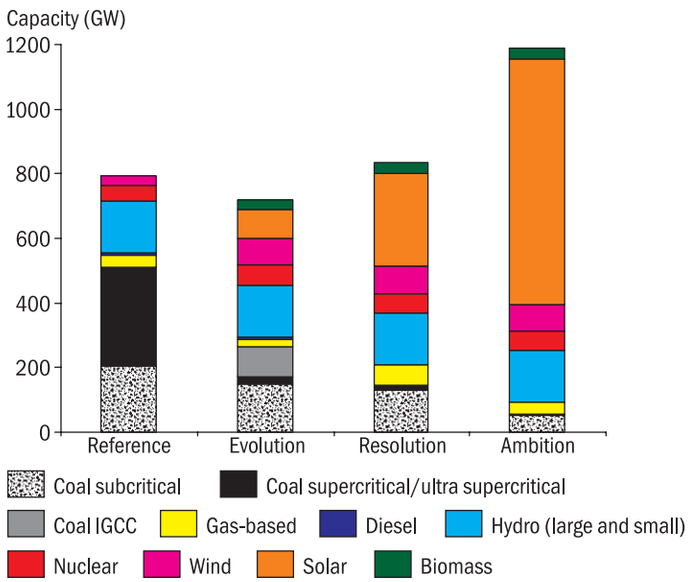


Figure 8 Technology deployment in the power sector across various scenarios in 2031/32

supercritical-based power-generating technologies. In the Reference scenario, IGCC technologies are not expected to be available for deployment, due to their relatively higher costs as compared to ultra-supercritical boilers. IGCC technologies are, however, not preferred in the Resolution and Ambition scenarios on account of high CO_2 emissions from coal-based technologies. Renewable-energy-based power generation increases from just 30 GW (all of it is wind-based power generation) in the Reference scenario to 203 GW in the Evolution scenario, which is based on a combination of wind, solar, and biomass, indicating a fairly wide diversification of renewable energy resources. Gas-based power generation is minimal because of the assumption of relatively higher cost of imported gas. Coal-based power generation capacity reduces from 512 GW in the Reference scenario to 266 GW in the Evolution scenario, which represents 48% less dependency on coal-based power generation. The share of power generation from renewables and nuclear increases from 30% in the Reference scenario to 59% in the Evolution scenario. This share increases further to 75% and to 92% in the Resolution and Ambition scenarios, respectively. The key technology that plays a pivotal role in this shift is solar thermal power generation, the share of which rises from 31% in the Resolution scenario to 61% in the Ambition scenario. The nuclear energy share in the Ambition scenario is around 5% of the total energy capacity, and this is based on the success of India's civil nuclear energy cooperation programme (100 GW nuclear capacity by 2036), which will also result in the deployment of thorium-based reserves in India, resulting in further energy security.

Transport sector analysis

As indicated in Figure 9, total fuel requirement in the transport sector decreases significantly from 577 MTOE in the Reference scenario to around 340 MTOE in the Evolution scenario and to even lower levels in the Resolution and Ambition scenarios.

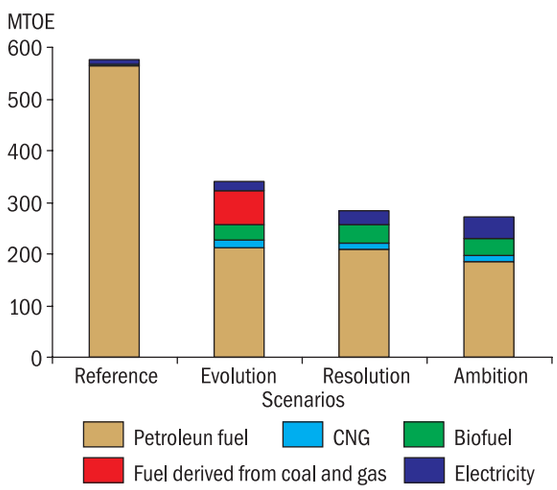


Figure 9 Fuel mix in the transport sector in 2031 (MTOE)

This reduction is due to various transport sector interventions such as increased share of rail in freight and passenger transport, higher share of public transportation in road-based movement, fuel efficiency improvements, higher penetration of CNG (compressed natural gas) vehicles, and so on.

