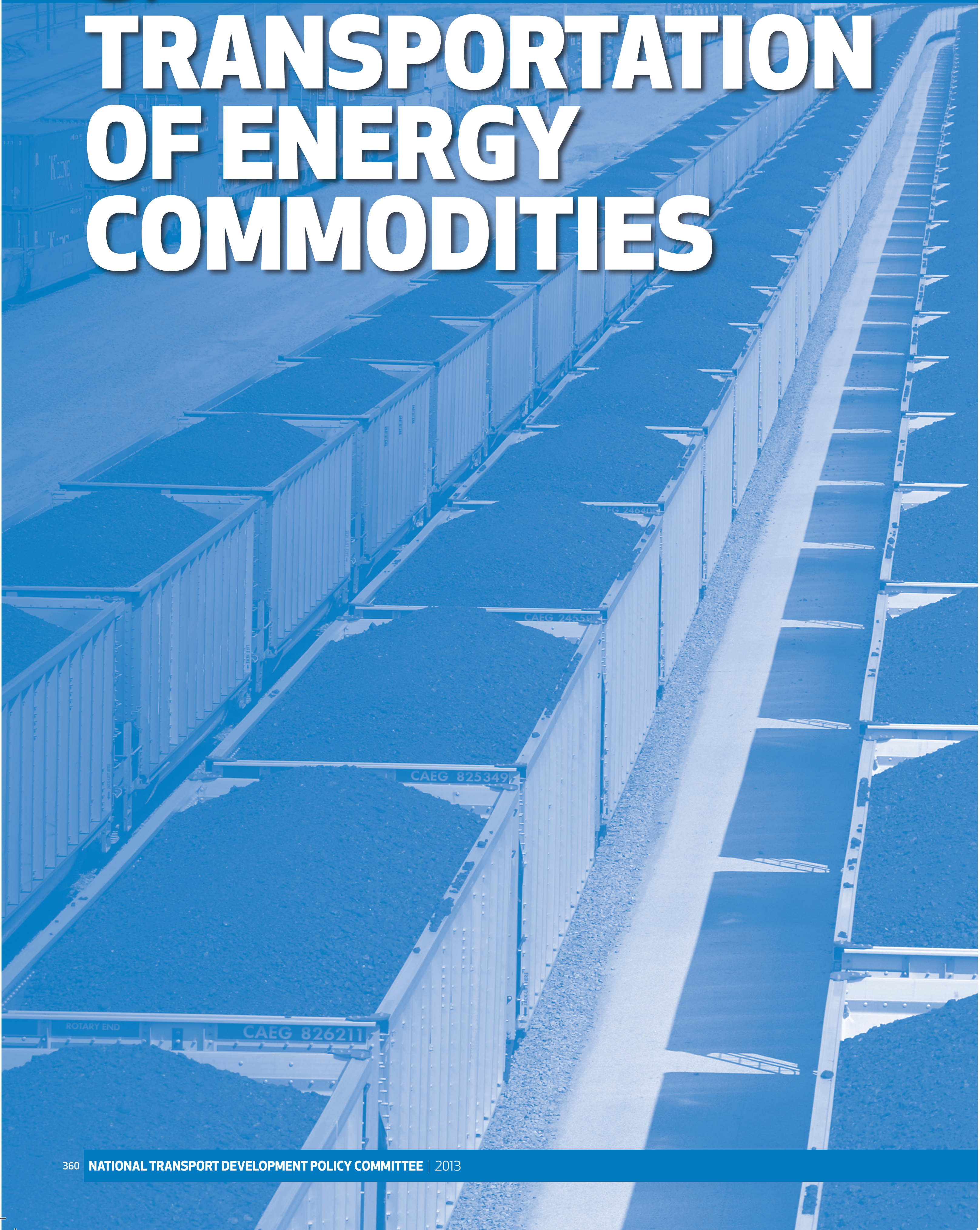
8. TRANSPORTATION OF ENERGY COMMODITIES

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8. TRANSPORTATION OF ENERGY COMMODITIES

The surge in economic growth, witnessed in recent years in India, has strained the capacity of its transport system as well as the energy supply, particularly electric power.

The government's ambitious development targets and plans, as well as popular discourse, attest to the importance of addressing such infrastructure constraints in a decisive manner over the next two decades, to sustain high levels of economic growth which is also inclusive.

Movement of bulk commodities is a major role of India's transportation system. Coal accounts for almost half the freight volume on Indian Railways, a major supplier of transport services to the electric power and steel industries. Indeed, the congestion caused by inadequate expansion in transport capacity to date, especially on crucial links and corridors, underlies issues such as security of supply chains, inventory of raw materials, port-handling, which affect industry.

The future poses profound challenges. Even if the ambitious aim to improve energy intensity is achieved, sustaining economic growth at 8-10 per cent per annum over the next two decades will require massive increases in power generation and transportation of bulk commodities such as coal, iron and steel.

Development plans from the key ministries of the government as well as initiatives and investment proposals from the private sector seek to address the above issues. The needs are vast and multifaceted while resources are limited. More importantly, the issues are intimately interrelated and the viability of solutions is interdependent, both in terms of the nature of the investment (e.g., transport coal or transmit power) as well as the timing and duration of execution. Hence a piecemeal approach to planning could be severely suboptimal, leading to colossal wastage of resources and time.

LOCATION OF PRODUCTION & SUPPLY

As a first step in assessing the transport requirements for bulk commodities, we identify the origins and destinations of the materials that have to be moved. Raw materials need to be moved from mines to production facilities, and finished products need to be moved from production facilities to the places they are used or consumed. We identify the location of domestic energy and mineral resources, the sources of commodity imports, and the location of production facilities. We also describe the current and projected transfer facilities. For some materials such as coal where domestic demand will outstrip domestic supply, imports will make up the deficit. Therefore, we also describe briefly the geostrategic considerations likely to affect the import of coal.

Coal, oil and natural gas are the three primary commercial energy sources. Being the most abundant fossil fuel in India, coal is by far the largest source of energy and meets about 50 per cent of the country's commercial energy needs. About 35 per cent are met by oil, with more than 80 per cent of that oil being imported. While natural gas accounts for 10 per cent, the consumption of natural gas has risen faster than any other fuel in the recent years.

Table 8.1
Major Reserves of Coal
[Billion Tonne]

NO.	COAL FIELD	STATE	GRADE OF COAL	GROSS GEOLOGICAL RESERVES (BT)	TYPE OF COAL
1	Talcher	Odisha	F	46.64	Thermal Coal
2	Ib Valley	Odisha	F	22.52	Thermal Coal
3	North Karanpura	Jharkhand	F	13.35	Thermal Coal
4	South Karanpura	Jharkhand	F	6.30	Thermal Coal
5	Rajmahal	Jharkhand	D-E	16.20	Thermal Coal
6	Korba	Chhattisgarh	D-E	11.76	Thermal Coal
7	Hasdeo-Arand	Chhattisgarh	D-E	5.18	Thermal Coal
8	Mand-Raigarh	MP	D-E	23.77	Thermal Coal
9	Singrauli	MP	C-E	12.76	Thermal Coal
10	Wardha Valley	Maharashtra	D-E	6.26	Thermal Coal
11	Godavary Valley	AP	D-E	22.05	Thermal Coal
12	Raniganj	WB	B-E	25.83	Thermal & Semi coking
13	Jharia	Bihar	LVM , C–E	19.43	Coking
	TOTAL			**232.05**	
	AVERAGE ASH CONTENT: 38-40 PER CENT, AVERAGE HEAT RATE 4,000 KCAL/KG				

Source: Working Group Report (2013).

In addition to the bulk transport needs of the energy sector, we also look at the needs of the steel industry. The most important raw materials for the steel industry are iron ore and coking coal. India has very significant amounts of good quality iron ore resource, a significant amount of which was being exported until the recent ban by the Supreme Court. But the steel industry relies heavily on imports of coking coal as much of the national reserves have a high ash content rendering them unsuitable for steel-making.

COAL

About 80 per cent of the potential coal bearing area of 18,000 sq km has been covered by regional exploration. Based on these and more detailed explorations, India's total geological resource has been estimated to be about 286 billion tonne (Bt) of coal. Of this 114 Bt is proven resource, while 137 Bt and 34 Bt are 'indicated' and 'inferred' respectively. Only about 12 per cent of the geological resource contains coking coal; the bulk is non-coking coal. Indian coal is classified into grades, A through G, based on its gross calorific value (GCV) with grade A coal having the highest GCV.

