Economist Intelligence Unit

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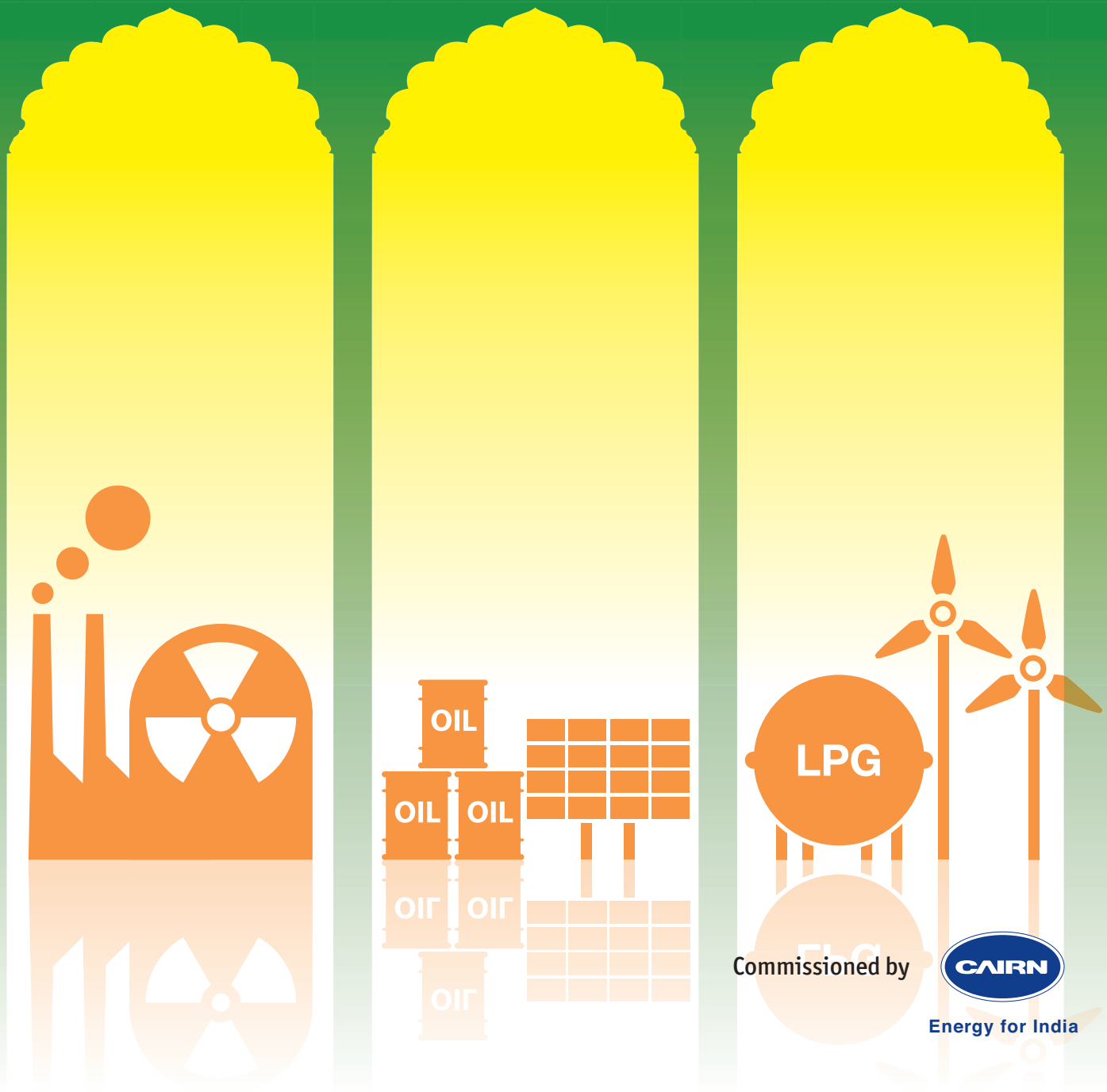
Empowering growth

Perspectives on India's energy future

A report from the Economist Intelligence Unit



Commissioned by CAIRN Energy for India

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Preface

Despite India's roaring economic growth over the past decade, and its citizens' growing belief that it is finally ready to join the league of global superpowers, the country remains vulnerable to occasional dysfunction. Nothing typifies this better than the blackout in July 2012 that left some 600m people without electricity. Reforms that began in 1991 have gone some way towards improving the efficiency of India's energy sector, but serious impediments to investment remain. As a result, India's energy supply is constantly playing catch-up to the demands of its burgeoning economy. Can India's energy sector continue to power its economy in the long term?

This question was the starting point for this paper. The Economist Intelligence Unit (EIU) asked prominent figures from research, industry and academia to consider India's long-term energy future. Their contributions, in the form of essays and in-depth interviews, tackle the fundamental issues India must consider when plotting a sustainable and secure energy future. These include: the need to address domestic price distortions and other inefficiencies; prospects for renewable energy; how to encourage greater energy efficiency; how to meet the energy needs of industry and commerce; challenges in distribution and infrastructure; and what India can learn from other countries' energy strategies.

Cairn India commissioned this project but had no editorial input into any of the sections below, which are solely the work of the authors.[1] Their contributions can be summarised as follows:

1. India's energy future: The EIU view

***Martin Adams**, Energy Editor, Economist Intelligence Unit*

The EIU's view is that India's demand for energy will continue to expand rapidly, but domestic supply will be constrained by price distortions and other hindrances. This will increase demand for fossil-fuel imports. By 2020, domestic production will fulfil only half of India's fossil-fuel consumption, down from 60% today. This will add billions to its fuel import bill and deepen its energy security worries.

2. India's "energy trilemma": An international perspective

***Stuart Neil**, Director, and **Philip Thomas**, Scenarios Project Manager, World Energy Council*

Only a robust and coherent energy policy will enable India in the long term to manage the different elements in its "energy trilemma": energy security, equitable energy access and environmental impact mitigation. This is important because the global Energy Sustainability Index by the World Energy Council indicates that India's

[1] David Line and Sudhir Vadaketh of the Economist Intelligence Unit were the editors of the paper. Bina Jang assisted with project management, interviews and additional editorial duties. Gaddi Tam was responsible for layout and design; the cover image is by Wai Lam.

performance has been declining in all three dimensions, particularly energy security. In the medium term, it is vital for India to formulate holistic policies that will encourage investment in energy infrastructure, create a strategic energy mix, and promote coordination between the central and state governments so that the country's energy supply will be able match its economic growth aspirations.

3. India and the other BRICs: Energy and the implications for economic growth

***Charles Ebinger**, Senior Fellow and Director, and **Govinda Avasarala**, Senior Research Assistant, Energy Security Initiative, The Brookings Institution*

India has possibly the most uncertain energy future of any BRIC nation. Demand for energy in Brazil, Russia, India and China is expected to grow in tandem with rapid economic growth. While the first two are rich in energy resources and should cope quite well, India and China face a challenge, as domestic energy resources will fall far short of projected demand. China seems to be handling its energy deficiencies more determinedly than India, whose tentative energy policies suggest no immediate solutions. This is bad news for India's economy, which has already begun to slow. Promoting hard-nosed energy policies, however, could help to bring growth back on track.

4. India's energy strategy: Historical and future perspectives

***M Govinda Rao**, Director, National Institute of Public Finance and Policy*

Electricity supply and demand lie at the heart of India's energy future and its aspirations to maintain an annual GDP growth rate of 8% in the medium term. However, the power sector is hobbled by inefficiencies and bad pricing policies that have left the state utilities virtually bankrupt. This has particular ramifications for coal, the electricity sector's main fuel and a major element in India's energy mix. A growing reliance on imports of coal, as well as oil and gas, will exacerbate energy worries in the coming decade. Renewable energy provides only a little relief, but nuclear could be the energy of the future.

5. Industrial demand and energy supply management: A delicate balance

***Arunabha Ghosh**, Chief Executive Officer, Council on Energy, Environment and Water*

Indian industry, particularly manufacturing, faces a huge challenge to procure enough energy to fuel future expansion. It faces three scenarios: ignore the problem, with the risk that limited energy supplies will cap growth and investment. Or internalise it, by securing captive energy sources—which might skew governance and retard the adoption of cleaner fuels. Or innovate in policy and practice across the energy supply chain and manage demand. Only one of these scenarios can ensure a sustainable energy future.

6. The distribution and infrastructure challenge: Improving India's grid network and rural connectivity

***Rajiv Lall**, Vice-chairman and Managing Director, IDFC*

India's massive grid failure in July 2012 was symptomatic of deep-seated problems with the country's electricity connectivity. The malfunction flows down the entire supply chain, from generation to transmission and distribution. Rural connectivity is especially poor, despite official claims that 90% of villages are electrified. The solutions are easy to identify: better grid management practices, higher electricity tariffs, improved billing/collection and greater private participation in the supply chain. Finding the political will to implement these steps is the difficult part, but the country's continued economic development depends on it.

7. Renewable energy in India: For now or the future?

***Rahul Tongia**, Technical Advisor, Smart Grid Task Force, Government of India, and Adjunct Professor, Carnegie Mellon University*

Are renewable sources the answer to India's energy problems? Their potential is undeniable: in five years they could account for 18% of capacity—if only about 6% of generation. Wind and solar could contribute much of this alone. But scaling up renewables generation means resolving fundamental challenges of supply volatility, grid integration, geographic dispersion and uncompetitiveness. Someone must bear the higher costs of renewable power sources. While the central government has developed several policies to this end, states—and consumers—might be less eager to finance further renewables development.

Economist Intelligence Unit, October 2012

1 India's energy future: The EIU view

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Martin Adams
Energy Editor, Economist Intelligence Unit

In late July 2012, half of India was plunged into darkness as the country's northern, eastern and north-eastern power grids collapsed, leaving 600m people without electricity. Billed as the world's biggest ever, the power outage prompted one Indian newspaper to lament, "Superpower India, RIP".

Certainly the crisis was an embarrassment for India's government, businesses and citizens who of late have enjoyed India's recognition as one of the world's most dynamic economies. But though the power cuts of July 30th and 31st may have been unprecedented in scale, they were nothing new. In fact, many millions may barely have noticed the outages—an estimated 400m Indians lack any connections to the national grid, which is notoriously inefficient. Moreover, India's electricity woes are likely to remain severe, as demand for energy gallops ahead of supply. Energy consumption rose by half between 2001 and 2010, and the trajectory remains one of steep ascent.

The Economist Intelligence Unit (EIU) sees India's appetite for energy growing by 54% between 2011 and 2020, the end of our forecast period.

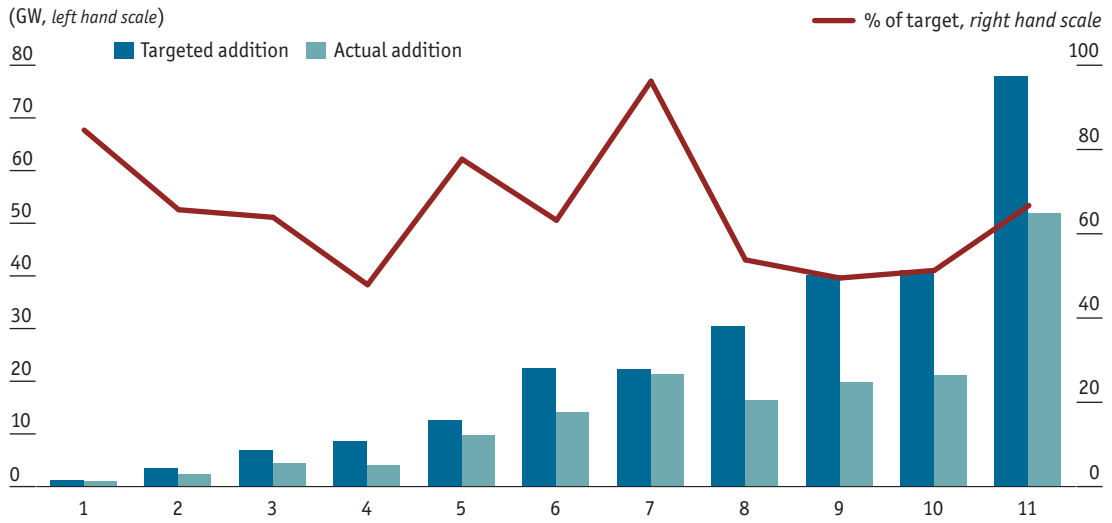
A range of problems, particularly artificially low energy prices, will exacerbate the difficulty of meeting surging demand and supporting economic growth. This article analyses the strained status quo and shows how India's energy future will unfold according to the EIU's core forecasts. It examines each energy sub-sector in turn, beginning with electricity.

Electricity: power struggles

Some hope that July's breakdown will jolt India's government into tackling its electricity inadequacies. But a loose wire runs through the entire electricity supply chain, and fixing the problem will be hard.

First, generation. The Electricity Act of 2003 encouraged private investment, spurring an

Chart 1: Electricity generation capacity



Note: Horizontal axis shows plan periods
Source: Planning Commission of India; Economist Intelligence Unit data/forecasts

estimated 65% increase in capacity between 2003 and end-2011. This nonetheless greatly undershot India's plans even as consumption jumped by 75% (see Chart 1). Compounding the dissatisfaction, existing plants often operate at half-capacity. Coal dominates the electricity mix, but affordable supplies are running short (see below). The need to buy expensive coal from Australia and Indonesia is placing long-term financial strains on power plants. This, and the low quality of India's domestic coal, are hobbling a grand plan to set up a string of new "ultra-mega power plants", many of which are meant to run on imported coal. So far, only one such plant, Tata Power's Mundra UMPP in Gujarat, is in operation.

Meanwhile, the transmission and distribution (T&D) system that brings consumers their intermittent power has its own problems. India has five regional grids and connections among them are poor. Efforts to build a so-called National Power Highway by 2014, to allow one grid's surplus to plug another's deficit, are ongoing. Its proposed outcome—seamless power transmission across the country—appears to be somewhat optimistic, given the overall deficiencies in electricity supply.

Then there is the soft infrastructure. Grid management is divided between officials of the central government and the states, an arrangement that seems unlikely to be overhauled soon. Local officials and politicians will be loath to surrender control over dispensing electricity—a valuable patronage tool. It is reportedly common for many consumers, including some public institutions, not to be billed for their power use. Agricultural consumers (read: rural voters) often can draw power for free, or receive steep discounts. Punishments for stealing electricity are rarely enforced.

Over time, not recouping the cost of providing electricity has effectively reduced swathes of state electricity boards (SEBs) to bankruptcy. They cannot invest properly in upgrading the inefficient grid. More than a quarter of India's electricity is thought to be lost in T&D. Such deficiencies mean that power demand typically exceeds supply by about 10% at peak times. Electricity outages are a common nuisance, so many firms (and homes) must install and maintain expensive back-up generators and batteries.