It is interesting to note that the use of petroleum products derived from coal and gas is as much as 67 MTOE in the Evolution scenario in 2031/32, but in the Resolution and the Ambition scenarios, owing to the efficiency loss associated with conversion and the constraints imposed on carbon emissions, coal-to-liquid/gas-to-liquid technology is not found to be attractive at all. CNG consumption increases in each of the alternative scenarios when compared with consumption levels in the Reference scenario.

Carbon dioxide emissions

The drop in total CO_2 emissions over the various scenarios is quite dramatic, with emissions in the Ambition scenario in 2031/32 only doubling from the 2001/02 levels, against a nearly eight-fold increase in the Reference scenario. In per capita terms, in 2031/32, India's CO_2 emission level decreases from 5 tonnes in the Reference scenario to 3.3 tonnes, 1.9 tonnes, and 1.2 tonnes, respectively, in the Evolution, Resolution, and Ambition scenarios (Figure 10).

Total system costs

A comparison of the discounted system cost (investment, operational, and fuel cost) across various scenarios indicates that this is less in all alternative scenarios when compared with that in the Reference scenario, being least in case of the Resolution scenario

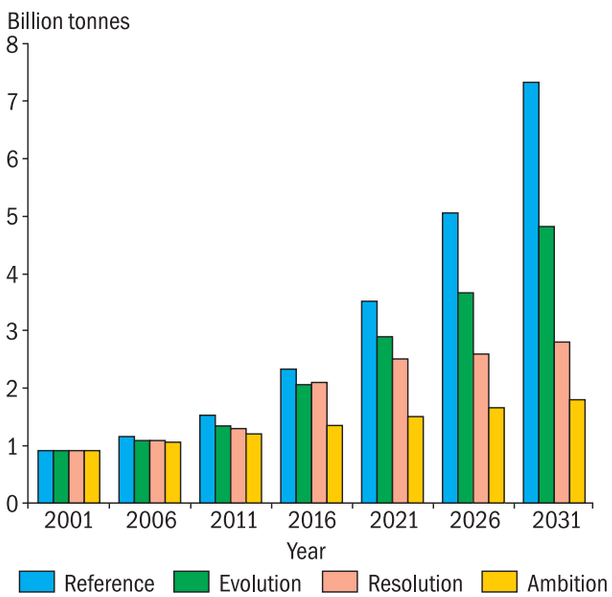


Figure 10 Carbon dioxide emissions across various scenarios (Gt)

(Figure 11). It is interesting to note that it is more economical for the country to move to the Resolution scenario than the Evolution scenario or a more stringent Ambition scenario. The Resolution scenario includes a larger level of options, which pay off over their lifetime due to higher efficiencies and/or reduced fuel costs. The Ambition scenario, on the other hand, needs to undertake options that do not pay off even in the long run due to the extremely stringent emission reductions required. It must, however, be noted that the options that need to be employed in the Resolution scenario require a fair level of effort in terms of removing policy and institutional barriers, apart from access to technologies and additional institutional and transactions costs of implementing these new and renewable energy technologies.

Figure 12 shows the discounted value of investment requirements across various scenarios over the modelling time frame. In the Ambition scenario, the technologies that would need to be deployed

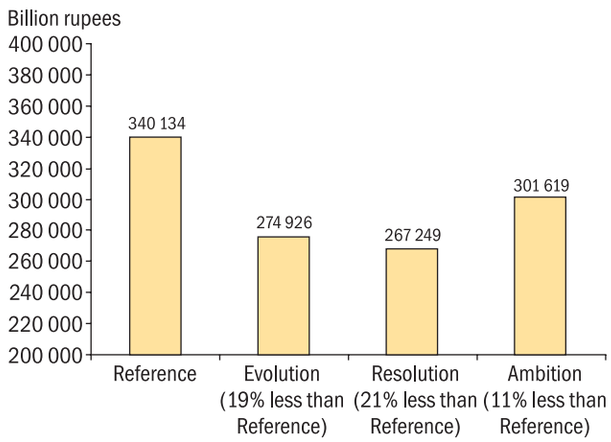


Figure 11 Total discounted system cost (billion rupees)