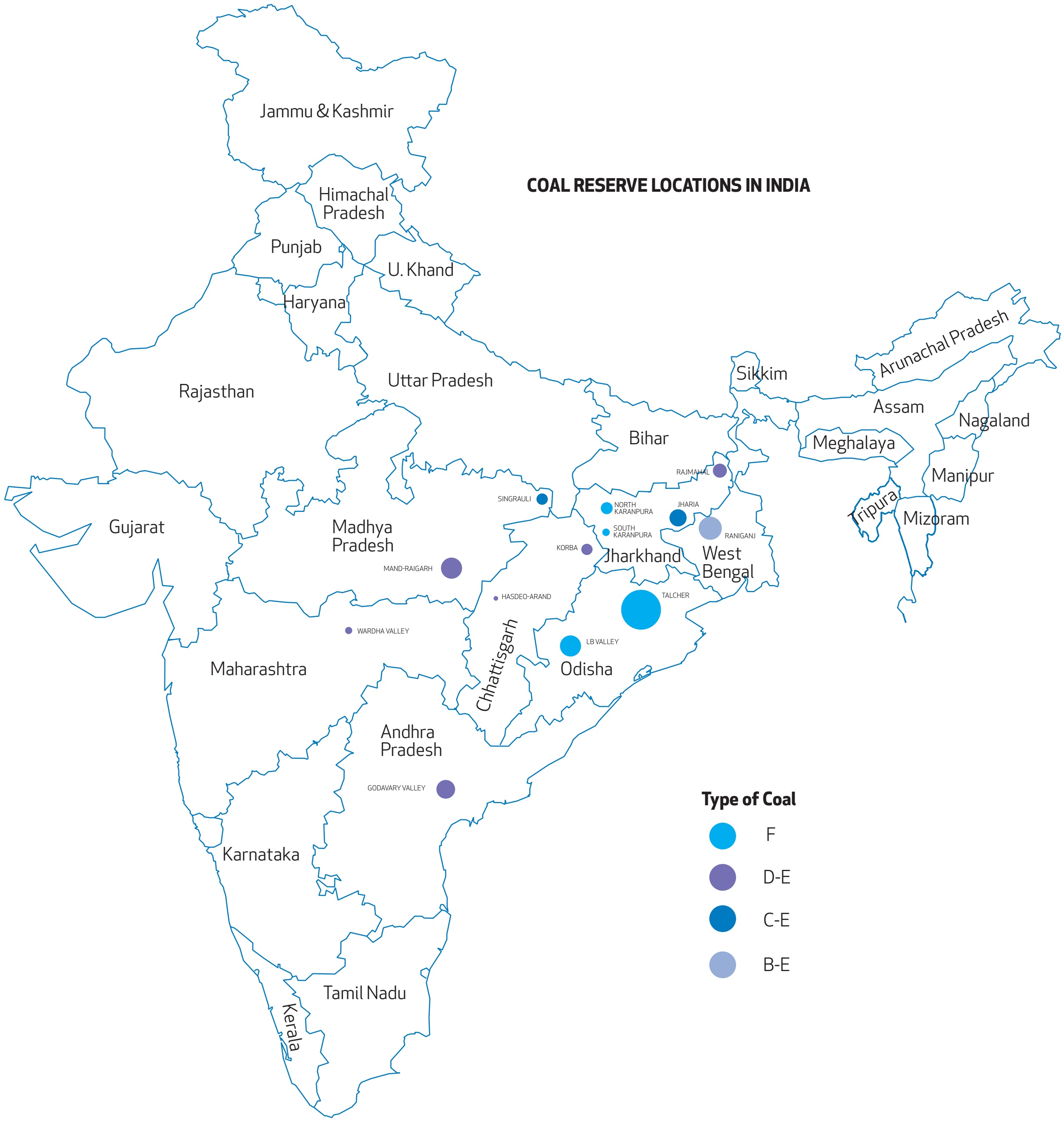
LOCATION OF COAL RESERVES

Coal India Limited (CIL) is the major indigenous coal producer and has seven production subsidiaries and an eighth subsidiary (CMPDI) that provides technical support to the other seven. Singareni Colleries Co. Ltd, jointly owned by the Governments of India and Andhra Pradesh, is also into coal production and supply.

Table 8.1 and Figure 8.1 show the major reserves of coal in the country that account for over 80 per cent of the national resource. These coalfields have a geological resource of about 232 Bt and lie mostly in the eastern part of the country.

Figure 8.2 gives the state-wise share of coal reserves. About 70 per cent of the reserves are in

Figure 8.1
Location of Reserves of Coal



Source: Working Group Report (2013).

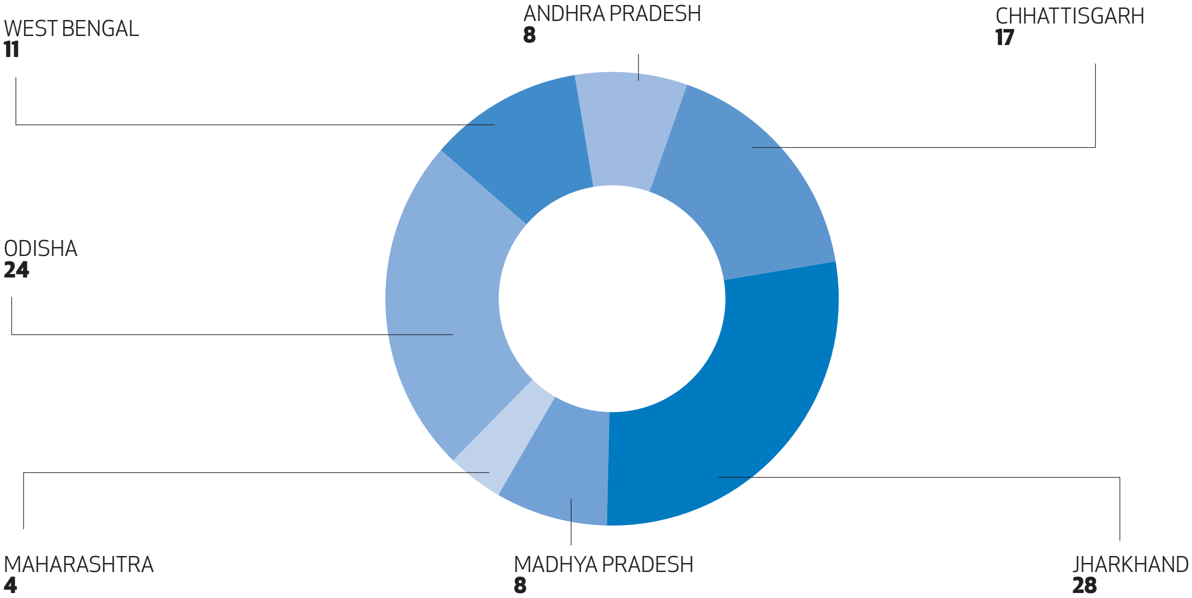
three states—Odisha, Jharkhand and Chhattisgarh. However, much of this coal is of the poor quality (mostly grade F, and some D or E).

The average growth rate for domestic coal over the next 20 years is 4.33 per cent. The growth is higher (6.5 per cent) during the first decade 2011-22 than the second decade 2022-32 (2.2 per cent). The overall growth rate is considerably lower than the rate at which the demand for coal is expected to grow, necessitating increased imports.