The EIU expects that, although the grid will continue to spread, improvements in electricity provision will be gradual and patchy. As in other policy areas in India, decentralisation is becoming the norm in addressing electricity problems. Experimentation is flourishing in some states—for instance, consumers are being offered a choice between paying more for a more reliable power supply and sticking with the low-cost, low-quality norm. Such innovations will lead to increasing disparities in power provision between well-managed and poorly run states.

At root, India's power troubles are political, making the afflictions of the SEBs particularly tricky to fix. The SEBs can become financially healthy only if subsidies are overhauled and they are permitted to charge market rates for power. They can then invest on the scale necessary to upgrade the dilapidated grid. But the EIU expects the political appetite for structural reform to be weakened by the series of state elections that begins in November 2012 and continues until the general election in May 2014, itself a powerful brake on reform. The chances of meaningful change before then are slim. Wringing payment from the poor for access to power is hardly a winning manifesto message.

Looking beyond that, however, the outlook for electricity reform is brighter, especially if the national poll delivers a government with a larger majority and a less fractious coalition. Beneath their populism, leaders of both main political parties understand the necessity for structural reform. That said, the Bharatiya Janata Party, currently in opposition, with its middle-class support base, might be able to push through a reform agenda faster than the Congress party, currently heading the ruling coalition. The Congress seems to have a greater tendency to pander to populist concerns for electoral purposes.

For now, the EIU assumes that politics will continue to influence the electricity sector. Brisk economic growth and changing consumption patterns, together with the usage stoked by subsidies, will drive demand for power. Electricity consumption is on course to swell by over 90% from 2011 to 2020, but generating capacity will grow by less than 70%, to 368.5 gigawatts (GW), during that period. Once power losses are factored in, there will be a shortfall. Outages will continue to stall the engines of industry and commerce.

Coal: mine the gap

If the fundamental problem in the power sector is that consumers buy electricity for less than it costs to generate, this has—and will continue to have—important ramifications for the fossil-fuel sector, not least coal.

It is India's most important natural resource; the country has the world's fifth-largest reserves. Coal fuelled 57% of India's electricity-generating capacity by mid-2012 and accounted for an estimated 43.4% of its gross domestic energy consumption in 2011. Yet the coal sector fails to live up to its financial potential, and there are shortages. State-owned Coal India Limited (CIL) mines four-fifths of India's coal output, but is obliged by the government to sell to power plants at below-market prices in order to safeguard electricity supplies. Unsurprisingly, CIL is criticised for inefficiency. Pricing distortion in the electricity supply chain will continue to prevent CIL from receiving market rates for its coal, thereby putting off investments in new mines and creating difficulties for private stakeholders in the company.

July's power outages provoked fresh calls to loosen restrictions on private-sector investments in coal mining. This would raise the level of technology and know-how. But state intervention throws up powerful disincentives to private participation. Private developers of power plants and the "captive" mines that supply them must wade through red tape to secure approvals. Financing is in tight supply.

In addition, ownership of national resources remains a sensitive subject. Protests against state land-grabs to build mines are spreading. A new land law, currently being debated in parliament, could help to clarify matters. But there is the potential for further disputes, which threatens to dampen private and state-led investment.

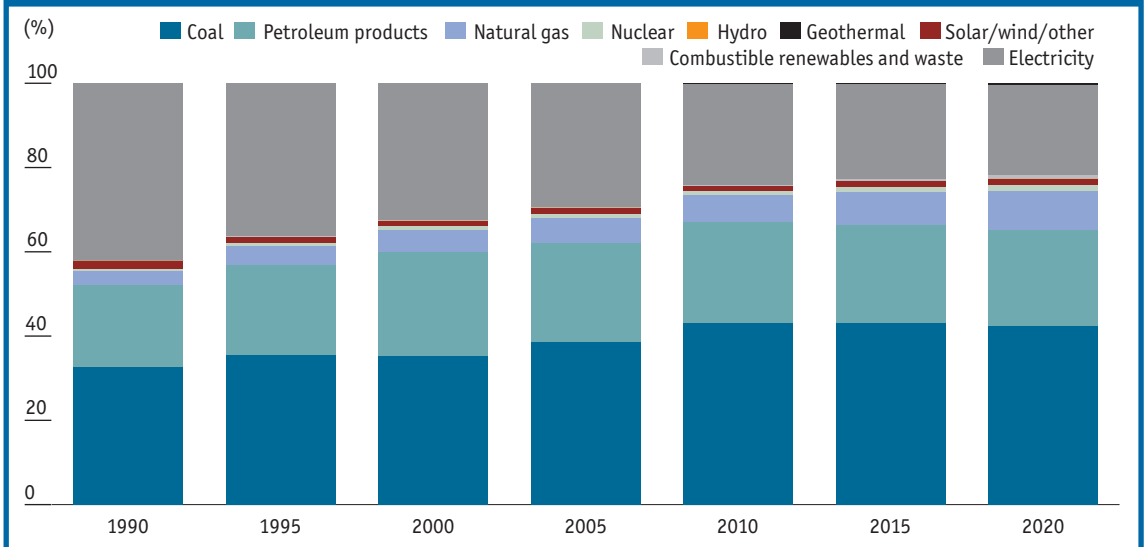
Furthermore, the ongoing Coalgate controversy hangs over private participation in the sector. The scandal, which has been simmering since early this year, reached a tipping point in early September with the publication of a report by India's federal audit authority, the Comptroller and Auditor General of India (CAG). This indicted the government's policies on the award of coal-mining concessions. The CAG contends that awarding 142 coal blocks without competitive bidding in 2004-09 led to windfall profits of around US$34bn for private firms. The most immediate fallout in the following months is political: India's opposition made hay out of the fact that India's prime minister, Manmohan Singh, was head of the coal ministry for three of the five years under question, calling for his resignation. Mr Singh challenged the CAG's findings and denied any allegations of corruption.

The furore has shone a spotlight on private miners, many of whom have not delivered on commitments to begin mining despite receiving allocations of coal blocks. An inter-ministerial group set up in July—following the tabling of the CAG's draft report—is currently investigating 29 coal blocks allocated to private firms. Owing to the delay in developing these mines, at time of writing an inter-ministerial review group had recommended that thirteen blocks be "de-allocated" and bank guarantees encashed in the case of further blocks. Given India's energy shortage, there is increasing pressure on private and state-owned miners to deliver the goods. Their failure to do so may well result in more de-allocations.

Also affecting output is India's geology, which makes coal extraction technically difficult. Deposits tend to be abundant in eastern states, such as Chhattisgarh, Odisha and Jharkhand, which are prone to violent disruptions by Naxalite insurgents, and far from where the coal is needed. Mines are therefore at the mercy of India's creaking railways.

The EIU assumes that pricing distortions, dilapidated infrastructure, red tape, tricky

Chart 2: % of India's gross domestic energy consumption



Source: Economist Intelligence Unit

2010 is an estimate, 2015-20 are forecasts

geology, inconvenient geography and virulent local objections will continue to hinder the coal sector. Output will grow from an estimated 257.7m tonnes of energy (mtoe) in 2011 to 320.2 mtoe in 2020. But there will still be a gap between supply and demand, sucking in more imports. Despite India's abundant reserves, coal's share in its energy mix will stagnate, standing at 42% in 2020 (see Chart 2).

Natural gas: unnatural progress

Gas, by contrast, will grow in relative importance. Planners want to capitalise on indigenous gas reserves believed to be considerably larger than India's oil endowment. The EIU treats with scepticism the predictions of an Indian shale-gas boom: the US government's Energy Information Administration in 2011 found that India had just 63trn cu ft of technically recoverable shale-gas resources (compared with China's 1,275trn cu ft, for instance). However, large offshore finds have helped to boost India's reserves from 0.8trn cu metres (28.25trn cu ft) in 2004 to 1.2trn cu metres (42.37trn cu ft) in 2011, according to the *BP Statistical Review of World Energy June 2012*. Assuming more discoveries are made, production will be able to expand from an estimated 46.4 mtoe in 2011 to 57.4 mtoe in 2020.

This prognosis also relies on India tapping foreign expertise to exploit hard-to-reach hydrocarbons. A generally problematic environment for foreign investors in India, however, means that joint ventures are likely to be vulnerable to bureaucratic delays. A cap on retail prices for fuel will continue to discourage investment and hamper production growth. Gas demand will outstrip domestic supply. As industry's needs grow and gas displaces coal in the power sector, consumption of natural gas will grow by 9% annually to 109.7 mtoe in 2020.

More gas imports will be needed, heightening energy-security worries. Liquefied natural gas (LNG) will be one source. On the bright side, India benefits from relative proximity to Australia, a burgeoning LNG provider. Nonetheless, Indian firms will face escalating competition, especially from their Chinese counterparts, to secure LNG contracts, which come with a high price tag. India is also exploring its pipeline gas options, although the outlook is challenging. Construction of the Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas link could be undermined by instability along the route. India cannot count on TAPI to shore up its gas security.

More gas imports and expanded domestic production will expand the proportion that natural gas claims in India's energy consumption to 9.4% at decade's end from around 6.7% in 2011. That is still a long way behind coal and oil.

Oil: less than slick

Oil is the most important element, after coal, in India's energy mix, and this will hold true at decade's end. But growing oil demand and a lack of domestic resources will aggravate worries about the security of oil supply. Oil imports grew by 47% year on year in fiscal 2011/12 (April-March). Currently, unreliable electricity supplies drive industry to become the largest source of demand for petroleum products.

Demand from the industrial sector will expand along with industrial activity. Even so, as vehicle take-up increases, by 2020 transport will rival industry as a source of demand for oil. Overall, consumption will grow by almost one-half between 2011 and 2020, to 263.2 mtoe.

Domestic oil supplies, from proven reserves that are just 0.3% of the world's total, will not keep pace. Again, subsidised prices disincentivise investment; a lack of skilled workers and shoddy infrastructure are familiar themes. The EIU expects production to rise gradually over this decade, from an estimated 865,000 barrels/day in 2011 to 975,000 b/d by 2020.

One change that could stimulate faster production would be the privatisation of India's

state-owned oil firm, the Oil and Natural Gas Corporation (ONGC). An initial sale in March of a 5% stake in ONGC evoked only tepid interest. However, the government may be inclined to sell off ONGC to temporarily plug the sizeable hole in the public purse. Since such a move would be controversial, it would therefore be unlikely to occur before the 2014 general election.

Non-fossils: rapid evolution

Of the other energy options, nuclear power currently plays a small role in India, but big plans are in the offing. Government officials have suggested that 600-700 GW of nuclear capacity could be built by mid-century. Yet even a target of 20 GW by 2020, compared with less than 5 GW today, appears optimistic. Opposition to nuclear power in India has grown louder in the wake of the Fukushima nuclear accident in Japan last year. The objectors fear the impact of earthquakes and flooding on proposed nuclear reactors near the coast, although resistance tends to be fragmented, often fuelled by local concerns. The EIU forecasts that by 2020 India will have managed to build a total of just 13.6 GW of nuclear capacity; this will generate electricity accounting for barely 1% of energy consumption.

Renewable energy, by contrast, is poised for impressive growth albeit from a very small base. India has rich renewable resources. Its installed wind-power generating capacity will almost double between 2011 and 2020; India is already the world's fifth-biggest market. Solar-power generating capacity will surge from less than 1 GW last year to 15.7 GW in 2020, thanks to favourable government policies and solar power's off-grid applicability, which allows it to reach regions that the electricity network does not. Hydropower, meanwhile, will account for nearly 60 GW of capacity by 2020, up from an estimated 44.3 GW in 2011. This falls short of government aspirations, owing to such impediments as the need to resettle communities displaced by dams.

At the end of the decade, in our view, wind, solar and hydropower will remain a tiny portion of India's energy use, inching up from 1.7% in 2011 to 2.3% in 2020. This measure excludes the prodigious burning of "combustible renewables and waste", which captures widespread use of wood for cooking (although this is due to decline slightly as the grid gradually broadens its reach).

Non-fossil fuels therefore will fail to shake the dominance of dirtier sources in India's energy mix. The country's carbon emissions from burning fuel will soar by 43% between 2011 and 2020—giving India little let-up in international climate-change negotiations. Yet, at the same time, supplies of domestic fossil fuels will be constrained for the reasons discussed, forcing a greater recourse to imports. The EIU projects that India's output of coal, natural gas and oil will, collectively, fulfil only one-half of its fossil-fuel consumption by 2020, down from about 60% today. This will add many billions of US dollars to its import bill. India's inability to rely more heavily on indigenous energy sources, whether renewable or fossil, will serve to deepen its energy-security worries.

2 India's "energy trilemma": An international perspective

Only a robust and coherent energy policy will enable India in the long term to manage the different elements in its "energy trilemma": energy security, equitable energy access and environmental impact mitigation. This is important because the global Energy Sustainability Index by the World Energy Council (WEC) indicates that India's performance has been declining in all three dimensions, particularly energy security. In the medium term, it is vital for India to formulate holistic policies that will encourage investment in energy infrastructure, create a strategic energy mix, and promote coordination between the central and state governments. Only by doing so will the country's energy supply be able match its economic growth aspirations.

Stuart Neil, *Director, and* ***Philip Thomas,*** *Scenarios Project Manager, World Energy Council*

India is the world's seventh-largest energy producer and the fifth-largest energy consumer, accounting for more than 4% of total global annual energy consumption. But these impressive statistics hide some sobering truths. India has one of the lowest per-capita energy consumption levels globally, at only 30% of the world average, according to the World Bank. Moreover, India's energy supply falls well short of growing demand. Even when seemingly available, it is unreliable and erratic: the power outage in most of northern India in July 2012 highlighted this.

In the medium term, pressures on energy supply are likely to persist. Energy demand in India will continue to grow rapidly over the next couple of decades, given the country's relatively high rate of growth and high urbanisation levels, and a growing middle class that will drive demand for consumer goods. India has been one of the world's fastest-growing economies over the past five years, with an average annual growth rate of roughly 8%. The Planning Commission of India believes that the country needs to sustain this growth rate over the next 25 years if the country is to eradicate poverty and meet its human development goals.

To achieve this ambitious target, India will need to increase its primary energy supply by four to five times, and its electricity generation capacity/supply by six to seven times, as compared to 2003/04 levels. By 2031/32 power-generation capacity should increase to nearly 800 GW from the current capacity of about 207 GW. For India's economic development to continue apace, it will

have to ensure three things. First, that adequate financing is made available for building and upgrading energy infrastructure. Second, that appropriate measures are taken to address skills shortages in the sector. Third, that the country selects and builds the right kind of energy infrastructure in order to diversify and modernise the country's energy mix.