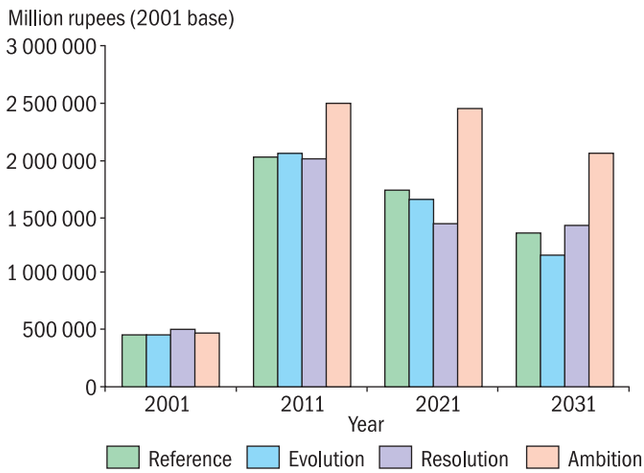


Figure 12 Total discounted investment cost (million Rs)

have investment needs that do not pay back even over the entire lifetime of these options. In the Evolution scenario, the additional level of investment, as compared to the Reference scenario, is generally lower, especially in the near term, which is due to a fair level of low investment options being available. In the Ambition scenario, higher investment options need to be pursued, as compared to the other alternative scenarios, in order to meet stringent emission constraints. On the other hand, in the Resolution scenario, the discounted investment costs are lower in the later time periods as compared to those in the Reference scenario, signifying that the alternative technological choices may indeed pay off over the lifetime of the selected options (even if the upfront investment costs are much higher when compared to those in the Reference scenario).

The lower investment costs in the Resolution scenario, as compared to the Evolution scenario in the short term, reflect the constraints that are imposed on choices in the Evolution scenario. A much more aggressive approach to efficiency and renewable energy even in the short term would be more beneficial not only to India but also to the entire world.

The discounted net expenditure on fuel is around 29% less in the Evolution scenario and 32% less in the Resolution scenario, as compared with that in the Reference scenario. Maximum percentage reduction is achieved in the Ambition scenario (37%), since it uses the highest level of renewable energy sources.

The total undiscounted investment cost in the power generation technologies across different scenarios over the modelling time frame is presented in Figure 13. This analysis, undertaken specifically for the power sector in terms of investment costs, indicates that while the investment cost in the Reference scenario is Rs 65 trillion, it increases considerably in the Evolution scenario and Resolution scenario to Rs 91 trillion and Rs 260 trillion, respectively, and to an even larger extent in the Ambition scenario (Rs 457 trillion). When compared with the Reference scenario, this translates to an increase

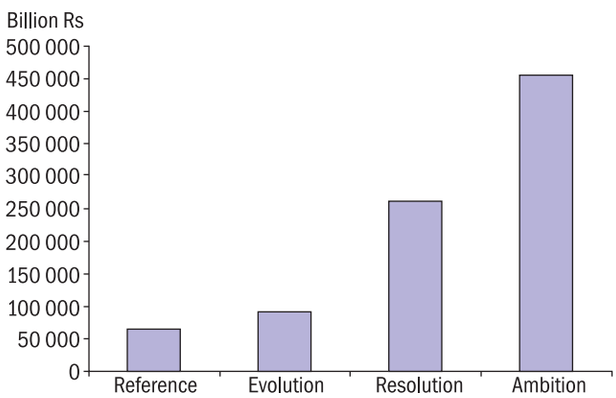


Figure 13 Undiscounted investment cost across different scenarios for power generation technologies (billion rupees)

of 39%, 300%, and 604%, respectively, in the Evolution, Resolution, and Ambition scenarios.