NATURAL GAS

Interest in using natural gas as a fuel is growing because of its lower environmental impact compared to coal and oil. It is increasingly being used in combined-cycle power stations because much higher efficiencies are possible with advanced technology gas turbines. The next largest gas consumer is the fertiliser sector. Gas is also used as a fuel in other industries and in the commercial and domestic sector. Figure 8.3 shows the

Figure 8. 2
State-Wise Share of Coal Resources
[Per Cent]



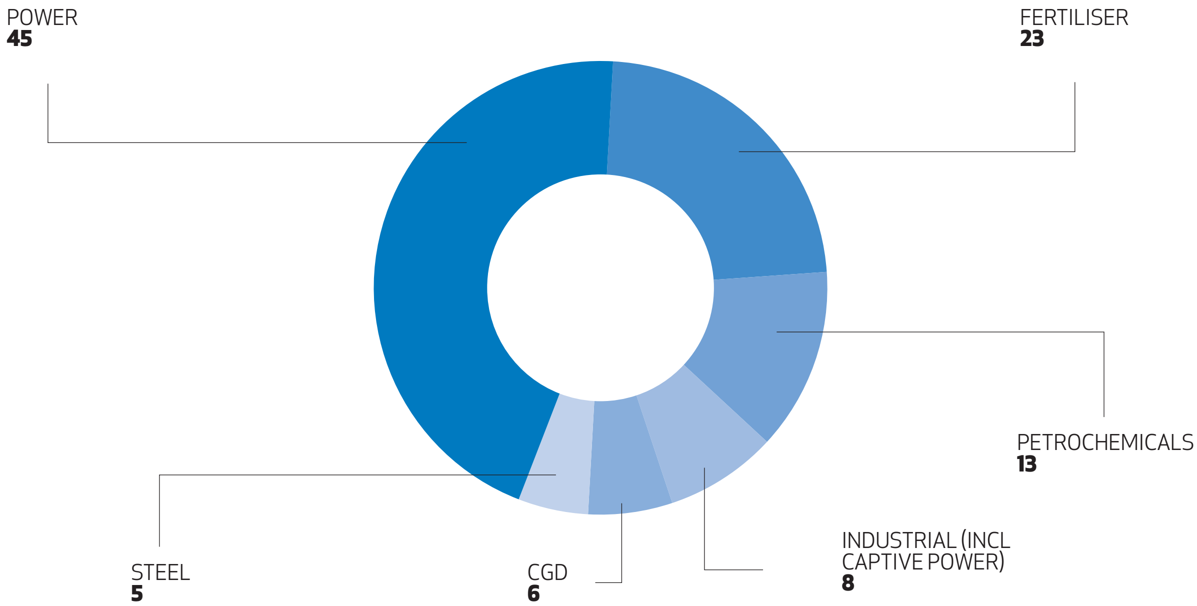
Source: Working Group Report (2013).

Table 8. 2
Forecast of Production by Coal Companies
[Million Tonne]

COMPANY	2011-12 (EST.)	2016-17	2021-22	2026-27	2031-32	COAL FIELDS
ECL	33	41	51	54	57	Rajmahal, Raniganj
BCCL	30	36	40	42	45	Jharia
CCL	51	83	110	117	124	North & South Karanpura
NCL	69	80	85	90	96	Singrauli
WCL	46	45	45	47	50	Wardha Valley
SECL	112	140	182	193	205	Korba, Mand, Raigarh, Hasdeo Arand
MCL	106	140	195	207	219	Talcher, Ib Valley
NEC	1	1	3	3	3	Assam
Total CIL	447	555	710	753	798	
SCCL	51	57	63	70	77	Godavari Valley
Captive	38	97	245	312	400	
Others	18	18	18	20	20	
All India	**554**	**721**	**1,036**	**1,155**	**1,294**	

Source: Working Group Report (2013).

Figure 8. 3
Sector-Wise Gas Consumption, 2010-11
[Per Cent]



Source: ICRA (2011).

Table 8. 3
Production from Existing Gas Fields
[Million Cubic Metre]

REGION	LOCATION	PRODUCTION
Eastern Off-Shore	• Krishna-Godavari Basin (off the coast of Andhra Pradesh) • North East Coast Basin (off the coast of West Bengal) • Cauvery Basin (off the coast of Tamil Nadu)	22,223
Western Off-Shore	• Cambay Basin (off the coast of Gujarat) • Mumbai Offshore Basin (off the coast of Maharashtra)	21,422
On-Shore	Andhra Pradesh	1,384
	Assam	2,729
	Gujarat	2,261
	Tamil Nadu	1,119
	Tripura	610
	West Bengal	41
TOTAL		**51,789**

Source: NTDPC Research.

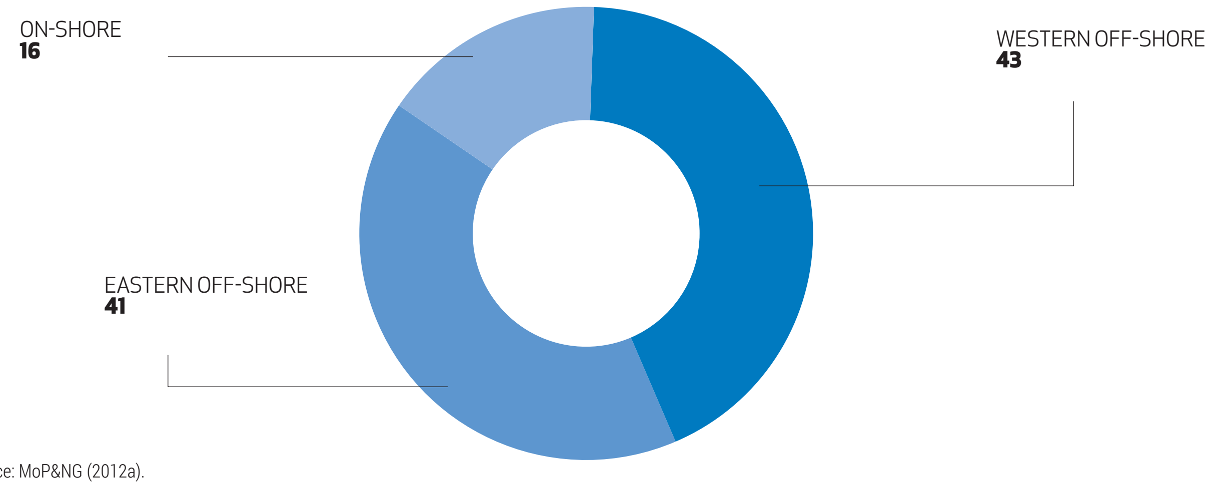
share of each sector in the total consumption of 177 million standard cubic metre per day (MMSCMD) in 2010-11.

Table 8.3 gives the main gas fields, and the production in 2010-11. As Figure 8.4 shows, the off-shore fields produce most of the domestic gas. With the recent decline in production in some of these fields, such as Reliance KG-D6 block, the contribution of off-shore production has decreased, but it still forms the bulk of domestic production.

Table 8.4 lists the gas fields being proposed for production in the next two decades. No new gas fields are proposed for the 15th Plan.

As Table 8.3 shows, domestic production of natural gas was 52 billion cubic metres (bcm) in 2010-11, corresponding to an average daily supply of about 140 MMSCMD. But consumption was 177 MMSCMD. The gap between consumption and domestic supply was met by imports of LNG. Currently, LNG re-gasification capacity in the country is 13.60 Mtpa (equivalent

Figure 8. 4
Geographical Share of Gas Production, 2010-11
[Per Cent]



Source: MoP&NG (2012a).

Table 8. 4
Additional Gas Fields Being Proposed

PERIOD	EASTERN OFF-SHORE	WESTERN OFF-SHORE	ON-SHORE
12th Plan	Mahanadi Basin (off Odisha coast)		
13th Plan		Andaman Off-Shore (off coast of Andaman & Nicobar Islands)	• Gujarat (Shale Gas) • West Bengal (Shale Gas) • Tripura
14th Plan			• Andhra Pradesh (Shale Gas) • Tamil Nadu (Shale Gas)

Source: Working Group Report (2013).

Table 8. 5
LNG Terminal and Re-gasification Capacity
[Million Tonne Per Annum]

TERMINAL	CURRENT CAPACITY	12TH PLAN	13TH PLAN
Dahej	10	15	15
HLPL Hazira	3.6	10	10
Dabhol		5	5
Kochi		5	10
Ennore		5	5
Mundra		5	10
East Coast		5	15
TOTAL	13.6	50	70

Source: Working Group Report (2013).

to 49 MMSCMD). Table 8.5 provides details and lists the additional expected LNG terminal capacity. Total gas availability, including domestic production, LNG imports and imports through trans-border pipelines will be about 360 MMSCMD by 2016-17 and 530 MMSCMD by 2021-22.