Formulating holistic policies

Towards this end, it is necessary to formulate holistic policies that account for all the key stakeholders shaping India's energy future, including the central and state governments and the relevant government ministries. All these entities must coordinate better when planning for a sustainable, strategic energy mix.

According to the global Energy Sustainability Index by the World Energy Council (WEC), India's energy security has been declining: in 2011, India ranked 84 of 92 countries on this measure, down from 58 in 2010. India also struggles in the other two dimensions of the "energy trilemma". Its performance in social equity is poor, mainly because a significant proportion of the population does not have access to electricity. India's environmental performance, too, is weak, due largely to poor air and water quality, high emissions from electricity generation, and high overall per-capita emissions.

Nevertheless, there are other countries with similar energy profiles. The WEC identified and grouped countries with similar energy priorities (see Figure 1, overleaf) in its annual country energy report.[1] India features in Group 1, alongside China, Algeria, Estonia, a few countries from the Middle East and others. Group 1 countries focus on providing affordable energy, often through highly subsidised energy costs. These countries score well in terms of social performance, although energy security and environmental indicators are negatively affected.

Group 2 comprises resource-poor countries, countries with limited industrialisation and countries that have widespread adoption of low-carbon technology. As a result this group, which includes Albania, Croatia, New Zealand, Finland and Denmark, performs poorly in terms of social equity but achieves higher scores on environmental impact mitigation.

Group 3 exhibits strong overall scores, with environmental impact mitigation the weakest dimension. This group characterises the main energy challenge facing developed, industrialised countries: how to sustain or enhance existing energy security and social equity while planning for a low-carbon future. On average, Group 3 countries, including Austria, Brazil, the UK and the US, perform best in the Energy Sustainability Index. Countries with more-sustainable energy systems tend to have policy frameworks that deliver a balanced score in all three dimensions of the energy trilemma.

A country's efforts to manage its energy trilemma must be viewed in the political context within which it operates. India has a federal structure, comprising a central government and 28 state governments. This two-tier political structure has influenced the manner in which India's energy sector has been regulated. Moreover, given that there are five different energy ministries in the central government—Petroleum & Natural Gas, Power, Coal, New and Renewable Energy, and the Department for Nuclear Energy—policy coordination can be tricky.

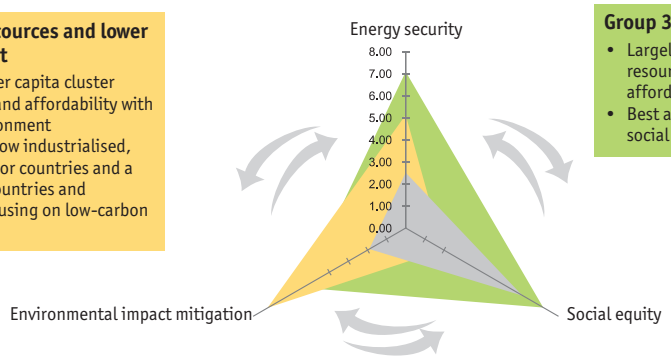
India's electricity blackout in July brings into sharp focus the policy gap between the central and state governments. Central power agencies adopt a national perspective, while their state-level counterparts are more concerned about meeting local needs first. A report by a central government enquiry committee found that one of the main factors contributing to the grid collapse was the excess withdrawal of electricity by state utilities. In addition to suggestions on technical and distribution issues, the report advised better

[1] "Policies for the future: 2011 Assessment of country energy and climate policy", World Energy Council, November 2011

Figure 1: Energy profiles

Group 2: Limited rescources and lower environmental impact

- Lowest average GDP per capita cluster
- Weak in social access and affordability with lower impact on environment
- Represents generally low industrialised, fossil-fuel resource poor countries and a small percentage of countries and developed nations focusing on low-carbon technology



Group 3: Balancing secure and affordable

- Largely developed nations with sufficient natural and economic resources to exhibit strong performance in energy security and affordable, accessible energy
- Best average index performance, with average GDP/capita equal to social equity strong cluster

Group 1: Highly affordable energy

- Lowest average index performance and includes many exporters
- Generally focus on providing affordable energy often through subsidies
- Weaker performance on energy security (highly intense energy use) and environment

Group 1: Highly affordable energy	
Algeria	Mongolia
Australia	Netherlands
Belgium	Pakistan
China	Poland
Cyprus	Qatar
Estonia	Saudi Arabia
Greece	South Africa
Hong Kong, China	Taiwan, China
India	Thailand
Iran (Islamic Republic)	Trinidad & Tobago
Israel	Turkey
Jordan	United Arab Emirates
Korea (Republic)	
Kuwait	
Libya/GSPLAJ	
Macedonia (Republic)	

Group 2: Less affordable and lower environmental impact	
Albania	Morocco
Botswana	Namibia
Cameroon	Nepal
Congo (Democratic Rep.)	New Zealand
Côte d'Ivoire	Niger
Croatia	Paraguay
Denmark	Peru
Ethiopia	Portugal
Finland	Senegal
Gabon	Slovakia
Ghana	Sri Lanka
Iceland	Swaziland
Ireland	Tajikistan
Kenya	Tanzania
Latvia	Tunisia
Lebanon	Uruguay
Luxembourg	

Group 3: Balancing secure and affordable	
Argentina	Mexico
Austria	Nigeria
Brazil	Norway
Bulgaria	Philippines
Canada	Romania
Columbia	Russia
Czech Republic	Serbia
Egypt	Slovenia
France	Spain
Germany	Sweden
Hungary	Switzerland
Indonesia	Syria (Arab Republic)
Italy	Ukraine
Japan	United Kingdom
Kazakhstan	United States
Lithuania	

Source: *Policies for the future: 2011 Assessment of country energy and climate policy*, World Energy Council

regulation to guard against overconsumption of electricity, and better coordination of planned outages between the states and regional grids.

Some of the federal-state tensions in the power sector stem from reforms that began with the Indian economy's liberalisation in 1991. Policy incentives were designed to attract private investment, but the initial drive was only for investments in generation, not distribution. Moreover, it soon became apparent that the private sector was not building as much capacity as government planners had hoped for. This was mainly due to outdated procedures and unclear regulations. During the 8th and 9th Five-Year Plans (1992-2002), actual capacity built by the private sector was only 6.8% of the government's expected capacity.

The Electricity Act of 2003 broke up the vertically integrated state electricity boards—the state electricity regulators—into separate generation, transmission and distribution entities. Since then, the central government has tended to focus on generation and transmission while leaving distribution to the states. But low electricity

tariffs, with cross subsidies, have led to financially weak state utilities. This has had an adverse impact on the entire electricity value chain. Generators have struggled to recoup their investments.

This challenge is not unique to India. Many countries that keep energy prices artificially low for social and economic reasons often face similar reduced levels of investment. Given low expected rates of return, the private sector struggles to provide the massive funding required to build energy infrastructure. Coupled often with changing policy frameworks, low energy prices constrain deeper private investment in a country's energy sector, which ultimately can lead to limited development, causing a "Catch 22" situation.

The WEC recognises developing countries' unwillingness to risk the vast sums of money needed to build an energy infrastructure if the expected revenues are too low. Countries such as South Africa have had to deal with this issue. Incidentally, there is unwillingness to invest even in developed countries such as the US, where electricity tariffs are low. These prices are depressed by the so-called shale-gas revolution, which has led US power manufacturers to switch fuel sources from coal to cheaply priced gas.

This has forced US coal producers to look internationally for buyers. The supply of coal in the international market is important for India. The bulk of its power generation is made up of coal and hydro, accounting for 55% and 21%, respectively, of total installed capacity by mid-2011. The use of these fuels is no surprise—India has the fifth-largest coal deposits and among the largest hydropower potential in the world. India's Ministry of Power estimates that demand for coal will grow by 9% annually in 2012-17.[2] This will be driven by plans to bring an additional 62 GW of coal-fired capacity online, which will account for 83% of total new generation capacity by the end of the forecast period. The private sector will build 64% of this new coal-fired capacity—an important shift away from reliance on publicly funded coal power projects.

But the coal sector also suffers from policy constraints. Recent domestic coal shortages have resulted in increased imports, subjecting power generators to commodity price swings. Many of them cannot afford the market price of imported coal, as their business model depends on access to domestic coal on favourable terms. In May 2012, Coastal Andhra Power, a subsidiary of Reliance Power, which belongs to one of India's biggest conglomerates, ceased work on its 4 GW Ultra Mega Power Project, citing the high cost of Indonesian coal. Given current regulations, unless fuel price increases are reflected in electricity tariffs to the end-consumer, Indian power producers will face an uphill task in trying to recover their investments when using imported coal.

Recent developments, however, point towards an oversupply of coal in the international markets, and this may have an impact on prices. More US coal is available because of the shale-gas revolution, and the prices of Australian thermal coal are declining, thanks to softer demand from China, where industrial growth has been slowing. In addition, EU and US commitments to lower carbon emissions mean that coal will be slowly edged out of their energy generation mix.

This presents a tough choice for policy makers in India and other developing countries. They may be tempted to increase their coal consumption at the expense of the environmental dimension of the energy trilemma. Even countries in the Gulf region, with significant fossil-fuel deposits, are looking to diversify their energy mix, with plans to invest significantly in solar and nuclear technologies.

India too is among a group of emerging non-OECD countries, including China and Russia, which is looking to diversify its energy mix through nuclear technologies. India's planned and

[2] "Report of The Working Group on Power for 12th Plan (2012-17)", Ministry of Power, Government of India, January 2012

proposed nuclear reactors represent 11% of the total 159 reactors being considered in non-OECD countries.[3] Nuclear, of course, is just one element of a diversified and sustainable energy system. For example, in India's rural areas, there is an important role for bottom-up, off-grid solutions, such as the village-based solar electrification projects championed by Sanjit "Bunker" Roy, an Indian social activist and educator.

In the long term, a robust and sustainable energy policy is best achieved by providing a balance between the needs of energy security, equitable energy access and environmental impact mitigation. Countries with a diversified energy mix tend to produce more sustainable energy systems. But in a dynamic world with constant energy pressures, it can be difficult for governments to achieve this balance.

In order to do so, governments need to establish coherent, predictable and transparent energy policies that adopt a holistic view. Truly successful energy policies will need to complement and interact with the needs of transportation, industry, environment and agriculture. Such an approach in the long term will lead to a more sustainable energy supply that will deliver the growth to which India aspires.

[3] "Nuclear Energy One Year After Fukushima", World Energy Council, March 2012

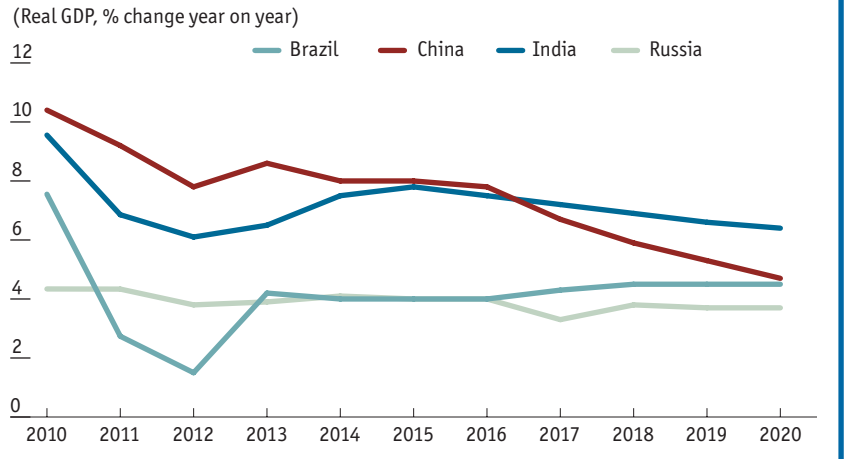
3 India and the other BRICs: Energy and the implications for economic growth

India has possibly the most uncertain energy future of any BRIC nation. Demand for energy in Brazil, Russia, India and China is expected to grow in tandem with rapid economic growth. While the first two are rich in energy resources and should cope quite well, India and China face a challenge, as domestic energy resources will fall far short of projected demand. China seems to be handling its energy deficiencies more determinedly than India, whose tentative energy policies suggest no immediate solutions. This is bad news for India's economy, which has already begun to slow. Promoting hard-nosed energy policies, however, could help to bring growth back on track.

Charles Ebinger, *Senior Fellow and Director, and* ***Govinda Avasarala,*** *Senior Research Assistant*
Energy Security Initiative, The Brookings Institution

Economic aspirations in Brasilia, Moscow, New Delhi and Beijing are inextricably linked to the strength of their national energy sectors.