Key modelling results

- The Resolution scenario seems to be the best for the country – it brings with it the highest levels of savings, entails investment that pays off over the lifetime of options, is likely to lead to lower level of fuel import dependency than the Reference scenario, and simultaneously prepares the country for decarbonizing the economy.
- However, achieving this scenario itself would border on the range of infeasibility. Tremendous efforts would need to be made to meet the targets set in this scenario – interventions here would include a major focus on barrier removal activities as well as on deployment of more energy-efficient technologies.
- The technology options of coal-to-liquid and gas-to-liquid are important for India's energy security but may not be the most optimal choices when more stringent carbon targets are set. As such, these can at best be seen as short-term options with a low existential life.
- The Ambition scenario, while being the most stringent in terms of CO_2 emission reduction, indicates lower savings when compared to the Resolution scenario. Moreover, it entails a much higher level of investment because of having to move to the most expensive choices for decarbonizing the economy under such a stringent emission reduction profile.
- India does not have enough degrees of freedom in its fuel technology choices to be able to significantly change its energy development pathway till 2017 (end of 12th Five-year Plan) at the earliest. However, it can definitely start influencing its infrastructure investment choices such that it does not lock itself into a high carbon pathway.

Moving on the desirable pathway

The alternative scenarios explored above provide the boundary conditions within which India can hope to find more climate-friendly paths of development. However, in order to be able to move along in the direction of what can be considered to be desirable pathways, India would need to make several adjustments, which would imply that it moves to a near complete dependence on electrical energy for all end uses and that around 90% of its electricity needs are met through nuclear, hydro, solar, and other renewable energy sources by 2031/32 (in the Resolution scenario) (99% in the Ambition scenario). This shift may not be feasible with the resources the country has at its disposal and/or in the accelerated time frame that the world would like it to follow. The next few paragraphs try and identify the key directional changes that need to be brought about and how the international community can help with this effort.

Clean power

With about 80% of its capacity needs yet to come into place between now and 2031/32 and 60% between 2017/18 and 2031/32, India's electricity sector lends itself well to clean interventions. Given India's historical belief that it has abundant coal resources and considering the constraints on availability and price of natural gas, the likelihood of this capacity being based on coal is extremely high. It is, thus, imperative that India be supported in moving as quickly as possible to completely carbon-neutral technologies. The options that have emerged as most feasible, with adequate support, are expectedly the renewable energy technologies of solar, wind, biomass, and nuclear.

It needs to be recognized that nuclear power would play a very significant role in the medium term and long term to meet base load power requirements. International cooperation for supply of enriched uranium and re-processing of spent fuel would be essential to accelerate the operationalization of India's three-stage nuclear programme, while sharing of technologies for disposal of highly radioactive waste will address the global concern about nuclear safety.

The Government of India should use the time period between now and the end of the 12th Five-year Plan to define and implement its approach to make this transition. It has already been recognized that biomass energy could play a significant role in the relatively short term as well, especially in meeting the energy needs of the rural population. Given that the government is keen on providing access to electricity to 400 million people, who are today deprived, there is an urgency to this task. Solar PV (photovoltaic) technology could also help fill in this gap, but its costs are still higher than the biomass technologies. However, an early introduction to the PV technology would be essential to pave the way for a near-term acceleration of this technology. This is of particular relevance because this technology is expected to meet decentralized as well as centralized power generation requirements in the transition time period and beyond.

In spite of its high cost as compared to conventional decentralized power generation (such as that based on diesel), the government has proactively defined market-based programmes to demonstrate, promote, and gain experience with solar PV technology. However, budgetary constraints have severely limited the scale of these programmes.

While the government has announced a policy for solar-based (thermal and PV) power generation, the programme is rather modest, with a capacity limitation of 50 MW for the entire country by 2011/12. Given that by 2031/32, India's power generation capacity requirement would be of the order of around 800 GW and

if solar has to play a major role, the scale of deployment of these technologies needs to be significantly larger and more rapid beyond 2017/18. Moreover, there would be a need to necessarily move towards solar thermal with storage to meet the base load requirements. This can be done by using international carbon-market-based mechanisms like programmatic CDM (Clean Development Mechanism).

The programmatic CDM would ensure upscaling and efficient deployment of solar technologies due to similar projects being based on predefined methodologies at the country level. However, the revenues generated from the CERs (certified emission reductions) under this programme would be insufficient to bridge the viability gap. Accordingly, there is a need for technology cost reductions by large-scale deployment and further R&D (research and development).