SHALE GAS

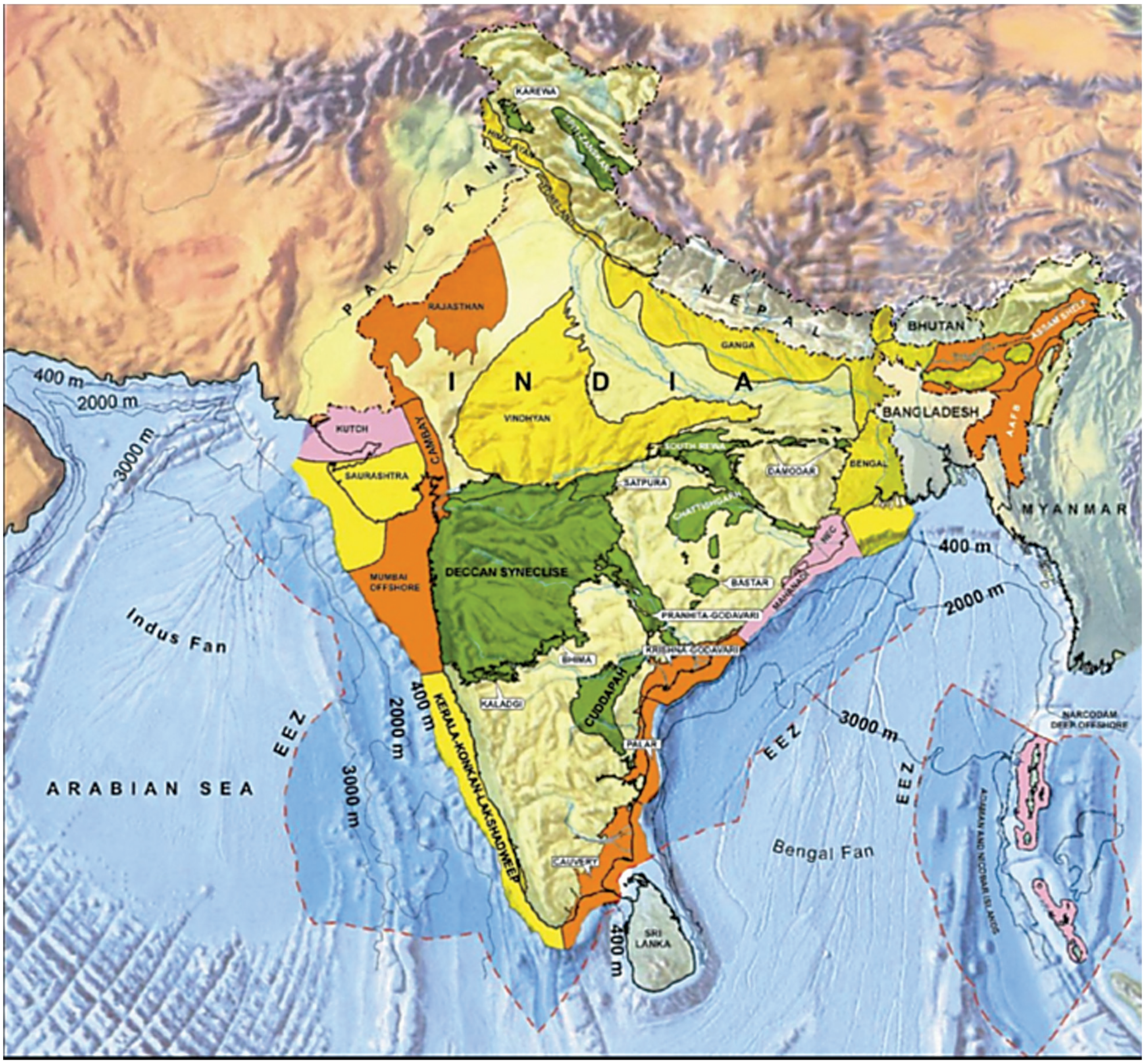
Shale gas is an unconventional source of methane (the major component of natural gas) consisting of gas trapped in rock formations. New technology to extract the gas is transforming the energy outlook in the US. Shale gas now accounts for about a third of its gas supplies and the price of gas has dropped dramatically.

Some of the on-shore sedimentary basins in India are reported to have organically rich shale, and India too has started looking into mapping of shale and generation of prospective sites. Identification of promising basins. DGH has shortlisted the following six sedimentary basins for exploration:

a. Cambay
b. Krishna-Godavari
c. Cauvery
d. Assam
e. Indo-Gangetic
f. Damodar Valley

It should be noted, however, that while prima facie shale gas may seem like a potentially abundant and cheap fuel, it is likely to bring with it its own con-

Figure 8. 5
Map of Sedimentary Basins in India



CATEGORY-I BASIN
(Proven Commercial Productivity)

CATEGORY-II BASIN
(Identified Prospectivity)

CATEGORY-III BASIN
(Prospective Basins)

CATEGORY-IV BASIN
(Potentially Prospective)

PRE-CAMBRIAN BASEMENT/ TECTONISED SEDIMENTS

DEEP VATER AREAS WITHIN EEZ

Note: An exclusive economic zone (EEZ) is a sea zone prescribed by the United Nations Convention on the Law of the Sea over which a coastal state has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources.
Source: Directorate General of Hydrocarbons (2012).

cerns about use. There are serious environmental concerns associated with the production of shale gas, related to water security, ground water pollution and land subsidence. Therefore, its production and use may be severely restricted unless solutions to these issues are found. If instead of increased gas availability, it is less than projected, then imports of coal would increase.

PETROLEUM, OILS AND LUBRICANTS (POL)

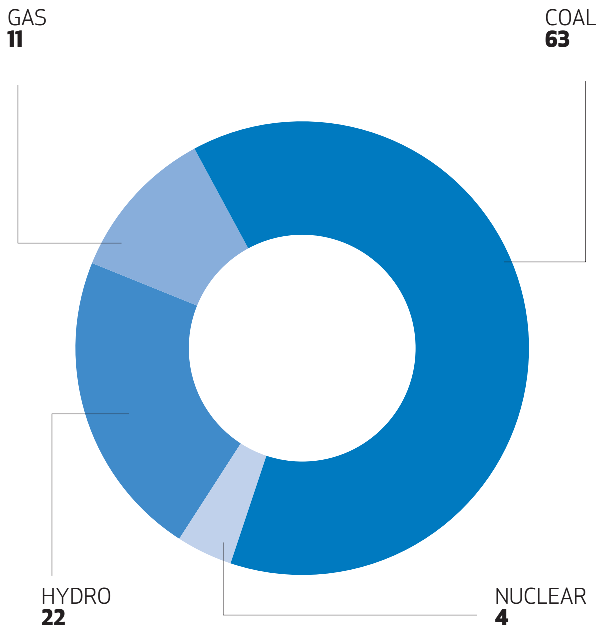
Even at the current low level of per capita consumption of energy, India imports over 70 per cent of its crude oil requirements (mostly from the Middle-East and Iran). As the economy grows and per capita consumption increases, the level of imports will increase. In 2010-11, the country con-

Table 8. 6
Production of Crude Oil, 2010-11
[Thousand Tonne]

REGION/STATE		PRODUCTION
ON-SHORE	Gujarat	5,905
	Assam/ Nagaland	4,719
	Arunachal Pradesh	116
	Tamil Nadu	234
	Andhra Pradesh	305
	Rajasthan	5,149
	Total On-Shore	**16,428**
OFF-SHORE	ONGC	17,002
	JVC/ Private	4,282
	Total Off-Shore	**21,284**
	Grand Total	**37,712**