Chart 1: Economic growth



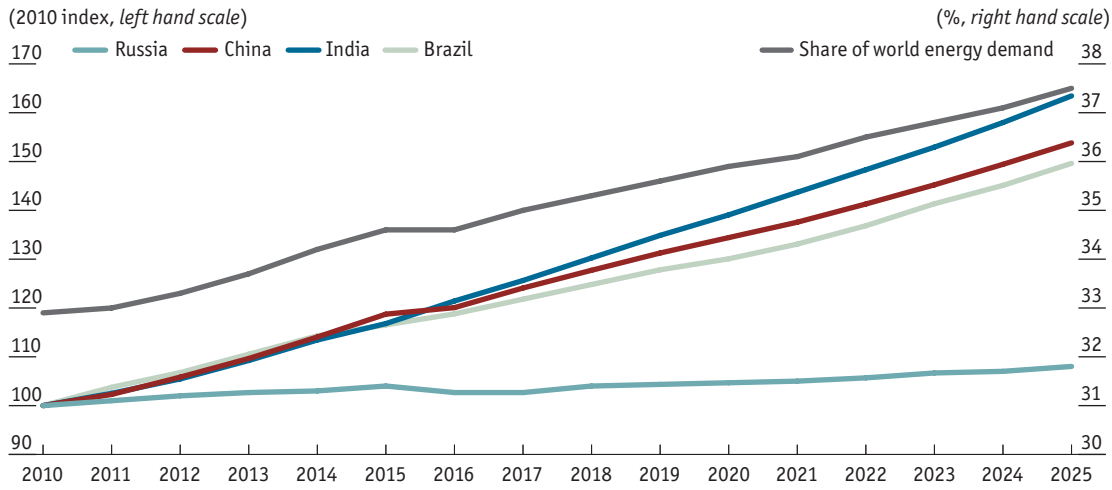
Source: Economist Intelligence Unit

According to EIU forecasts, the economies of Brazil and Russia will grow at an average annual rate of just over 4% until 2017, while those of China and India will grow at just under 9% and 8%, respectively (see Chart 1). The energy implications of this growth are stark—energy demand in the four BRIC nations will rise sharply. According to data from the US government's Energy Information Administration (EIA), by 2025 the BRICs, led by China, will account for nearly 38% of global primary energy demand, up from 27% in 2005.[1]

The critical question is: will the BRIC club in the pursuit of economic growth be able to meet its increasing energy demand? Some of its members will manage better than the others. Just as economic policies and circumstances differ among the BRICs, so do their energy sectors. Owing to their advantageous resource endowments and the

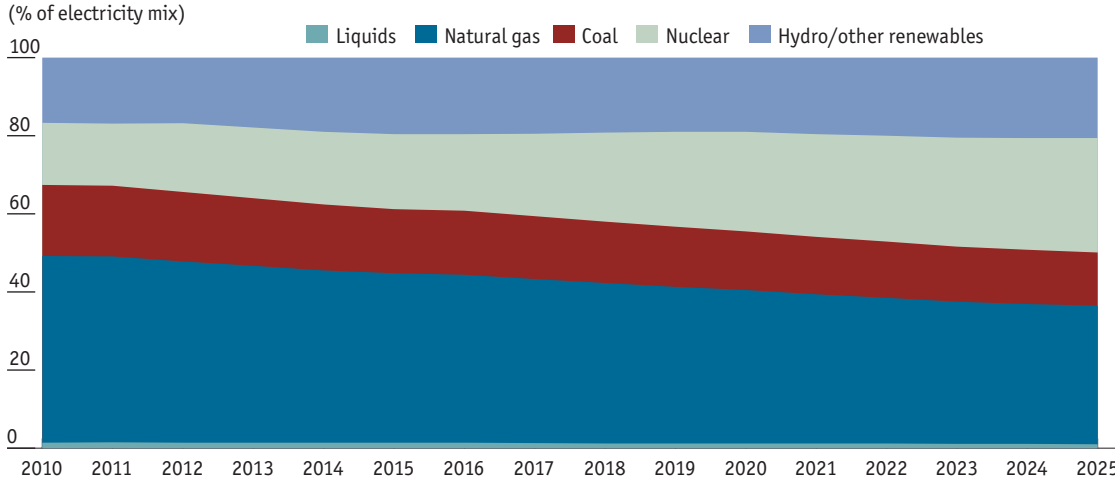
[1] Energy Information Administration, *International Energy Outlook 2011*

Chart 2: Energy demand in the BRICS



Source: Based on EIA data

Chart 3: Russia's electricity mix: 2010-2025

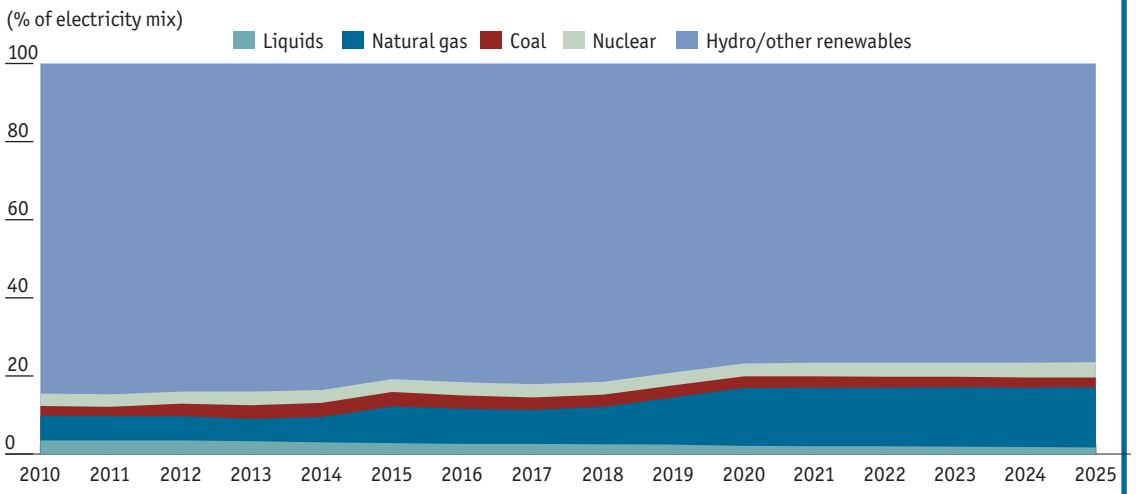


Source: Based on EIA data

nature of their energy consumption, Brazil and Russia are relatively energy-secure nations. China and India are not; the two countries are driving global energy demand with domestic resource bases that, for the most part, are insufficient to meet domestic demand. Superior infrastructure and a centralised government position China better for its rising energy demand, but India is perched precariously over a similar swell in demand at home. Indeed, India has the most unstable energy condition in the BRIC club, and possibly the most uncertain energy future of all.

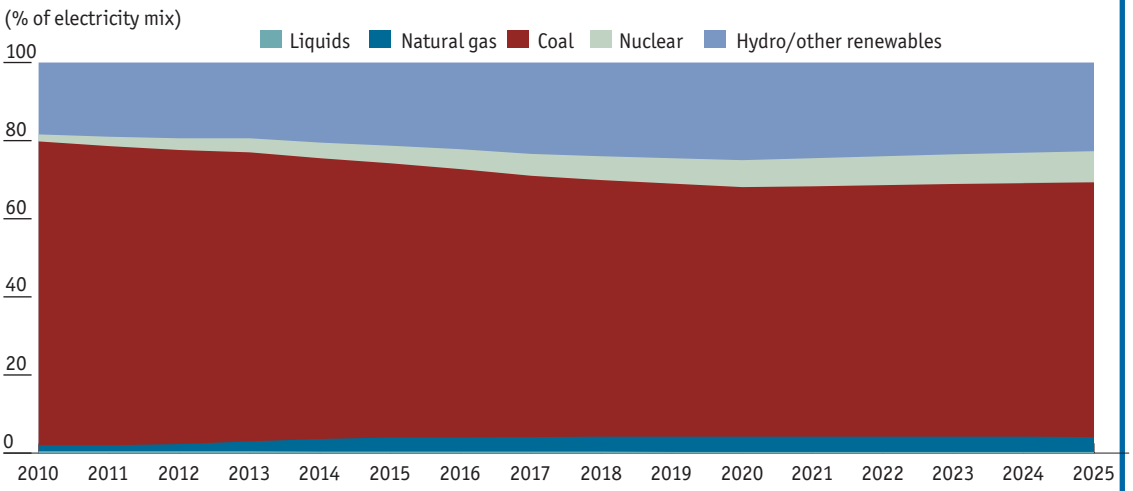
Given that India's energy demand is forecast to outpace China's after 2016 (see Chart 2), India needs to address its inadequate energy policies quickly in order to secure resources to satisfy its energy demand and, importantly, to sustain economic growth. It does not have the luxury of the kind of secure energy resources that Brazil and Russia rely upon. Both those countries are significant oil producers and are either major (Russia) or growing (Brazil) oil exporters. They are equally secure in other facets of their energy mix, as their electricity portfolios so clearly illustrate.

Chart 4: Brazil's electricity mix: 2010-2025



Source: Based on EIA data

Chart 5: China's electricity mix: 2010-2025



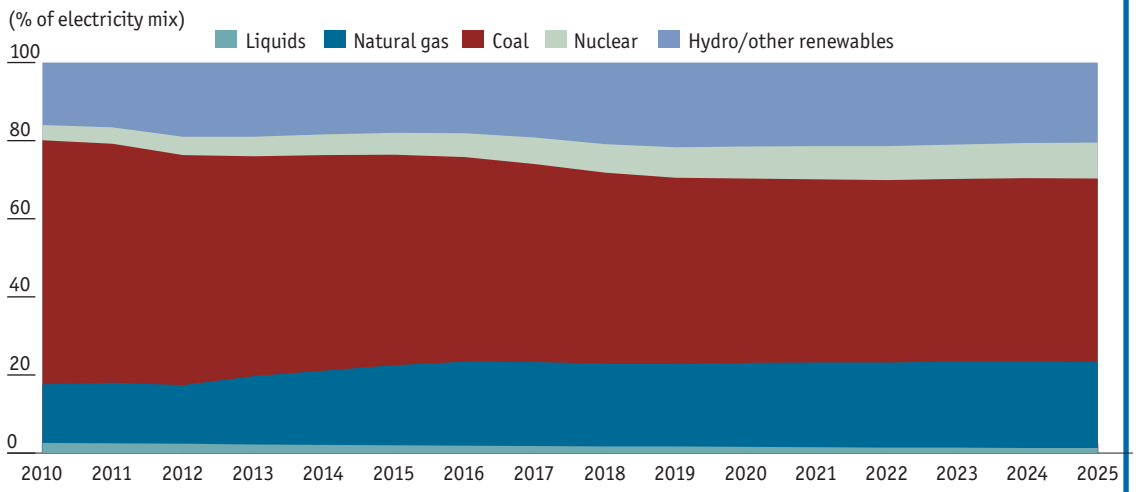
Source: Based on EIA data

Energy resources and electricity portfolios

Russia's electricity sector (see Chart 3) is heavily dependent on coal and natural gas—which it produces in abundance—but is also ramping up its reliance on nuclear energy. Russia is the world's fifth-largest producer of coal, which accounts for 20% of its electricity generation; it is also the world's largest producer and exporter of natural gas, which accounts for nearly half of its electricity mix. For its part, Brazil is almost entirely dependent on hydropower for electricity generation, and while a projected increase in demand for natural gas is likely to be met through imports, Brazil's hydroelectric capacity and potential limit its exposure to import disruptions (Chart 4).

In China and India, the biggest fuel source in the electricity mix is coal, a resource that both have in abundance. Coal is, and will continue to be, China's primary source of electricity in the near and medium-term (Chart 5).This is the case for India as well, with coal fuelling about two-thirds

Chart 6: India's electricity mix: 2010-2025



Source: Based on EIA data

of electricity supply (Chart 6). But domestic production of coal in India has grown at an annual average of just 2.6% between 2001 and 2011, compared with an annual average growth of 8% in electricity demand during the same period. Moreover, although India has abundant coal reserves, extraction has been partly hampered by disputes over land acquisition—a problem that does not occur to the same degree in China. A shortfall in domestic coal output has forced India to rely on expensive imports of coal, exacerbating its electricity-supply woes.

Comparisons with China make India's energy sector appear particularly troubled. India, unlike China, has vast swathes of populated land with no access to electricity. According to the International Energy Agency (IEA), 289m people in India lack even rudimentary access to electricity and 836m depend on biomass and other traditional energy sources for cooking.[2] By comparison, only 8m people in China lack access to electricity (in Brazil the number is just over 3m).[3] Indeed, India's electricity sector is woefully inept. Losses in transmission and distribution are roughly 25% of generation, compared with just 5% in China.[4] Rampant electricity theft and poor bill collection exacerbate the inefficiencies. Upgrading India's grids, however, will require an estimated US$632bn between now and 2035, according to the IEA, but the investment will not happen until India raises electricity prices to reflect the actual cost of generation.[5]

The obstacles to India's energy security come into sharper focus when viewed through the lens of the massive power outage that struck the country's north in July 2012. The grid failure underscored the treacherous dependence of India's economy on its fragile energy and electricity sector. It also highlighted the urgency for India to tackle a huge energy deficit by implementing policies to encourage energy conservation and demand-side management, and stimulate investment in energy production and infrastructure.

Inefficient consumption and inept conservation of energy lay at the root of the July blackout, which apparently was triggered by an unexpected surge in electricity demand from the agricultural sector. It is likely that a poor monsoon prompted many farmers to take advantage of subsidised electricity supplies to pump water for irrigating their fields, thereby spiking demand and forcing state distribution companies to overdraw electricity from the grid. This, coupled with a newly integrated but inefficient grid, caused the power outage. While they may not have single-

[2] "World energy outlook", International Energy Agency, November 2011

[3] There is no data point for Russia.

[4] According to the World Bank's database (http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS)

[5] "World energy outlook", International Energy Agency, November 2011

handedly deterred the crisis, rational energy and electricity prices would certainly have limited its scale by promoting conservation and more efficient consumption. (China, for its part, has slowly been reforming its electricity prices; Russia offers free electricity because it has the resources to do so, while Brazil has the opposite problem—its electricity prices are too high.)

The supply side of electricity generation also failed the Indian grids in July. Domestic production of the fossil fuels that power India's economy has been stagnant, hobbled by government-regulated pricing, byzantine regulatory frameworks and numerous logistical obstacles. This is particularly true for coal, domestic production of which over the past ten years has not kept pace with surging electricity demand. As mentioned earlier, India has abundant reserves, but land-acquisition disputes, a complicated regulatory environment, state-controlled Coal India's monopoly on coal mining, and transportation bottlenecks all conspire to prevent sufficient domestic coal from reaching major demand centres. As a result, India has had to rely on more expensive imported coal. But because electricity is largely sold at low, subsidised rates (because of political compulsions), electricity generators cannot pass on the higher cost of imported coal to consumers. The ultimate result: a crippling shortage of both coal and electricity.[6] Both imports and subsidised prices add a burden to the economy.

Reliance on other energy resources

Turning to energy resources other than coal is problematic for India. Like China, it has huge domestic demand and insufficient supply, and is much more dependent than Brazil and Russia on imported fuels for energy. As far as oil is concerned, both China and India are in the same (shaky) boat. Both are experiencing a surge in demand for oil, even as domestic production is stagnating. Both are seeking to obtain foreign oil assets, in an effort to procure supplies—with varying degrees of success.

Despite this similarity, China's outlook for energy security is much brighter than India's. China's relatively small projected growth in natural gas demand will be largely met by imports, but its supplies are relatively secure; it is forecast to have a surplus of available gas until 2020. This security is the result of long-term contracts for liquefied natural gas (LNG) with countries like Australia and Qatar. There is also the advantage of feeding from an existing natural-gas pipeline from Turkmenistan to China, and an expected pipeline from Myanmar to China. Beyond 2020, China's supply of natural gas will depend on its success in developing potentially huge shale-gas resources.

In India, while officials are optimistic about the potential for large domestic shale reserves, the hurdles of infrastructure and regulatory policies suggest that developing these resources is not a near-term possibility. This is problematic, because domestic conventional natural gas resources, namely the offshore D-6 block in the Krishna-Godavari basin, have not been as lucrative as once predicted. And if industry shifts from coal to gas in the power sector, demand for gas will grow, enhancing the need for imports. But imports will provide little respite for India's gas sector because the state utilities are unable to pass on the higher costs to consumers.

Choosing nuclear energy as a promising future source, as Russia seems to be doing, is fraught with its own challenges. Disputes over land rights and the Indian government's disagreements with foreign nuclear-reactor vendors over liability have constrained the development of new nuclear facilities. Public concern in India about the safety of nuclear power plants is growing (more than it is in other BRIC nations), particularly after the Fukushima crisis in Japan. Renewable energy, for its part, while seeing impressive growth rates, is still expensive and dependent on government support. In any case, it cannot be scaled up to meet India's burgeoning energy demand.