Accelerated renewable energy use

India also has a vast untapped wind energy potential of about 65 000 MW, which is likely to increase to 100 000 MW after complete mapping of the wind energy profile. Although, wind energy has come of age and is commercially viable, it needs to be tapped to its full potential at an accelerated rate, with its current installed capacity being 8500 MW. Technology transfer in the manufacture of wind turbines to suit India's wind profile and large-capacity wind turbines of over 5 MW are needed to significantly increase the wind potential. Currently, India's offshore wind energy potential is completely untapped. To map and exploit this potential, technology transfer will be needed. India also needs to accelerate the tapping of its hydropower potential of 160 GW. The current hydropower installed capacity is only 36 GW.

Given its vast solar energy potential, India needs to rapidly demonstrate and deploy not only solar PV but also solar-thermal-based power generation, with storage both at the centralized and decentralized levels. Joint R&D for efficiency enhancement, adaptation and cost reduction as well as technology transfer will be required to facilitate this process.

The biofuels option

Recent initiatives in the bio-diesel sector indicate that although India has large tracts of wasteland, population and livelihood pressures create substantial competing demands for this resource. Therefore, the production of bio-diesel may get severely limited unless substantial improvement can be brought about both in the productivity of bio-diesel plantations as well as in the overall use efficiency of the product, including by-products.

While the Draft Biofuels Policy of the Government of India emphasizes on the use of molasses for ethanol production, the attractiveness of this route is questionable due to the high energy intensity of sugar cane production and the alternative uses to which molasses can be put. It is extremely difficult to envisage a diversion of any productive land in India to energy crops due to the rising

population pressure and food security concerns. The only option that would be attractive would be to use second-generation biofuels derived from biomass waste material. There is a need to enhance the efficiency of second-generation technologies and make them available at the earliest to developing countries such as India.

Decentralized energy provision

Nearly half of India does not have any access to either electricity or good quality, reliable electricity. Almost all of such people live in rural areas, and extending the grid to them could be both capital-intensive as well as inefficient, especially if it can be foreseen that the shape of things to come is very likely to change. Therefore, it may be worthwhile to quickly make the transition to decentralized power generation technologies – the most sensible options for India being those of solar and biomass. India already has made a commitment to provide electricity to all households by 2012, which may extend by a few years. Instead of making investments in extending the grid to all these areas, the higher private cost option of renewable energy should be encouraged as needed. The very existence of an electricity grid, because of the sunk investments it represents, could be a disincentive to move to renewable energy.

Prudent planning for supply and investment in fossil fuels

Non-coking coal imports

Given the carbon footprint of coal and the need for the country to move towards cleaner energy pathways, the role of coal is expected to decline in the future. India is currently importing approximately 30 MMT of coal, and even under an assumption of aggressive efficiency improvements, the country would need to import roughly 180 MMT of coal by 2017.[1] This, of course, assumes that India's domestic production remains at around 400 MMT up to 2017. India can definitely explore faster development of its domestic coal resources if it is assured of alternative energy development pathways for the future, which would imply near zero coal imports. An early indication of the choices available to the country could again help avoid potentially infructuous investment in the coal import infrastructure.

Oil refining capacity

The shift in meeting mobility needs through the use of electricity-based options can result in substantial reduction in the demand for the transport sector fuels. Combined with the substantial efficiency improvement across sectors, this will adversely impact the viability of new refineries, unless the export market for products continues to be vibrant. However, the import of diesel into the country would continue to be high. Diesel consumption could be substituted further if biofuels were to become attractive. R&D efforts in enhancing productivity of bio-diesel and second-generation biofuels for transport can go a long way towards achieving this.

[1] TERI results

Refinery technologies for production of advanced cleaner fuels to meet transport emissions beyond Euro IV norms should be made available. The resistance that Indian refineries put to the shift to Euro IV fuels due to the high investment needs and their inability to recover this investment through fuel prices resulted in a delay of several years. New programmes would need to be put in place to both encourage such an upgradation of new and proposed refineries as well as to overcome the price barrier on high-performance vehicles.