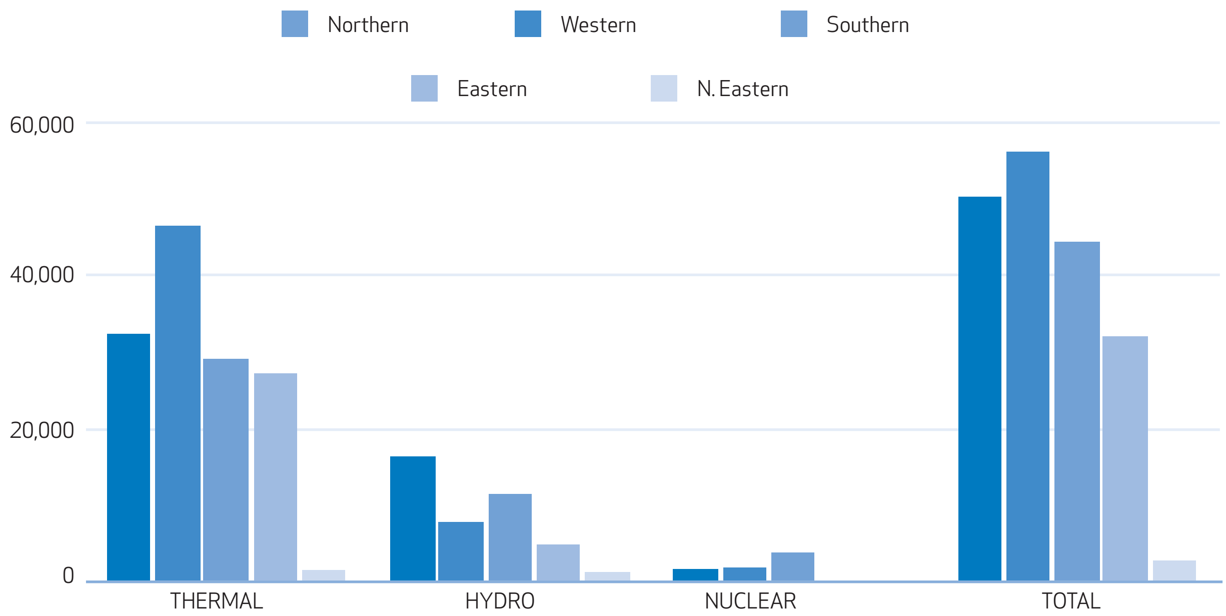
Source: MoP&NG (2012a).

Figure 8. 6
Generating Capacity Mix at End of 11th Plan
[Per Cent]



Source: Working Group Report (2013).

Figure 8. 7
Regional Contribution to Generating Capacity
[Mega Watt]



Source: Working Group Report (2013).

sumed 206 Mt of crude oil, of which 38 Mt was produced domestically and 164 Mt, imported[1]. About 74 per cent of the above domestic production was by government-owned companies (ONGC and OIL) and the rest by private companies or joint ventures.

Hydrocarbons (petroleum and natural gas) are found in sedimentary basins. Figure 8.5 is a map showing the 26 sedimentary basins that have been identified. However, only seven basins—Cambay, Assam Shelf, Mumbai Off-Shore, Krishna-Godavari, Cauvery, Assam, Arakan and Rajasthan—have commercial production. Kutch, Mahanadi and Andaman-Nicobar basins are known to have accumulation of hydrocarbons but there is no commercial production yet.

Table 8.6 gives the amount and location of current crude oil production from the seven sedimentary basins for 2010-11 (provisional). A little over half the production occurs off-shore, and the on-shore production is spread across several states.

REFINERIES

In keeping with the growing demand, the refining capacity of petroleum products has increased either by the expansion of capacity at existing refineries or by setting up new refineries. As of June 2011, there were 21 refineries in the country out of which 17 were in the public sector. Thirteen of them are in the coastal states. The total refining capacity is 193 Mtpa, which is far higher than the domestic requirements, making India a net exporter of petroleum products[2]. In 2010-11, India exported about 42 Mt of petroleum products[3].

1. MoP&NG (2011).
2. MoP&NG (2013).
3. MoP&NG (2011).

POWER PLANTS

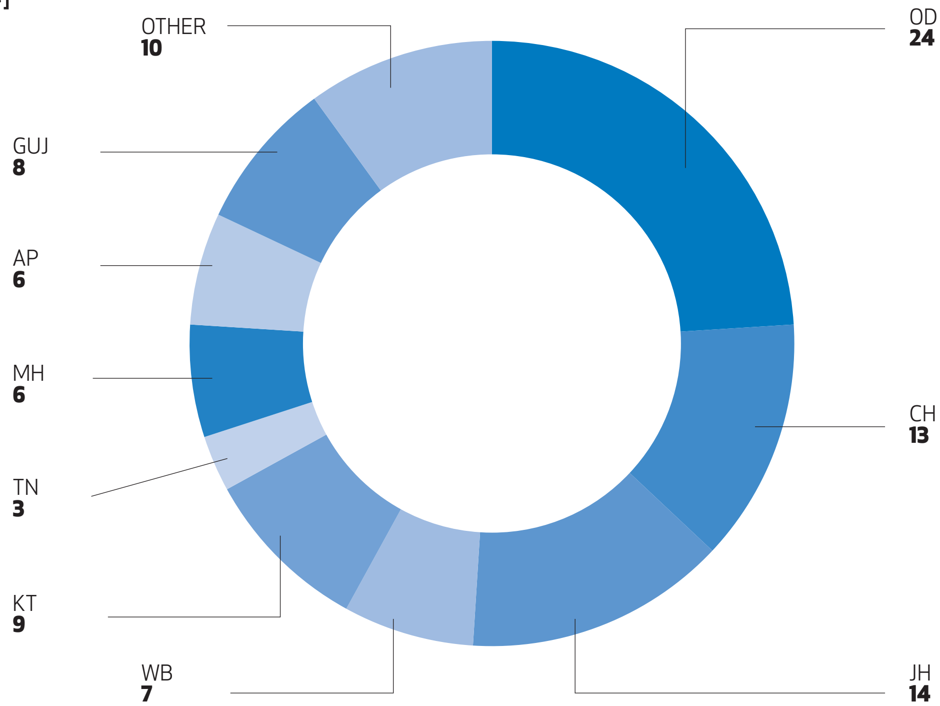
LOCATION OF EXISTING CONVENTIONAL GENERATION

At the end of the 11th Plan, generating capacity was about 175 GW, excluding generation from renewable energy sources. As Figure 8.6 shows, coal is the dominant fuel in electricity generation, firing about two-thirds of the country's capacity. Figure 8.7 shows the regional contribution to generating capacity. Coal fired capacity is distributed across the country except in the Northeastern region, with the Western region being the biggest contributor. Currently, the Northern region, including the hilly regions of HP, J&K, Uttarakhand and Punjab, has the most hydro capacity, followed closely by the Southern region. The contribution of the North-Eastern region is miniscule currently but is expected to grow as more of its very large hydro potential is realised.

There are several factors related to land, environmental impact and public acceptability that constrain the amount of generation capacity that can be added in a particular state. Land acquisition in recent times has become a critical issue for developers of plants for power and other key commodities such as steel. Land is increasingly becoming a scarce resource and its availability is posing a serious challenge for future development of plants.

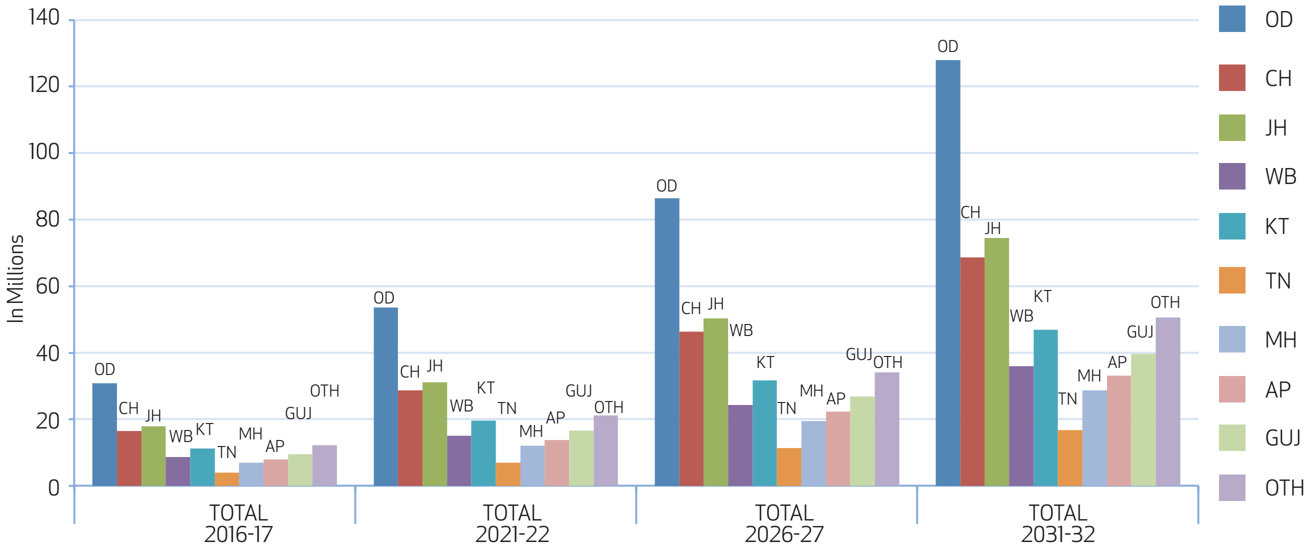
Power plants can have severe social and environmental impact: air pollution; production of large quantities of ash; water pollution due to ash ponds and deposition of mercury. In addition, thermal power plants require large amounts of water which can severely stress local water resources.