[6] Part of this section has been adapted from "Emerging Power Failure", *Foreign Policy*, August 1st, 2012, by Charles Ebinger and Govinda Avasarala.

A threat to economic growth

Bringing the cycle of economic growth and energy demand full circle, India's energy-policy deficiency has resulted in two new threats to economic growth. First, it has burdened the banking sector with a portfolio of non-performing loans to power plants. The state electricity boards too are swollen with debt, and the government has made clear that it will intervene and either underwrite outstanding debts or request the banks to reduce the debt obligations of the boards. Second, India's growing dependence on oil is a drag on the economy. As prices for most petroleum products in India are subsidised, the government and upstream national oil producers compensate for marketing losses out of their own budgets. Pricing reform will not dramatically change India's import dependence on oil; even increased production will not make India self-sufficient. But market-determined prices will get rid of the unsustainable subsidies on the balance sheets of both the government and the oil companies. This will certainly help to curb India's growing budget deficit and in turn help economic growth.

Will such initiatives be too little, too late for India? Will its slowing growth and meandering energy and economic policies result in India becoming the first "fallen angel" among the BRIC nations, as Standard & Poor's, a rating agency, warned in a June 2012 report?[7] Perhaps not. The country has ample opportunities to readjust its economic compass and plot the best course to energy security. Unlike China, where the government can make unpalatable energy decisions relatively quickly, or Russia and Brazil, where they do not need to because of the abundance of energy resources, India has a government that finds it difficult to push through painful energy reforms. But if India is to continue as a vibrant emerging market, it will have to tackle its energy-security weaknesses immediately. If it cannot, BRIC may lose an 'I'.

[7] "Will India be the first BRIC Fallen Angel?" Standard & Poor's, June 2012

4 India's energy strategy: Historical and future perspectives

Electricity supply and demand lie at the heart of India's energy future and its aspirations to maintain an annual GDP growth rate of 8% in the medium term. However, the power sector is hobbled by inefficiencies and bad pricing policies that have left the state utilities virtually bankrupt. This has particular ramifications for coal, the electricity sector's main fuel and a major element in India's energy mix. A growing reliance on imports of coal, as well as oil and gas, will exacerbate energy worries in the coming decade. Renewable energy provides only a little relief, but nuclear could be the energy of the future.

M Govinda Rao*
Director, National Institute of Public Finance and Policy

Economist Intelligence Unit: What have been the key changes in India's energy strategy following the economic reforms that began in the 1990s, given the relationship between GDP growth and energy capacity?

M Govinda Rao: Energy sources in India comprise coal (42% by consumption), oil (24%), natural gas (7%), combustible renewables and waste (22%), other renewables (2%), and nuclear (1%). In India, energy from hydrocarbon and coal constitutes two-thirds of energy consumption, and from renewables and waste one-fourth. Almost 70% of the petroleum products consumed in the country are imported. An overwhelming proportion of hydrocarbon fuel is consumed for transportation, though a small proportion is used for generating electricity for captive consumption. While the problems of energy used for transportation are mainly on account of domestic exploration, imports and pricing, the issues relating to electricity have far-reaching ramifications for industrial progress. Therefore, my focus here is on electricity supply.

In the early years following independence in 1947, much of the investment in energy, particularly in electricity, was by the state electricity boards (SEBs). However, with growing industrialisation, demand for power increased significantly and the SEBs were unable to make the required investments to meet growing demand. The central government started to make substantial investments in generation and the National Thermal Power Corporation (NTPC), founded in 1975, was entrusted with the task of substantially augmenting generation capacity. With the entry of the central government in

* This interview was conducted by email in August-September 2012.

generation in a big way, additional investment in generation by the states stagnated.

The liberalisation of the economy in the 1990s saw substantial additional investment in the manufacturing and services sectors, accompanied by a sharp increase in demand for electricity. Even the public sector was unable to meet the increasing investment requirements, and the central government went about liberalising the sector. The Electricity Act of 2003 provided the framework for private-sector participation. The reforms that followed resulted in unbundling the generation, transmission and distribution sectors. It also mandated the appointment of independent regulators for electricity. In subsequent years, while private-sector participation in generation has increased, its presence in transmission has been negligible, and the distribution sector continues to be predominantly in the hands of state governments.

In the initial years, the government focused on generation of electricity from hydroelectric sources. However, the problem of rehabilitation of those displaced by hydroelectric projects, and the opposition from environmental groups on the one hand and the abundance of coal deposits on the other, resulted in the expansion of coal-based thermal generation.

The exploitation of renewable sources of energy remains commercially unviable. The development of energy from nuclear sources has been beset with the problems arising from the international sanctions after India's detonation of a nuclear device in 1998. At present, the opposition from anti-nuclear groups and the non-availability of processed uranium are major deterrents. Thus, the overwhelming proportion of energy continues to be generated from coal-fired thermal plants.

The opening up of generation and the introduction of open competition has led to private players aggressively bidding for projects (often at unviable prices). This has led to substantial investment by the private sector in the past few years, often by borrowing huge amounts from the financial system. However, land acquisition and environmental clearances for the projects have posed serious difficulties on the supply side. Regarding coal, there has been a sharp increase in its international price, port capacity is inadequate for its import, and transporting it to the power plants has posed serious difficulties for independent power producers.

On the demand side, due to their poor state of finances, the state power utilities have preferred to force several hours of outages rather than buy power at spot prices in the open market. The governments—both at the centre and in the states—do not have the financial resources to invest in the energy sector themselves, nor have they developed a satisfactory framework for the participation of the private sector. Not surprisingly, underinvestment in the electricity sector is significant.

EIU: Industrial demand for energy is expected to shoot up, given that the government wants manufacturing to account for 25% of GDP in coming years, compared with 14% currently. How do you envisage India's energy demand growing in the coming decade?

MGR: The significant augmentation of electricity-generation capacity is an important prerequisite to increase manufacturing's share of India's GDP, and to increase its competitiveness. India's economic growth trajectory has not followed the conventional pattern of the secondary sector replacing the primary sector, and finally leading to the predominance of the services sector. There are a number of reasons for this, but an important one is the inadequate and unstable supply of power. To ensure a stable electricity supply, most industries have had to rely on captive generation of power, often using diesel as a fuel, which is expensive.

The National Integrated Energy Policy of 2005 estimates India's energy elasticity with respect to GDP at 0.8.[1] However, most other estimates are higher. Even if the low estimate of 0.8 is taken, energy supply will have to increase at a rate of about 6.4% every year if the annual average target of 8% GDP growth is to be achieved in the medium-term.

In June 2012 India had a generation capacity of 205.34 GW, with an additional 31.5 GW through captive power generation. If India grows at an annual average of 8%, generation capacity will have to increase to an estimated 778 GW by 2032, based on the current structure of the economy. The International Energy Agency estimates that India will add between 600 GW and 1,200 GW of new power-generation capacity before 2050. Ensuring an environment that enables faster growth of the manufacturing sector would require a faster increase in the supply of electricity.

EIU: What are the prospects for the renewable energy sector in addressing the current shortfall in electricity supply?

MGR: In recent years, there has been considerable focus on enhancing the share of renewable energy [in India's energy mix] and reducing the consumption of fossil fuels. Due to concerted efforts [by private players and the government], and incentives such as government subsidies, renewable energy has grown at an average annual rate of 23% during this decade. In March 2012, renewable energy generation was 25,000 MW and this constituted 12.5% of installed capacity. Almost 70% of the renewable energy generated was from wind. The government plans to build an additional 30,000 MW of renewable-energy capacity during the next five years. About half of this will be from wind, 33% from solar power, 7% from small hydro and 9% from biomass.

While the focus on renewable energy is important to minimise the adverse environmental consequences of power generation using fossil fuels, at current levels of cost per unit, even after subsidies, it is uneconomical. Much more research and development is necessary in order to make it viable.

EIU: What do you see as the strategic rationale for solar and nuclear energy, and for natural gas?

MGR: The strategic rationale for solar energy is clear. In a country where sunshine is plentiful for a major part of the year, harnessing this renewable and environmentally friendly energy source is important. However, the large spaces required to erect solar panels and, more importantly, solar power's economic viability have hindered progress in harnessing this source.

Nuclear power is the energy of the future. This is the most economical source in the long run. However, initial capital costs are high, the supply of uranium is uncertain and there will be considerable dependence on nuclear powers for both fuel and technology. More importantly, the Fukushima nuclear disaster in March 2011 has demonstrated the vulnerability [of nuclear reactors] and the serious consequences to human life and welfare [of their failure]. It is important to demonstrate the safety and security of nuclear energy in order to make it acceptable. This is because the required increase in generation capacity to attain 8-9% economic growth, without environmental damage, can be achieved only when the government makes substantial investments in nuclear power.

The strategy for the natural gas sector is to explore unexplored areas. Even so, it is doubtful whether the government can depend on domestic supply of gas for its energy needs. A more important strategy consists of laying pipelines in India's east and west to import gas from Myanmar and Iran, respectively. The former would require laying a pipeline across Bangladesh and the latter a pipeline from Iran that would have to pass through Pakistan. These options are not going to be easy and therefore cannot be considered viable solutions in the medium-term.

[1] Energy elasticity is an energy indicator of the ratio between growth in energy consumption and economic growth. A smaller elasticity number for a country suggests it is using its energy more efficiently. The energy elasticity of developed countries ranges from 0.1 to 0.6.

EIU: How critical is pricing in finding solutions to the current energy shortfall?

MGR: Pricing of energy according to its value is important to ensure efficiency, be it petroleum, natural gas or electricity. Controlled pricing of both energy inputs and outputs is a major problem in India's energy supply chain. It is important to auction coal blocks rather than allocate them administratively, for example, and to free the price of coal to market forces.

Let us look again at electricity. Attempts to keep the price low will invariably require keeping the price of inputs low, eventually resulting in an inadequate supply. Most state utilities have not revised electricity tariffs, which already are artificially low, for several years because this economic decision has been politicised. The patronage system of appointments to the electricity regulatory commissions makes them compliant to political decisions. So, the tariff order in Tamil Nadu state was issued in 2011 after an eight-year gap. Similarly, the state of Rajasthan hasn't seen a revision in electricity tariffs since 2005, and the states of Haryana, Tripura and Nagaland since 2006. The situation is not much better in other states.

A severe fall-out from this poor pricing policy is the huge losses suffered by the electricity utilities. Most of them do not audit their accounts regularly, and in any event some of these audits may be suspect. The (political) decision to supply free and unmetered power supply to farmers is a major thorn in the side of the state utilities, which have no chance of recovering their costs.

But the state governments are loath to meet the losses through budget allocations, so the utilities have had to borrow from the banks (albeit with state-government guarantees). The aggregate fiscal deficit in 2009–10 for the states was budgeted at about 2.3% of GDP, but off-budget liabilities, because of the power sector, can be as high as 1.5%.

Saddled with hefty losses and unsympathetic governments, the state utilities have barely invested in generation, transmission and distribution. Unwilling to buy power at market prices, they prolong load shedding (intentional power outages). The consequent declines in demand affect the "plant load factor" and power generators slow down generation. In one situation, NTPC, the largest generator of electricity, was forced to lower its output because the state electricity utilities preferred to prolong load shedding rather than pay market prices for electricity.

Unless concerted action is taken on pricing, the problem of scarcity—even when there is capacity—will continue. Companies like NTPC cannot generate and sell power if the state utilities prefer blackouts to supplying electricity to consumers.

EIU: What do you consider to be India's energy future towards 2020?

MGR: An annual economic growth rate of 8% cannot be achieved without cleaning up the policy maze in the power sector. The kind of bailout offered to electricity entities under the Accelerated Power Development and Reforms Programme[2] can only inject oxygen for a short time, but will not solve the structural problems. Instead, India will need to confront its enormous energy deficit by moving away from an administered price regime and allowing the market to determine the prices of inputs (coal and gas) as well as electricity. As far as the state electricity boards are concerned, it is necessary to subject them to [strict] budget constraints, and enable them to adopt commercial decisions without interference from the government.

Unfortunately, even though the Electricity Act of 2003 intended the regulators to be independent, most of them, being retired bureaucrats, have only carried out orders from their political masters. To the extent that the bailout is linked to reduction in transmission and distribution losses, and the revision of tariffs to equating average cost with

[2] The Accelerated Power Development and Reforms Programme (APDRP) is an Indian government initiative to improve the financial viability of the state power utilities and reduce distribution losses, among other objectives. It aims to do this by providing investment and incentive financing to the utilities. Launched in fiscal 2001 (ended March 31st 2002) as the Accelerated Power Development Program, APDRP was renamed in the following fiscal year.

average revenue, and to the extent that the states are prepared to implement the reforms effectively, things might improve. However, past experience does not provide much hope.

Overcoming the energy deficit and ensuring adequate growth for the sector in the future requires a comprehensive set of reforms. These include: stable supply of fuel for generation, efficient transmission and distribution, and rational pricing of electricity. Attempts to control the price of electricity have led to controlling the price of inputs. Poor pricing policy on the one hand, and a perpetuation of monopoly on the other, has constrained the supply of coal. Attempts to allocate coal blocks to power generators have only led to cronyism. Ensuring a stable supply of power for industrial growth requires a comprehensive overhaul of the policies in the sector. Unless the government undertakes a complete overhaul, the much-needed investments in generation, transmission and distribution will not be forthcoming.

In the medium-term, India's energy security remains reliant on imports of oil, gas and coal, which is a strain on the government budget. Coal will continue to be the dominant fossil fuel in India's energy mix, and oil a major component. There is a growing demand for both fuels, but supplies of oil are limited and India has to buy an increasing volume from overseas, exposing itself to vulnerability in its oil security. Gas has grown in significance, but sufficient discoveries have not been made to ease India's energy concerns. As far as renewable energy and nuclear energy are concerned, they will continue to contribute just a tiny amount to energy security in the coming decade. However, despite concerns about safety, nuclear is the energy of the future.

5 Industrial demand and energy supply management: A delicate balance

Indian industry, particularly manufacturing, faces a huge challenge to procure enough energy to fuel future expansion. It faces three scenarios: ignore the problem, with the risk that limited energy supplies will cap growth and investment. Or internalise it, by securing captive energy sources—which might skew governance and retard the adoption of cleaner fuels. Or innovate in policy and practice across the energy supply chain and manage demand. Only one of these scenarios can ensure a sustainable energy future.