Natural gas investments

The supply scenario in the context of natural gas is rapidly evolving in India. From an annual production of 32 BCM (billion cubic metres) in 2006/07, the country has moved to an expected production of 74 BCM, once the newer established finds[2] have come into production. The recently defined Gas Utilization Policy of the Government of India allocates a higher priority to the use of gas in the fertilizer sector, followed by petrochemicals, while power comes last. On the assumption that India's technological and financial needs to move to a low carbon pathway are met, this policy seems logical. It is only when domestic natural gas production moves well beyond the needs of its fertilizer industry that the consumption of domestic natural gas for power generation purposes becomes more attractive than the use of domestic coal. Importing natural gas for power generation does not seem to be an attractive option. Therefore, it is imperative that India is supported in its efforts to put in place/explore its sedimentary basins through effective investments and access to deep and ultra deep sea horizontal drilling technology. The use of the excess domestic natural gas, if any, would obviously be a more climate-friendly option than the use of domestic coal for power generation. India's experience in the last NELP rounds has seen limited interest by the large oil and gas MNCs (multinational companies).

Energy efficiency/ demand management

In spite of the efforts made by the Government of India, there has been limited penetration of energy efficiency technologies, which is due to the high upfront investment requirements and lack of awareness about these technologies. While the government should continue to make efforts in enhancing awareness and creating markets, it is expected that developed countries would facilitate/ provide the best available technologies either by setting their manufacturing units or by licensing their technology for manufacture in the country. Large-scale programme supported by multilateral organizations and market mechanism such as programmatic CDM would further accelerate deployment of energy-efficient technologies.

[2] There have been substantial gas finds in the K-G Basin; for instance, Reliance (15 TCF [trillion cubic feet]) and Gujarat State Petroleum Corporation (20 TCF).

Some of the large industrial units in India are using state-of-the-art technology. However, there is a need to continually upgrade technology. This can be addressed by having a multilateral financing mechanism to phase out inefficient and obsolete technologies. Adaptation of state-of-the-art technologies to suit Indian conditions calls for undertaking cooperative R&D efforts right from the inception.

In small-scale industrial sector, adoption of energy-efficient options is low. The major constraints for small-scale industry are high upfront investment for adoption of these technologies, limited availability of funds, and inadequate know-how about latest energy-efficient technologies. To address this issue, the international technology suppliers should facilitate technology transfer by licensing manufacturing within the country at an acceptable cost and large-scale deployment within the sector.

Moving to cleaner transport

India's vehicle ownership levels and mobility needs are still extremely basic. However, as per some recent trends, it can be expected that there would be an explosion of mobility demands in the future. It is, therefore, imperative that the transport sector in particular experiences a course correction at the earliest, so as to not tie itself into infrastructure straitjackets that are detrimental to the long-term needs.

A massive shift towards the use of electrically driven public transport systems and towards the use of cleaner personal vehicles based on hybrid technology and/or advanced batteries would need to take place. The Government of India already has in place a major incentive programme to facilitate the introduction of mass transport systems in cities in the JNNURM (Jawaharlal Nehru National Urban Renewal Mission) programme. However, the programme, as it is currently defined, leaves the choice of transport options to the city government, depending on the socio-economic and spatial characteristics of the city. It is incidental that a number of cities are attracted to the Metro option that the city of Delhi is building – more for the prestige and symbolic value. Similarly, the debate on the economic viability of the electrification of railway tracks has raged on for decades, with the freight and passenger movement through electrified traction being 60% and 49%, respectively.

These programmes need to be re-defined to explicitly recognize the long-term advantages of electricity-based options. City governments should be encouraged to leverage central government support and local resources to garner international technological and financial support to ensure an *accelerated* development of efficient city transport options. The well-established method of competitive discovery of viability gap funding required could be the agreed basis for international financial support based on technological commitments. Thus, for example, Germany could commit to providing its MAGLEV technology for a specific city/corridor and use the above-defined approach to determine the

additional financial support it would need to provide to facilitate technology transfer and deployment.