Figure 8.8
State-Wise Share of Steel Capacity
[Per Cent]



Source: Ministry of Steel (2012a).

Figure 8. 9
Projected Crude Steel Capacity in Major Steel Producing State



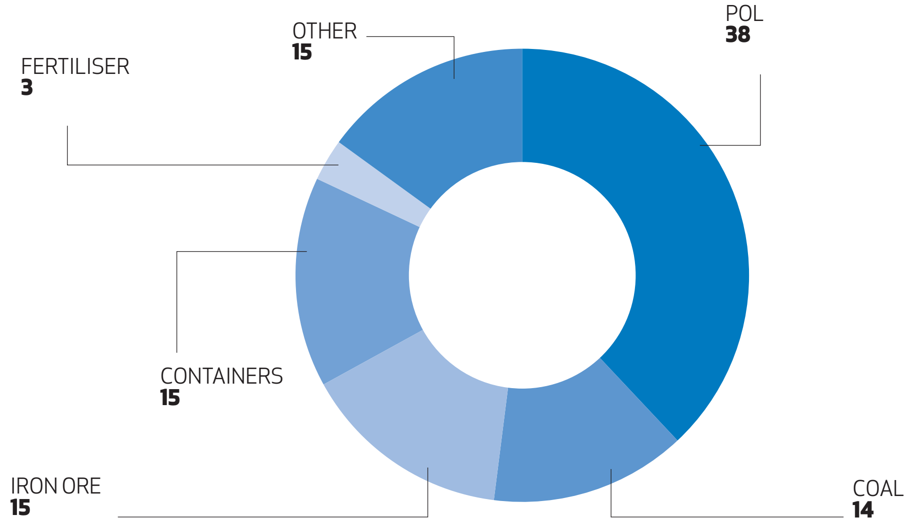
Source: Ministry of Steel (2012b).

These issues were considered in setting limits on state-wise capacity addition in the modeling exercise to identify locations for new power plants.

IRON & STEEL PLANTS

Steel capacity is located mostly near iron ore mines in the mineral-rich states. As Figures 8.8 and 8.9 show, Odisha, Jharkhand and Chhattisgarh together will have more than 50 per cent of the steel capacity through most of the next two decades. In fact, there is a definite shift in the investors' choices of location towards Odisha. Its share of steel capacity is expected to increase from 12 per cent in 2010-11 to 25 per cent by 2016-17 and remain at that level for the next two decades. In addition, there is a preference for large plants which currently constitute about 65 per cent of the steel capacity. This share is expected to

Figure 8.10
Commodity-Wise Break-Up of Port Traffic, 2010-11
[Per Cent]



Source: Ministry of Shipping

increase to 76 per cent in 2016-17 and remain at that level for the next two decades. These locational and size preferences are likely to continue because it is expected that Blast Furnace Basic Oxygen Furnace (BF-BOF) technology and other hybrid technologies using hot metal will continue to predominate.

Small and medium units which now use about 70 per cent sponge iron will gradually shift to using scrap as the country accumulates more scrap. When that happens, there could be a shift of steel capacity to the steel-consuming areas. However, that is likely to happen only towards the end of the study period and is expected to be gradual.

PORTS

Ports are an important component of the transport system for the import and export of bulk commodities. They could also play a significant role in the movement of bulk commodities within the country through coastal shipping. However, this potential has been exploited very little.

India's 12 Major Ports are administered by the Union Government, while the 200 notified Non-Major Ports are under the state governments and union territories.

In 2011-12, total cargo handled by Indian ports was 913.9 million tonnes. As Figure 8.10 shows, POL, coal and iron ore make up 67 per cent of the cargo handled by Indian ports, while POL has the biggest share.

MAJOR PORTS

The 12 Major Ports handled 560 million tonnes of cargo traffic during 2011-12, more than 60 per cent of the country's total seaborne cargo. This figure comprises cargo loaded, cargo unloaded and transhipped to the tune of 194 million tonnes, 341 million tonnes and 25 million tonnes respectively. The capacity utilisation—560 million tonnes against 697 million tonnes was approximately 80 per cent.

In 2005, a Committee of Secretaries was set up to establish policies to improve port connectivity. The Committee recommended that each major port should be connected, at a minimum, by a four-lane road and a double-line rail (Chapter 4, Volume III on Ports and Shipping).

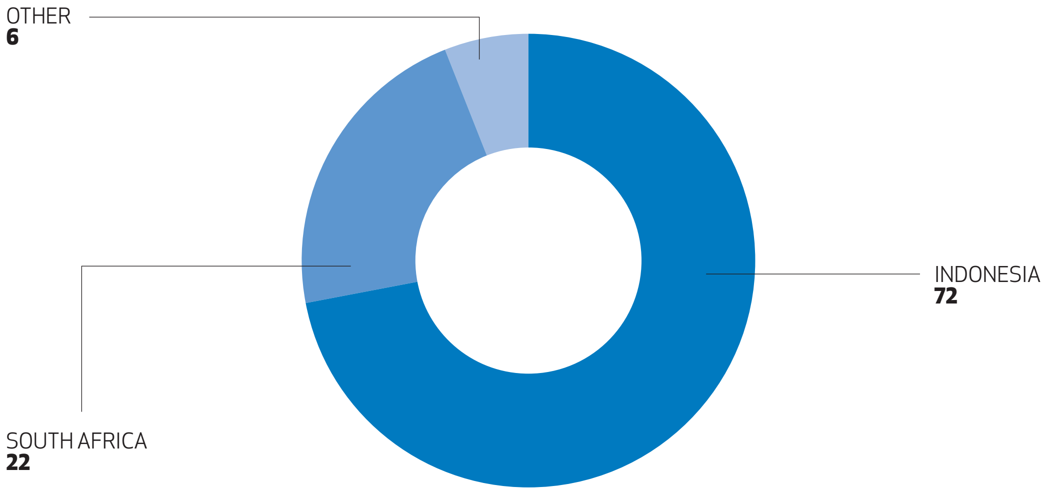
NON-MAJOR PORTS

Of the 200 Non-Major Ports, only a few ports are well-developed and provide all-weather berthing facilities. In 2011-12, only 61 ports—including ports at the Andaman and Nicobar Islands—were reported to have handled cargo traffic. Non-Major Ports in India collectively handled 354 million tonnes of traffic in 2011-12; up from 96 million tonnes in 2001-02. The CAGR in traffic during the decade was 14 per cent; double that for Major Ports. POL and its products (44 per cent) was the single largest commodity handled at Non-Major Ports in 2011-12.