Arunabha Ghosh
Chief Executive Officer, Council on Energy, Environment and Water

The average Indian uses less energy than the average Chinese or Brazilian. And certainly much less than the average American or consumer in other developed nations. Consider this: in 2009 the average Indian used 560 kg of oil equivalent (kgoe) of energy. This was half the usage of the average Brazilian (1,243 kgoe), one-third of the average Chinese (1,695 kgoe), and one-twelfth of the average American (7,051 kgoe). Similarly, the average Indian in 2009 consumed just 571 kWh of electricity, compared with 2,631 kWh used by the average Chinese and 12,914 kWh by the average American.

Why does low energy use per person matter for India's industrial development? For a start, energy access is closely associated with human development progress. India's large, youthful population cannot become the foundation of the country's economic growth—fuelling income generation and demand for industrial products—if its schooling and studying are hampered by unreliable (or absent) power supplies, or its health endangered by exposure to polluting traditional fuels at home. Moreover, low levels of energy use usually reflect low levels of energy supply—which means that in India's energy-constrained economy, industry is competing for limited resources with several segments of society, not least an aspirational middle class.

Indeed, final energy consumption is dominated in India by the residential and industrial sectors, with the former taking a slightly larger share of the total energy pie (34% versus 33% for industry).[1] Industry uses a third of all electricity to run machinery, among other purposes. Since electricity generation is heavily dependent on coal, using 222.1m tonnes of oil equivalent (mtoe), it follows that industry is a significant user of

[1] Final energy consumption is defined as the total energy consumed by end-users such as households, industry and agriculture, excluding energy used by the energy sector itself.

coal (although this consumption goes beyond electricity generation). Industry consumes more than 90% of coal used in final energy consumption, a third of natural gas and a fifth of oil products. Coal makes up nearly half of industry's final energy consumption total of 163.3 mtoe (see Chart 1) and oil products account for 19%, while natural gas accounts for just 4%.

Under pressure: industry jostles for energy

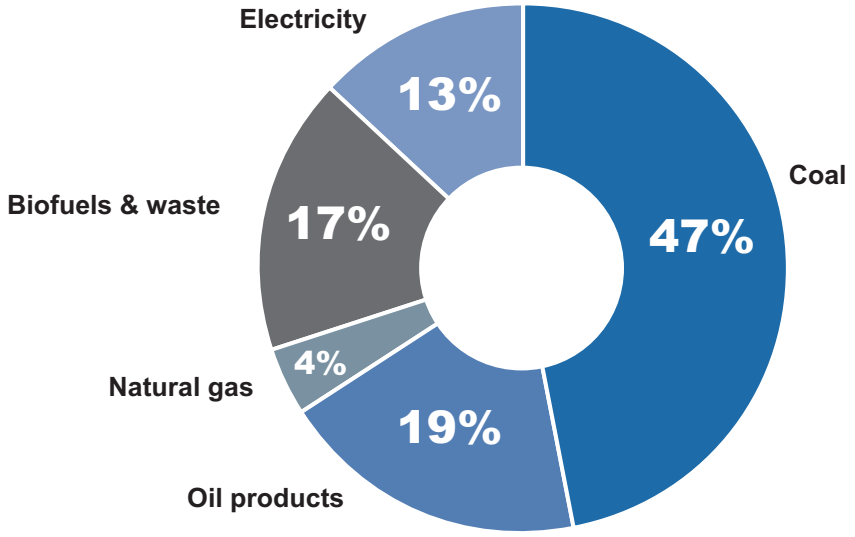
With demand expected to spike over the next few decades, competition for energy supplies is set to intensify. According to the International Energy Agency (IEA), energy demand in India from 2009 to 2035 will show the highest growth rate in the world. A dominant user of almost all energy sources, the industrial sector will feel the most pressure, although so too will the other two sectors, agriculture and services. Indeed, the services sector, which includes hotels, transport, communication, finance, real estate and business-related facilities, has a huge appetite for energy that is likely to grow. (Transportation is expected to show the sharpest rise in energy demand until 2020.) In agriculture, greater mechanisation and use of irrigation pumps on India's farms will mean greater demand for energy.

Government planning is expected to sharpen demand in the energy-hungry industrial sector. Manufacturing, which accounts for a little over half of industrial output, has been slated for a big push. The National Manufacturing Policy sets the lofty ambition of increasing manufacturing's share of national income from about 15% currently to 25% by 2025, creating 100m jobs along the way. But the policy does not spell out the energy resources needed to realise this vision. Although energy intensity has eased in manufacturing, falling by about 55% during 1992-2007, some studies indicate that this has been largely due to substituting alternative fuels for coal and changes in relative shares of different industries compared to actual increases in energy efficiency.[2]

Industrial sub-sectors that clamour for energy include iron and steel, which accounts for 16%

Chart 1: Final energy consumption by industry

(%, fiscal 2010, ended March 31st 2011)



Source: *Energy Statistics 2012*, Central Statistics Office, Government of India

[2] Because manufacturing straddles several industrial sub-sectors, it is difficult to determine from available data what proportion of final energy consumption by industry it accounts for.

of final energy consumption, and transport equipment, which accounts for about 7% (see Chart 2). But a large chunk (65%) of final energy consumption is classified as "non-specified". (This means it has not been attributed to sub-sectors despite being categorised under industry—a challenge for energy data collection and analysis.)

The main energy sources for industry vary by sub-sector. To the extent that final energy use is measured across different sub-sectors, coal provides 88% of energy use for iron and steel production, and 100% of energy use in non-metallic minerals, pulp and paper, and construction. By contrast, oil products are dominant in the chemicals and petrochemicals sub-sector, providing 94% of its energy requirement. Transport equipment, machinery, and mining and quarrying also rely entirely on oil products. There are other energy sources available for industry (see Chart 3) but government statistics do not break down their shares across the various sub-sectors. Clearly, there is a need to improve energy data collection and analysis, in order to understand and prepare for changing patterns of energy demand and usage in industry.

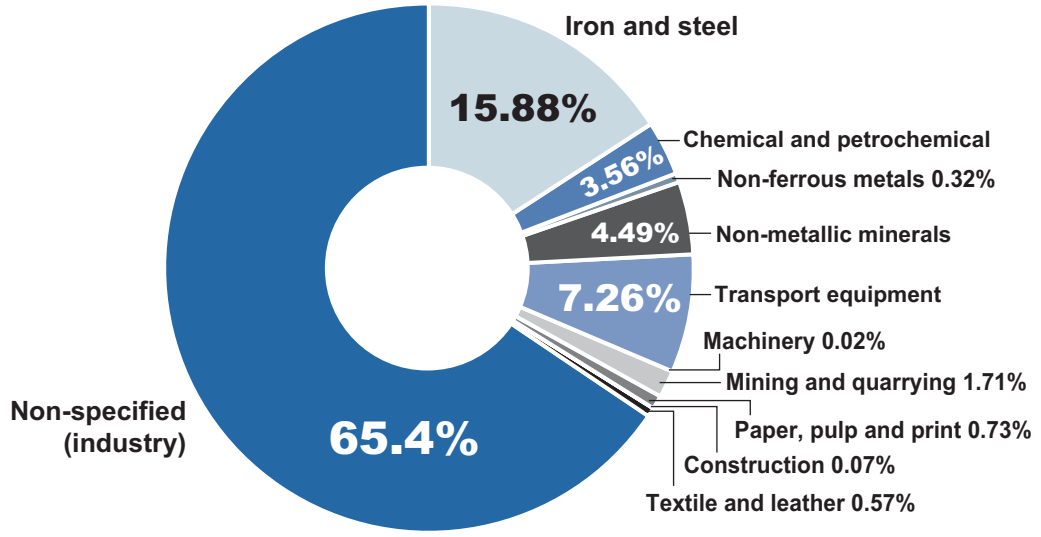
Higher economic growth = higher industrial growth = higher energy demand

To add to industry's energy pressures, the government aims to rev up economic growth overall. But if the Indian economy grows by an average of 9% a year until 2030, the International Energy Agency estimates that industrial energy demand will swell by three times, to more than 520 mtoe. The greatest increases in energy demand are expected in the energy-intensive sub-sectors: pulp and paper (which will see a seven-fold increase), aluminium, and iron and steel (which will both see more than five-fold increases). For all three sub-sectors the main energy source is coal, for which they will have to compete with electricity generators.

Further energy anxiety will come from a burst of developmental activity from states like Bihar, Chhattisgarh, Jharkhand and Odisha. After decades of being dismissed as the country's

Chart 2: Shares of industrial sub-sectors in final energy consumption

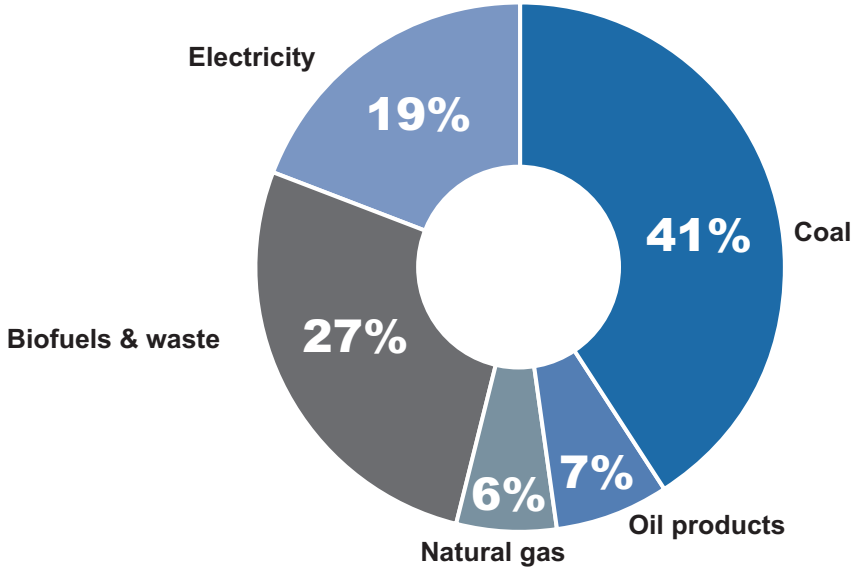
(%, fiscal 2010, ended March 31st 2011)



Source: *Energy Statistics 2012*, Central Statistics Office, Government of India

Chart 3: Shares of energy sources used by "non-specified" industry

(%, fiscal 2010, ended March 31st 2011)



Source: *Energy Statistics 2012*, Central Statistics Office, Government of India

basket cases, these states have begun in recent years to post some of the fastest economic growth rates in India. This is good news for the states, and for the country as a whole, but it means a sharp rise in energy demand in these states in all sectors.

Indeed, rapid growth in industry during the past decade has already led to soaring electricity consumption in that sector (see Chart 4, overleaf). Industry is not alone, however. Electricity consumption by the domestic sector outstripped that of agriculture for the first time during the same period.[3] But as agriculture grows from its current near-stagnant annual growth rate of less than 2%, its electricity consumption will also increase. Then either demand-side energy efficiency must be ramped up across all sectors or supply must increase.

Bottlenecks in supply

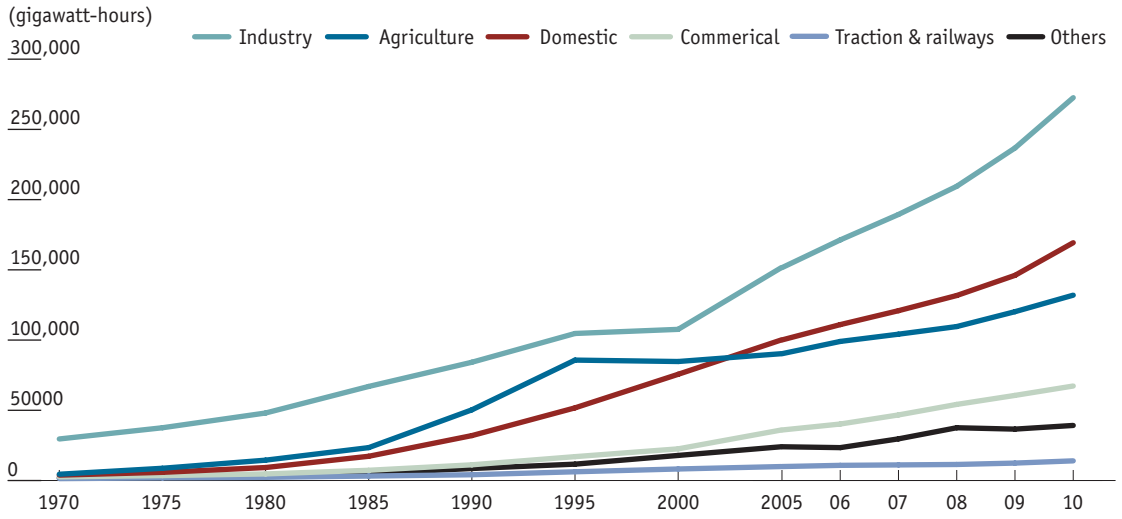
Therein lies the rub. India's primary energy supply was 659.7 mtoe in fiscal 2010 (ended March 31st 2011). When the Planning Commission of India drew up the Integrated Energy Policy in 2006, it estimated that an average annual GDP growth rate of 9%, combined with improving energy efficiency, would imply a primary energy demand in 2032 of 2,043 mtoe, a threefold increase over current supply. Future energy supply is unlikely to meet that demand.

First, domestic production of critical primary energy products has slowed in recent years (see Chart 5, overleaf). Crude oil production has remained flat for the past decade, and natural gas output has fallen short of growth expectations by increasing barely 1% annually since 2005. Even coal, of which there are abundant reserves, suffers from low growth rates primarily because of difficulties in extraction in forested areas. As a result, India's net imports of key energy sources are climbing—crude oil imports have jumped by 10.5% annually since 2005, coal imports by 12% annually.

Secondly, the infrastructure to handle the rising energy demand and subsequent imports is inadequate. While coal imports are expected to rise sharply to 343m tonnes in 2016 (a 432% increase over 2010), only four major ports handle coal imports (for a capacity of 63m tonnes), so minor ports pick up the slack. The major coal

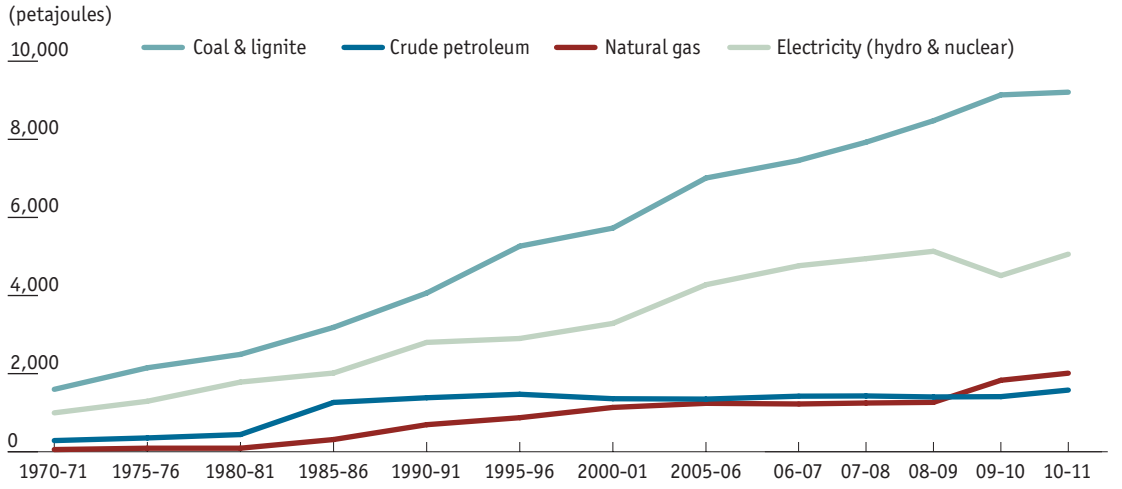
[3] The share of domestic intake might in fact be higher because unaccounted-for losses are often attributed to agriculture rather than to inefficiencies elsewhere in transmission and distribution.