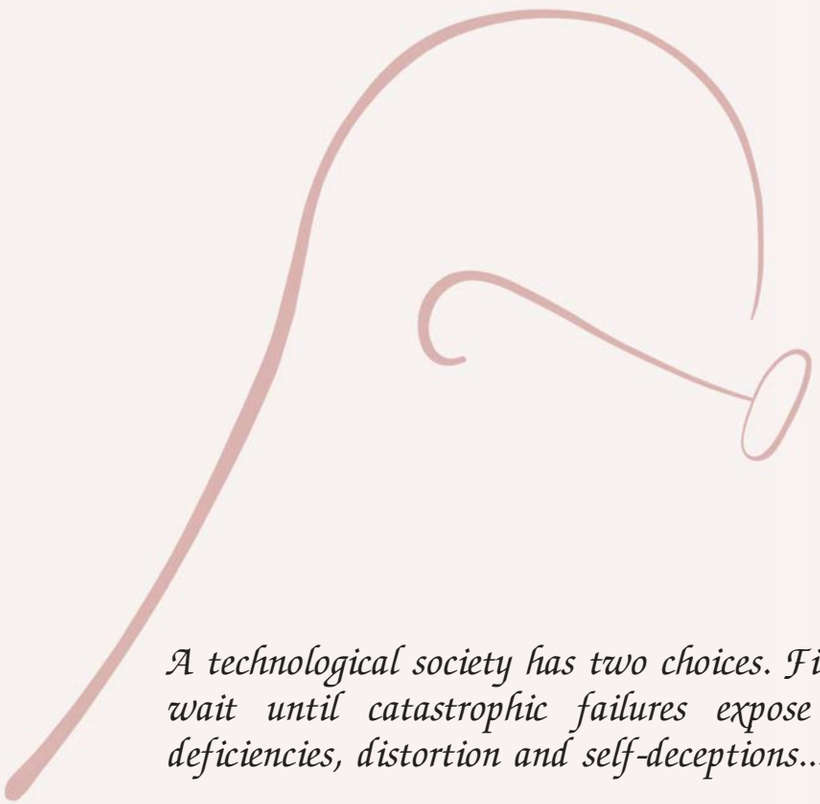
The Government of India should also define a clear time frame for shifting to hybrid technology and/or on battery technology for the production of all new vehicles. To facilitate this transition, the industry would need to be compensated appropriately for foregone returns and encouraged to move its production lines along desirable paths. Developed countries should be inspired to participate in such an initiative while the Government of India works towards correcting its current fiscal regime to incentivize the production of targeted efficient vehicle technologies. This can be facilitated through public procurement of IPRs (intellectual property rights) for large-scale licensing to developing countries to enable technology transfer and achieve economies of scale.

Incremental finance needs

If India moves along the business-as-usual pathway, the cumulative investment required in the power generation technologies, from 2001/02 to 2036/37, would be $1.4 trillion. However, if India were to move along a low carbon pathway, these investment requirements are expected to increase by four to seven times. However, it needs to be recognized that the increase in actual energy system cost would be somewhat lower than the capital cost because of the shift to renewable energy technologies. Even so, budgetary constraints would hamper the efforts of the government to move to a lower carbon path. Taking into account the likely evolution of the renewable energy and energy efficiency markets and the economies of scale that may then accrue, the financial support needed to move to low-carbon pathway would be even lower than the estimated increase in the energy system cost. As such, if this increase has been estimated to be of the order of $700 billion, an initial planning for setting up a Fund of approximately $200 billion ($20 billion per year for next 10 years) may be undertaken. Obviously, this amount would not need to be set aside at one go, and the actual size of the Fund could be dynamically estimated.

In sum

What the above analysis presents is the potential of India's contribution to finding a climate solution. How much can be realized is a function of both the responses of the international community as well as the Government of India. Maybe it would be possible to move away from the current rhetoric if concrete and comprehensive long-term agreements could be arrived at, with binding and linked responsibilities on both sides?



A technological society has two choices. First it can wait until catastrophic failures expose systemic deficiencies, distortion and self-deceptions...

Secondly, a culture can provide social checks and balances to correct for systemic distortion prior to catastrophic failures.

Mahatma Gandhi

For further details, contact

Dr Ritu Mathur, Associate Director
or
Dr Atul Kumar, Fellow
Energy Environment Policy Division
TERI
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003

Tel. 2468 2100 or 4150 4900
Fax 2468 2144 or 2468 2145
India +91 • Delhi (0) 11
E-mail ritum@teri.res.in or atulk@teri.res.in
Web www.teriin.org