IMPORT OF COAL

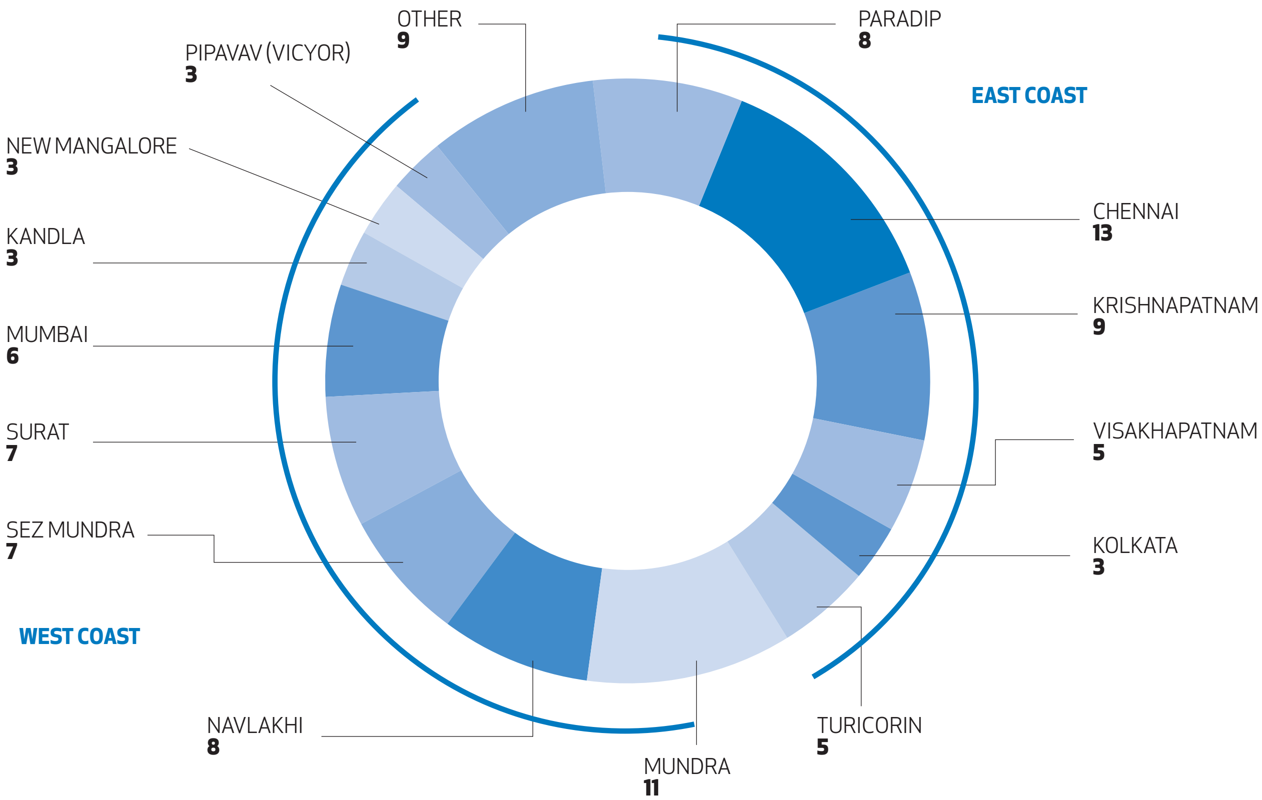
As discussed earlier, imported coal will bridge the deficit between the demand and domestic supply. In the case of thermal coal, this deficit is likely to increase because production of domestic coal will increase at a slower rate than demand. In the case of coking coal, there is limited availability in India and we are already importing a large part of the country's requirements. As steel production is expected

Figure 8.11
Import of Non-Coking Coal by Country of Origin, 2010-11
[Per Cent]



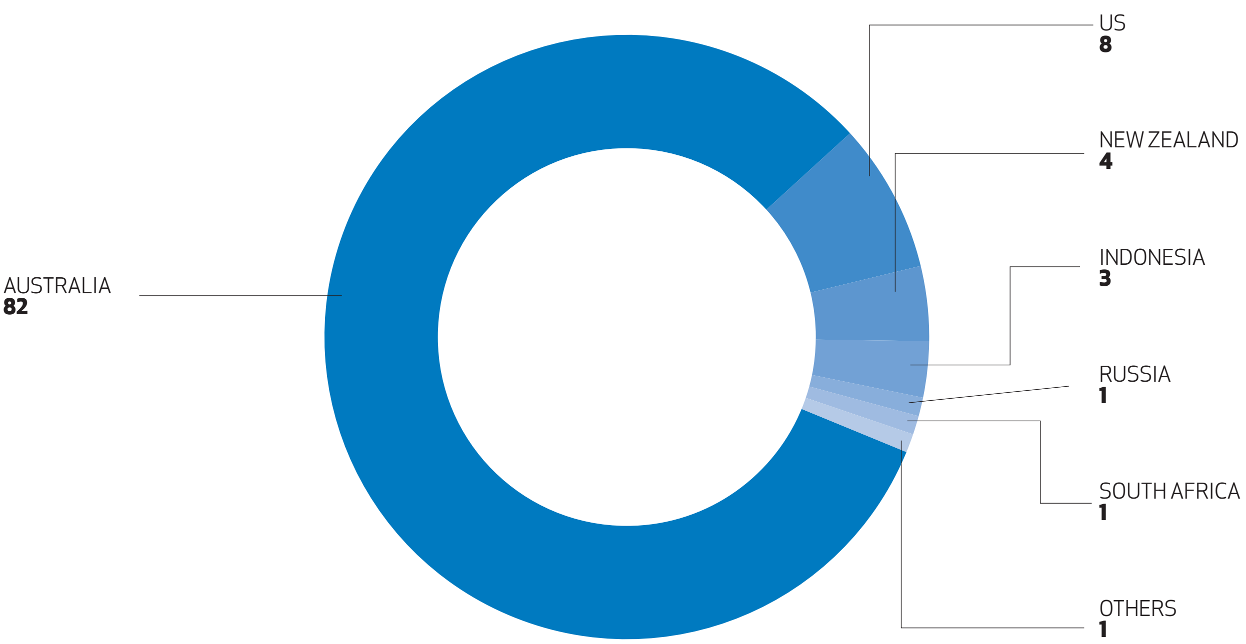
Source: Coal Controller's Organisation (2012b).

Figure 8.12
Destination Port-Wise Non-Coking Coal Imports, 2010-11
[Per Cent]



Source: Coal Controller's Organisation (2012b).

Figure 8.13
Import of Coking Coal by Country of Origin, 2010-11
[Per Cent]



Source: Coal Controller's Organisation (2012b).

to increase rapidly, the import of coking coal will also grow similarly. Imported coal is of considerably better quality than domestic coal. While most of the domestic coal has a Gross Calorific Value (GCV) in the range of 3600-4200 kcal/kg, the imported coal has a GCV in the range 5200-6500 kcal/kg. Australian coal is at the higher end of the range, Indonesian coal at the lower end and South African coal in the middle. Therefore, less imported coal is required than domestic coal for producing the same amount of electricity. A reasonable approximation is that one tonne of imported coal is equivalent to 1.5 tonne of domestic coal.

Using the data for FY 2010-11 to illustrate the pattern of India's coal imports, we see from Figure 8.11 that almost all the imported non-coking coal comes from Indonesia and South Africa with Indonesia being by far the biggest supplier (72 per cent). Figure 8.12 shows that these imports are roughly evenly distributed between destination ports on the east and west coasts.

Figures 8.13 and 8.14 show the pattern of coking coal import. Australia is clearly the predominant supplier (80 per cent). Relatively smaller amounts are also sourced from US, New Zealand, Indonesia and South Africa. About the 80 per cent of the coking coal goes to four ports on the east coast—Paradip, Kolkata, Vishakhapatnam and Krishnapatnam which are located close to large steel plants.