Chart 4: Electricity consumption



Sources: *Energy Statistics 2012*, Central Statistics Office, Government of India; Central Electricity Authority

Chart 5: Production of primary sources of energy in India



Note: Thermal electricity is not treated as a primary source of energy

* 1 petajoule = 277.7 gigawatt-hours

Sources: *Energy Statistics 2012*, Central Statistics Office, Government of India; Ministry of Coal; Ministry of Petroleum & Natural Gas; Central Electricity Authority

ports are located along the eastern coast, which made sense historically because most power plants were located in the east (closer to the coal fields). But now some of the ultra-mega power plants are being constructed in the western states, where an industrial corridor between Delhi and Mumbai is also being planned. Either new railway freight lines will have to be built or more port facilities will have to be opened along the western coast, or both.

Likewise, the largest terminals for importing oil and liquefied natural gas (LNG) are along the west coast (closer to West Asian sources). But new sources of oil and gas from South-east Asia and further afield will require infrastructure development in the east as well. Finally, investments in grid infrastructure have long lagged a supply- side focus on electricity generation, not only in terms of transmission and distribution networks, but also of the staffing, training,

modelling and scenario planning crucial to the management and efficiency of a national grid.

Energy management for industry: ignore, internalise or innovate?

Given the yawning gap between energy demand and supply, it appears that industry, particularly manufacturing, is walking an energy tightrope if plans for rapid expansion go ahead. What are the prospects for balancing industrial energy demand with energy supply?

Under one scenario, the problems are simply ignored; there is no strategic approach to address energy demand or the need for energy efficiency within industry, nor is there a process to secure access to resources at home or abroad. In such a scenario, the best case would be for industry to grow to the extent of available energy. Power plants might have to write down usable capacity based on fuel availability, and iron and steel or other heavy industries might limit their production. A worse outcome would be a reversal of investment trends as Indian and foreign firms hold back on investing capital in new industrial capacity. Manufacturing and job creation, as envisaged, would stumble, and the share of industry (and manufacturing) in the economy could stagnate or even decline.

A second scenario envisages industry internalising, and taking the lead in securing access to captive energy. These could be via allocated coal blocks or captive generation of electricity. Industry also might seek private and exclusive access to other energy sources such as building natural gas terminals and re-gasification facilities. Again, a benign outcome would be an increase in energy efficiency in the form of either lower consumption because of higher energy costs, or better management of resources by the private sector. A less desirable outcome would be heightened corruption and opacity in the awarding of contracts and resource blocks—already a concern. There could be increased demand for (polluting) diesel fuel for captive electricity generation, say, in small and medium-sized plants. This in turn would skew energy governance even further, as both industry and agriculture would continue to expect inefficient subsidies on diesel and certain other fuels.

A third scenario proposes that the energy challenges will spur innovation. At a policy level, initiatives would focus on energy efficiency. For instance, the recently launched Perform, Achieve and Trade scheme for energy efficiency certificates could be expanded to cover more of industry (eight sub-sectors are covered currently). More importantly, the scheme could be deepened by offering incentives not only for overall plant energy efficiency but also for increasing efficiencies along the entire production process. Giving support to energy efficiency in small and medium-sized enterprises, which might not always have the financial and technical resources to undertake large efficiency-promoting investment, would be another approach. That said, energy efficiency would only ease some of the pressure, as the energy saved would be supplied to other firms.

Policy innovation involves appropriate energy-resource mapping for all sectors so as to anticipate and prepare for potential vulnerabilities in physical supply or fluctuating energy prices. This approach might push for rationalising energy supplies, and reducing, removing or narrowing the subsidies that badly distort India's energy market. Innovation could also occur in the energy infrastructure and supply chain. This would not be limited to building more port capacity (to handle imports of coal or oil and gas; two new LNG terminals should get commissioned by the end of 2012), new rail freight corridors (to supply energy to emerging industrial clusters) or transmission lines (for both fossil-fuel and renewable energy sources). Infrastructure innovation would include investing in software for energy management, training of grid operators, and building up a parallel "soft" energy infrastructure.

Energy-management innovation also could be found in technologies. For instance, work is already under way on solar power, second-generation biofuels and energy efficiency at a virtual US$125m Joint Clean Energy Research and Development Center.[4] Promoted by the Indian and US governments, the R&D centre is co-financed by research consortia comprising government, academic and corporate entities from both countries. Other initiatives include the National Mission on Enhanced Energy Efficiency, National Mission on Clean Coal Technologies, and National Solar Mission, all of which are part of the National Action Plan on Climate Change.

Technological innovation need not be restricted to upstream exploration and extraction activities for mineral resources. Technological breakthroughs in smart grids, usage efficiency, reduced land and water requirements, and better energy storage capacities, among other initiatives, could help to reduce demand at one end and improve stability of supply at the other.

Ultimately, energy demand for industry cannot be viewed in isolation, at the expense of critical human development priorities of energy access and overall economic growth across all sectors. The approach that industry takes to address its energy management issues—ignore, internalise or innovate—will determine Indian industry's development at an economic, environmental, social and political level. It has little choice other than to manage its energy supply in a sustainable way.

[4] The Council on Energy, Environment and Water acted as a facilitator for the initiative, but did not seek any funding for itself.

6 The distribution and infrastructure challenge: Improving India's grid network and rural connectivity

India's massive grid failure in July 2012 was symptomatic of deep-seated problems with the country's electricity connectivity. The malfunction flows down the entire supply chain, from generation to transmission and distribution. Rural connectivity is especially poor, despite official claims that 90% of villages are electrified. The solutions are easy to identify: better grid management practices, higher electricity tariffs, improved billing/collection and greater private participation in the supply chain. Finding the political will to implement these steps is the difficult part, but the country's continued economic development depends on it.

Rajiv Lall
Vice-chairman and Managing Director, IDFC

The blackout in northern India in July 2012 left more than 600m consumers without electricity for several hours. Many Indians might remember experiencing a similar grid collapse and power outage in 2001. That crisis catalysed a flurry of activity that culminated in the Electricity Act of 2003. The act brought about some important changes: it separated generation, transmission and distribution activities, strengthened the regulatory system, and introduced power trading and open access (i.e. the sale of electricity directly to consumers outside purchase agreements with distributors). Nevertheless, while much has been done over the past few years, several of the core issues identified more than a decade ago have yet to be properly resolved.

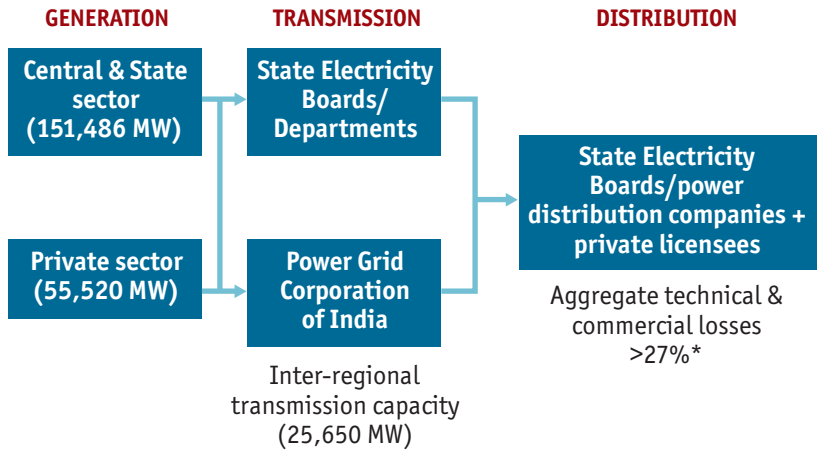
The grid failure of July 2012 has triggered debate about what went wrong and what needs to be done to prevent a similar crisis from reoccurring.

The problems with electricity in India are severe. Annual per-capita consumption is less than one-third of the global average. About one-third of India's population, mainly in rural areas, still lives without electricity. Nearly half of India's rural households are estimated to have little or no access to electricity (even though an electricity line may connect to their village). Those who do have access, whether in urban or rural areas, deal with unreliable supply and frequent power outages. Last-mile reliable connectivity to the grid remains elusive.

Weak links in the electricity supply chain

There are weak links across the entire electricity supply chain, which comprises fuel supply, generation, and transmission and distribution (T&D). India opened up power generation in

Figure 1: Indian power sector



* AT&C losses are the difference between energy input and energy for which revenue is realised after accounting for collection efficiency.

Source: IDFC; Power Grid Corporation of India

the 1990s to the private sector, which it is now responsible for about 30% of the total generating capacity of about 200 GW. However, fuel supply remains under the monopoly control of the public sector, as does T&D.

Transmission assets within individual states are owned and managed by the respective state governments, while inter-state transmission is the responsibility of the central-government-owned Power Grid Corporation of India (see Figure 1). A very small percentage of the transmission network has been built through joint ventures with the private sector. The distribution of power to the end consumer remains the responsibility of the various state-government-owned electricity boards, with very few exceptions.

The past five years have seen an unprecedented surge in generation capacity, led by the private sector. The other (mostly government-owned) links in the electricity supply chain have failed to keep pace, causing severe imbalances and stresses in the system.

One of the key challenges in transmission planning is that generation capacities are not distributed evenly across the country. The source of generation and the point of consumption are often a long distance apart. Inter-regional transmission capacity is currently only about 26 GW. This must at least double over the next five years. Apart from the huge levels of investment required, developing a robust transmission network faces other challenges such as right-of-way and environmental issues. One way to minimise both right-of-way issues and technical losses during transmission would be to accelerate the shift towards high- and extra-high-voltage transmission lines, so that bulk power can be carried long distances with fewer transmission towers.

The challenges arising from the vast geography of the country limit the reach of the grid into remote areas. Besides rapidly augmenting transmission infrastructure, there is a need to explore options for decentralised, off-grid solutions. In addition, the grid architecture must be designed to enable handling the increase in renewable power generation.

Urgent attention needs to be given to the acquisition and maintenance of reliable protective systems and equipment that can respond to a crisis in a timely manner. The goal is to have a "smart grid" that can monitor its systems, detect and isolate any stresses, and take corrective measures on a real-time basis.

Even as new generating capacity has been added, not enough attention has been given to investment in the T&D sector. For every rupee spent on creating generating assets, the country spends only about half of that in creating or augmenting T&D infrastructure (the desired thumb-rule ratio is 1:1). Since the government cannot meet the requirements, the only way to fill the gap is to allow private-sector participation in transmission.

The distribution sector has a direct impact on the overall commercial viability of the power sector and the consumers who pay for the service. The sector is, regrettably, the weakest link in the electricity supply chain. As with transmission,

the distribution sector has suffered from severe underinvestment. The dire financial condition of the state electricity boards (SEBs) and distribution companies has left them struggling to replace and repair outdated or substandard equipment and install new metering technology.

Based on the latest data available, the estimated losses for distribution companies in fiscal 2011 (ended March 31st 2012) stood at about US$14bn. About half of these losses were covered by subsidy support from state governments, still leaving these companies with annual losses of about US$8bn.

These losses arise due to the gap between the cost of supply and per-unit revenues. This gap occurs for two reasons: high aggregate technical & commercial (AT&C) losses, and tariffs that are kept artificially low for political reasons. For every unit of electricity purchased, the distribution companies are losing about Rs1.2 (about 2 US cents). As generating capacity increases, the distribution sector actually incurs greater losses because the revenue earned per unit falls quicker than the cost of buying electricity. AT&C losses were still over 27% in 2011. Meanwhile, a large proportion of non-technical losses are caused by theft—that is, the illegal tapping of electric wires—and faulty electric metering. Much of the agricultural sector has historically not even been metered, enabling the manipulation of actual T&D loss figures.

The path to power

High distribution losses and rising power purchase costs, without commensurate increases in tariffs, have ensured that distribution companies continue to bleed. Some states have begun to increase tariffs to reduce this gap, but their efforts are not nearly enough. The historical populist practice of allowing free or cheap supplies of power to the agricultural sector has led to the industrial sector cross-subsidising the supply of electricity to agriculture. The result is prohibitively high costs to industry and very low tariffs for agriculture and rural consumers.

The first step must be for the State Regulatory Commissions to restore some balance to the tariff structure, enabling the distribution companies to return to commercial viability. They can only do this by demonstrating the capacity and sophistication to make bold regulatory decisions independently from government.

The Electricity Act of 2003 created the legal basis for the sale of electricity directly to consumers outside traditional power purchase agreements with distribution companies. The introduction of open access set the stage for competition in the sector. However, state electricity distribution companies have resisted open access because the competition it implies would cause them to lose their most valuable revenue-generating customers and drive them even deeper into financial distress than they are today. If implemented at least for industrial consumers, open access would dramatically improve efficiency in the sector.

The government launched the Accelerated Power Development Reforms Programme over a decade ago to incentivise states to strengthen their T&D systems and reduce AT&C loss levels to a targeted 15%. This initiative encourages the use of information technology, automation, demand-side management, metering, energy accounting and auditing for reduction of distribution companies' losses. But recent statistics show the programme has a long way to go to fulfil its mandate.

As mentioned, ownership of distribution companies lies mainly in the public sector. Some private ownership experiences in cities such as Delhi, Surat, Ahmedabad and Mumbai have been successful in improving operational parameters. But unless there is political will to adopt better management practices, increase tariffs and improve billing and collection, it will not be possible to reduce losses in state electricity distribution companies. Only private participation in the distribution segment will solve the problem in the long term.

India's continued economic development relies on successful reforms. Indeed, there is little doubt that rural electrification is vital for poverty reduction. Rural power supply in India has historically lagged in terms of service and penetration. The Rajiv Gandhi Gramin Vidyutikaran Yojna (Village Electrification Programme), launched in 2005, is an effort to provide electricity to all in rural areas. A capital expenditure scheme, it has been successful in delivering electricity to 21m new households. Although official estimates say 90% of India's villages are electrified, electricity at the doorstep of the poorest households in many states is still a distant dream.

The rural distribution system is constrained by an inadequate network and various maintenance problems, often due to the poor financial health of state-owned utilities, which constrains investment. Rural connectivity will not improve unless the distribution companies can be made financially viable. If the cost of operation and maintenance for grid connections in rural areas is high, then transparent, recurring budgetary support should be designed to meet this challenge. In villages and rural habitations where grid connectivity is not feasible or cost-effective, off-grid solutions can be explored for supply of power.

While many of India's electricity problems have been under discussion for years, unless the T&D sector is operated along commercial lines and there is political will to bring about the required changes for it to do so, many challenges will persist. So while the recent blackout in the entire north of India has (once again) brought to the fore the need for urgent action to improve the performance of the power sector in general, and the T&D sector in particular, given the political nature of the problems, one can only hope that this time around the country's leaders will bite the bullet and implement what is necessary.

7 Renewable energy in India: For now or the future?

Are renewable sources the answer to India's energy problems? Their potential is undeniable: in five years they could account for 18% of capacity—if only about 6% of generation. Wind and solar could contribute much of this alone. But scaling up renewables generation means resolving fundamental challenges of supply volatility, grid integration, geographic dispersion and uncompetitiveness. Someone must bear the higher costs of renewable power sources. While the central government has developed several policies to this end, states—and consumers—might be less eager to finance further renewables development.

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** All views expressed in this essay are personal.*

India loves renewables. It is perhaps the only large country with a dedicated Ministry of New and Renewable Energy, better known as MNRE, and the government overall has a number of programmes and national missions related to renewables and sustainability. As demand for all kinds of energy burgeons in the coming two decades, supply is expected to rise sharply (although it will still fall far short of needs). Part of that supply will be achieved through renewable energy, the growth of which is almost inevitable. How much of a share it will contribute, and what it will cost, however, remain uncertain.

Renewables currently make up 12.1% of India's total energy capacity of 207 gigawatts (GW), but share of generation is likely closer to 4%, perhaps lower. With short-term growth rates for renewables higher than for the sector overall, by 2017 their share of capacity is projected to be approximately 18%.

Renewable sources: current status and future potential

Renewable energy as defined in India primarily covers four forms: wind, solar, biomass and mini-hydro.[1] The installed grid-connected capacity of 3.4GW of mini-hydro is slightly higher than the capacity for biomass, but biomass is growing faster, especially factoring in combined heat and power plants. While wind turbines and solar photovoltaic systems for electricity have the most visibility, biomass is the largest renewable source, accounting for a quarter of India's total energy consumption.

[1] Large hydro sources are considered "conventional", despite their renewable nature, but their growth is likely to be constrained due to socio-environmental and logistical challenges. Other renewables include waste-to-power systems, and fledgling technologies like tidal power.

Biomass (mostly wood and, if available, cow-dung cakes) is used for cooking in about two-thirds of India's homes, and the overwhelming majority of rural ones. While theoretically sustainable, use of biomass is mostly without attendant reforestation. It also places an enormous burden on families, which might spend an hour or more each day gathering firewood. Even more problematic is the use of inefficient stoves, which waste fuel and cause severe air pollution, particularly affecting the health of women and children who traditionally spend more time at home.

Urbanisation, increasing affluence and improved supply-chain logistics will hasten the shift away from wood biomass towards commercial cooking fuels, especially liquefied petroleum gas (LPG). While biomass's share of primary energy is projected to fall to 10% by 2030, the International Energy Agency projects absolute consumption will grow marginally from an estimated 165 megatonnes (MT) today to 175 MT by 2030.

Solar thermal energy has marked potential—especially for heating water, but it can even provide cooling based on vapour absorption cycles or other innovations, which are available but not yet commercially widespread. The city of Bangalore has mandated the installation of solar water heaters before an electricity connection is provided, but such schemes barely scratch the surface of the potential at a national level. Israel, for example, made solar water heaters mandatory for all new homes (except select high-rises), leading to penetrations of five-sixths of homes, and China has already installed over 180m sq metres of solar thermal panels.

The modest adoption of solar thermal energy in India is despite favourable economics: payback periods are about five years, even before factoring in central government capital subsidies of up to 30% and electricity discounts in some cities. Even the national mission target of 20m sq metres of solar water heaters by 2022—itself ambitious, given this is almost four times the total installed capacity to date—isn't as grand as it sounds. Assuming the size of panels to be 2-3 sq metres per home, this is an order of magnitude lower than the projected growth of homes over the same period.

Solar power overall (both photovoltaic and solar thermal power generation) has developed robustly over the past decade, and it is no longer considered just an off-grid solution. A prominent initiative, the Jawaharlal Nehru National Solar Mission (JNNSM), is devoted to creating grid parity and domestic competitiveness, while harnessing 20 GW of grid-connected and 2 GW of off-grid solar power by 2022. Aggressive bids under the JNNSM have produced—albeit so far only on paper—grid-connect megawatt (MW) sized plants generating at about 15 US cents per kilowatt-hour (kWh), among the lowest in the world. While total installed solar capacity is currently modest (about 1 GW), a significant increase is expected in the coming decade, especially in its latter half.

Even this enormous growth is a tiny fraction of the theoretical capacity for solar power. An area of 100sq kilometres could power hundreds of gigawatts of capacity (depending on conversion efficiency and fill factor). This would be at peak capacity, but Indian solar radiation is among the highest intensity in the world: it has a large available area receiving 5.5kWh per sq metre per day, principally in less-populated regions. By contrast, the best parts of Germany (the world leader in per-capita consumption of photovoltaic energy) receive a third less sunlight.

But in terms of generation, the prize goes to wind power. Even in the absence of a bold direct target, wind power has done quite well, with capacity reaching 17,875 MW by August 2012, the fifth highest in the world. It is also growing briskly: the actual growth of wind power capacity over the 12th Five-Year Plan (2012-17) may exceed the official target of 2,400 MW per year.

Wind power in India has developed in phases, partly based on the support mechanisms in place. These included very high depreciation allowances, which were supplanted by generation-based incentives, feed-in-tariffs[2] and now Renewable Energy Certificates (RECs).[3] Given that electricity is a concurrent (that is, a central and state) subject in India's constitution, the main pricing decisions for power purchase and retail are taken at the state level. Each state offers different support for renewables;for wind power, feed-in prices mostly range from Rs3 to Rs4.5 (around 6-8 US cents) per kWh.[4]

How much potential is there for wind? For many years, the government cited a figure of about 50 GW, but this was based on 50-metre hub-heights and 2% of land usage.[5] By using 80-metre-high tower hubs for modelling, the potential has roughly doubled. Assuming greater land availability, and a willingness to pay more per kWh, some studies indicate 600 GW of potential wind energy. Unfortunately, many of the best (windiest) sites are already taken by early adopters of wind power, added to which India's wind speeds are at least one, if not two, classes lower than those for good sites in North-western Europe or the US.[6] This raises costs, making a Rs3 per kWh tariff less attractive.

The good news is that India is innovating low-wind-speed turbine technologies, and state policies are fixing land-usage regulations to allow dual use of agricultural land for wind power generation without "conversion"—a costly and time-consuming logistical process. All of these initiatives are likely to lead to continued growth in wind power—more so than solar power. This is even before tapping offshore wind, which is at the prototype deployment stage.

Testing the potential: Mind the gap

Worldwide, renewables face a challenge of economics, especially when compared with conventional power. Renewables also face fundamental problems from a grid perspective, namely variability and unpredictability. The plant load (that is, capacity utilisation) factors for most renewables are about three to four times lower than that of a new conventional (coal-fuelled) plant. So a capital cost of US$1.2/watt for wind—almost 50% higher than that for a coal-fuelled plant, albeit for a power source with no fuel costs—begins to look less attractive. Solar's capital cost per watt is about double that of wind.

These costs also have an impact on system planning, since these resources are for the most part not dispatchable.[7] The end-July 2012 blackouts reinforced the challenge of grid balancing and management. While wind power may account for 8.6% of capacity in India today, it accounts for only about 3% of generation (and most of that occurs around the monsoon, when demand is not at its highest).

Another major issue for renewable resources in India is that they are heavily geography dependent: five states produce most of today's wind power and solar power's potential is similarly concentrated. This poses economic and operational challenges for these states. Tradable RECs have been introduced to overcome the financial implications, but the practice is young and promoters cannot use both RECs and preferential tariffs.

At grid level, transporting power from a windy or sunny site is a well-known problem—but one that just needs transmission infrastructure to be resolved. Much harder is grid management to handle enormous variability. For example, the south Indian state of Tamil Nadu has about 45% of its capacity as wind power. When the wind dies suddenly, there is virtually no peaking power available, and feeder-level load shedding in the state is far worse than it is in most of India.

Given these challenges, is charging a premium for renewables appropriate? For off-grid or remote applications, any premium over average grid prices may be competitive, especially

[2] A feed-in tariff is a policy mechanism aimed at encouraging investment in renewable energy technologies by offering long-term contracts to renewable energy producers, typically meant to cover the cost of generation plus healthy returns. Wind power has a lower tariff per kWh than, say, solar photovoltaic, which is offered at a higher price that reflects its higher costs.

[3] RECs aim to create a market for "green" generation, which can be traded independently of the energy generated and sold. Thus, states with low renewable potential can finance renewables in other states.

[4] A snapshot is available from the Ministry of New and Renewable Energy at http://mnre.gov.in/file-manager/UserFiles/policy_programme_wise.htm

[5] Hub height is the distance from the turbine platform to the rotor of an installed wind turbine; it indicates how high a turbine is from the ground, excluding the length of the turbine blades. Wind speed increases with height above ground. Most deployments worldwide today have hub heights of 80 metres or 100 metres.

[6] Wind classes from 1 to 7 are speed/power density-based categories. Many remaining sites in India are only class 2 (typically called "marginal"), which might produce 30% less output than a class 3 site; US and off-shore Europe deployments focus on class 4 or higher sites, if possible.

compared to diesel or kerosene (which are heavily subsidised). But the economics of renewables depend on scale. Wind turbines are best at megawatt size, and only photovoltaic panels are close to being scale-appropriate for households. Biomass power systems are typically village-sized, if not larger, and the same goes for mini-hydro. As for solar power, even if it will remain competitive with diesel as demand for energy increases, today it is mostly not competitive with grid power—even factoring in the latter's system losses, grid capital costs and other inefficiencies.

Looking beyond issues of scale, peak electricity demand comes in the evening, especially for lighting, necessitating a battery or other power-storage technology for standalone units. Ultimately, in India, unlike parts of Sub-Saharan Africa, the transmission and even medium-voltage grid reaches the majority of villages—the challenge is sending power over the last mile, to the home. This will remain a problem with village-level generation technologies.[8] There are approximately 30,000 remote and distant villages where extending the grid is considered expensive, and for these areas the government offers 90% capital subsidy options for renewables-based decentralised distributed generation.

Even if every un-electrified home in India were given a solar panel and battery, enough for limited basic needs, it would still only translate to a capacity of 6 GW (60m homes x 100 watts). Given plans to attain 20 GW of solar by 2022, most of this would have be generated in large, grid-connected farms, in many ways not dissimilar to the 17.8 GW of wind power today. At that point, solar power would need to compete with grid power, since it would be generating more energy (kWh) than firm, dispatchable capacity (kW). Even power using "expensive" imported coal currently costs about half the price of aggressively priced solar power.

Land is another challenge that applies to India more than to other countries. The diffuse nature of many renewables, combined with over-population, makes the cost of land a significant factor in the cost of energy; it may even set a practical limit to capacity. This is particularly problematic in the case of biomass. Despite the premium that liquid biomass fuels offer over electricity on a US$/MMBTU basis, production levels are modest.[9] India's sugarcane output is similar to Brazil's on a productivity basis, but policies for food over fuel constrain its potential for creating ethanol. For biodiesel produced from, say, *jatropha*, a non-food oil-rich plant, even a proposed modest (10%) blend would make it the third-largest crop in India, covering a land-area larger than the state of Tamil Nadu.

Policies and support: green from the government

Despite these challenges, the advance of renewables is inevitable. Present growth rates indicate that their share of capacity will increase measurably in the coming years. Their small size and rapid construction schedules also help renewable power projects. However, the enormity of scope and the relatively diffuse nature of renewable power sources mean that even game-changers like storage technologies (that go beyond proven pumped hydro) or smart grids are unlikely to create a dramatic upturn in renewables' share of India's total energy output. They will jog business-as-usual projections for renewables upwards by just a few per cent.

Indeed, constraints on the growth of renewables are likely to come from the project developers themselves, based on the challenges of implementation. For its part, the Indian government is putting its might behind renewables in policy and practice, including a cess on coal power for a green fund. Even if a technology is expensive, the government has always believed in costs-plus support (as the much lower price of mini-hydro compared with wind and solar attests). It has even advocated a policy of socialising costs—for example, a

[7] That is, able to be delivered at the request of power grid operators, from generating plants that can turn supply on or off and can adjust power output based on demand.

[8] A much more subtle challenge for the grid isn't the last mile connection *per se*, but ensuring availability of supply.

[9] MMBTU=Million British thermal units

proposed cost-sharing for deviations in output for wind power. For solar power, a subsidiary of NTPC (a behemoth public-sector thermal generation company) will be the nodal agency for contracts, at least for the first phase. This helps to not only lower the risks for investors in solar, but also soften the economic blow for purchasing utilities via blending or pooling power across solar and non-solar. However, it doesn't address the underlying long-term fundamental issues of costs and pricing.

Nonetheless, renewables will continue to garner government support, especially from policymakers at the centre. Renewables are "green" and ostensibly sustainable, and they are wholly domestic, increasing energy independence. But India's states are less gung-ho. Renewable Purchase Obligations, varying by state and based on the National Tariff Policy of 2006, have came into force recently. But these are conservative (for example, the state of Karnataka had reached its target on day zero). More serious is the fundamental issue of finance: all the states are in deficit, at an average of 2.7% of state GDP as of March 2011. In the long run, economics will be a determinant of scalability: at what point will renewables reach true grid parity?

As for Indian consumers, do they love renewables? Except for a small niche, it is unclear whether they are ready to pay more for green power, at least beyond a minimal load such as for lighting. When hundreds of millions lack electricity connections—and even those who have a connection often face hours of power outages every day—green power may be the last thing on their minds.

Suggested further reading:

India's Ministry of New and Renewable Energy's website (www.mnre.gov.in) has several reports, white papers, subsidy schemes, and other documents that give an overview as well as extensive details of India's renewable energy policies and initiatives.

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