INTERNATIONAL COAL MARKET

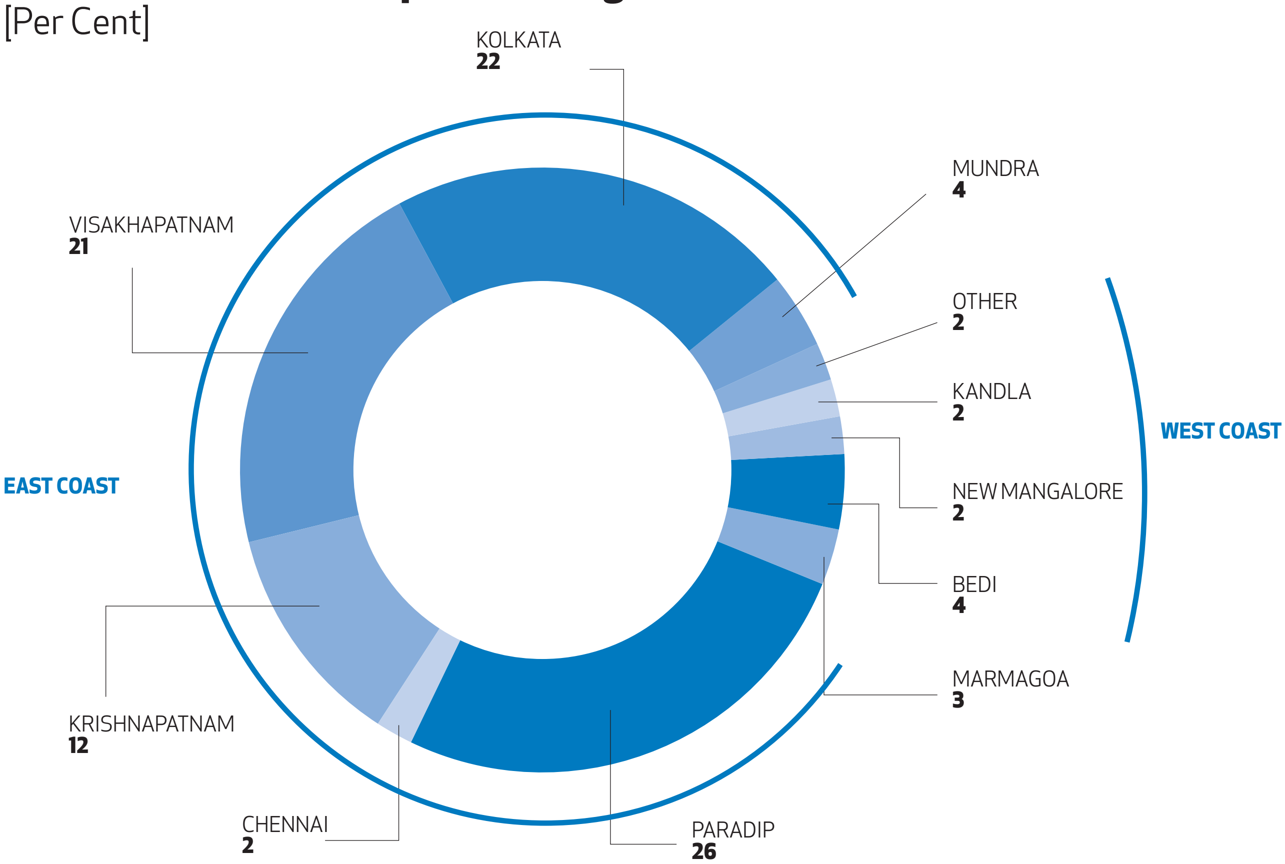
In 2009, China and India's imports of non-coking coal constituted about 12.5 per cent and 6.4 per cent respectively of the global market of 736 Mt. With imports by other countries remaining relatively steady, China and India are expected to account for about 90 per cent of the growth in the global market[4].

As China's consumption of coal accounts for about half the global consumption, a relatively small mismatch between its domestic supply and demand is likely to have a major effect on global markets[5]. China will be the driver of the global market. There are several uncertainties about whether Chinese domestic production will be able to meet the country's growing demand. One, In addition to boosting production at existing coal mines, new coal mines will need to be developed. Two, some of the new mines are very far from the major industrial cities, posing transportation challenges for infrastructure that is already congested. Three, as China intends to reduce the environmental impact associated with its coal consumption, significant investment will be required to upgrade power plants[6].

Most forecasts expect prices for thermal coal to remain high and hover around $100 per tonne (in current dollars) for the next several years[7].

4. CLSA (2010).
5. IEA (2011).
6. Ibid.
7. CLSA (2010); KPMG (2012); World Bank (2012).

Figure 8.14
Destination Port-Wise Import of Coking Coal, 2010-11
[Per Cent]



Source: Coal Controller's Organisation (2012b).

FUEL REQUIREMENTS FOR THE POWER SECTOR

India is geographically a vast nation with widely-dispersed population centres and burgeoning economic activity. As the economy modernises and diversifies its production base and living standards rise, reliable and affordable access to electricity in requisite quantities has become a critical imperative for sustainable and inclusive growth.

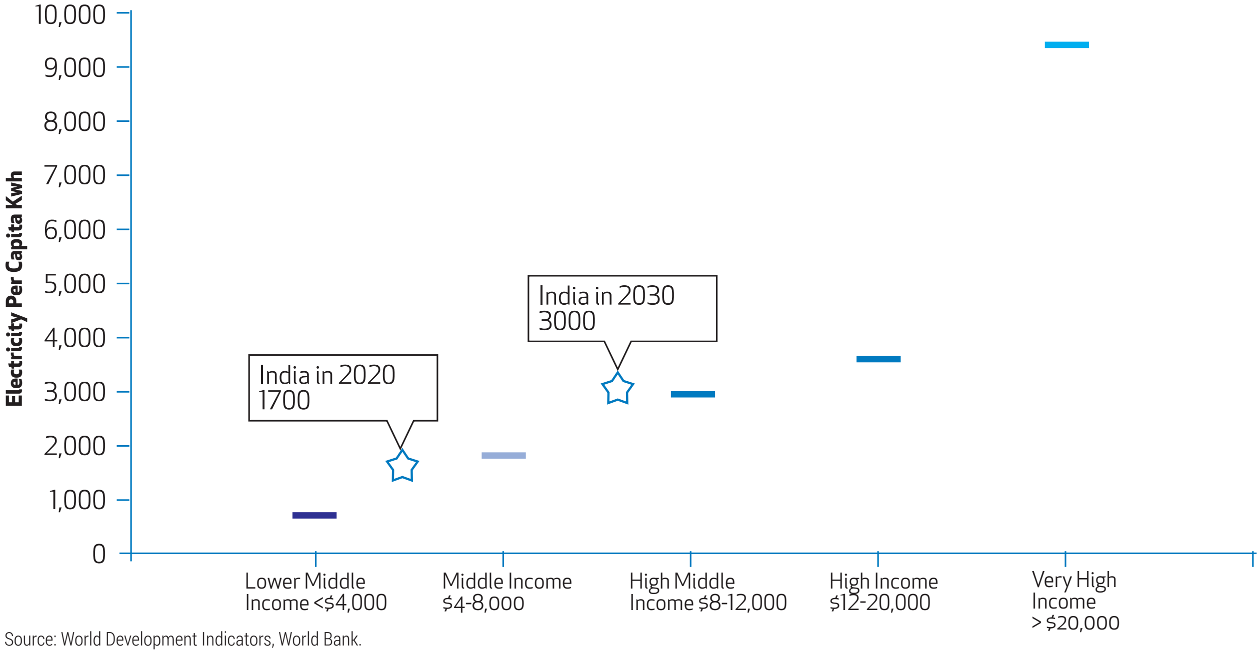
The primary energy supplies required to generate electricity include fossil fuels (coal, oil and natural gas), hydropower, fissile nuclear materials and renewable (mainly solar and wind) sources that are available in varying degrees domestically but fall chronically short in meeting needs in the aggregate. The current mix (both in terms of installed capacity and actual generation) is dominated by coal with a growing role for natural gas. This is likely to remain so for the next 20-30 years at least. India's coal reserves are concentrated in the eastern states, notably Chhattisgarh, Jharkhand and Odisha, as well as Madhya Pradesh, Bihar, Andhra and Maharashtra.

It is evident from the spatial distribution of domestic energy resources that energy needs to be transported over fairly long distances to make it available at the locations of electricity demand. Indeed, transportation of coal for power generation accounts for roughly 50 percent of the rail freight in India, contributing considerably to the increasing congestion in several key corridors of the railway network. Another telling indicator is that the cost of transporting coal to distant power generation facilities is often as much or more than the price of coal at the mine.

Energy imports are the pre-eminent component of our trade imbalance and current account deficits, and a major source of vulnerability to price shocks. Until recently, concern was focused almost exclusively on the hydrocarbon (petroleum) sector. Now attention also needs to be turned to coal availability. Coal imports have grown rapidly in the last few years, making India among the top two importers of steam coal whose entry and anticipated role in the international market is cited as a factor contributing to the rise in prices witnessed a couple of years ago.

There are several implications for the transport system. On the one hand, it is argued that transport bottlenecks have contributed to unreliability of delivering domestic coal to power plants. Others blame the inability to lift coal from mines (and/or nearby

Figure 8.15
Electricity Use and Per Capita Income



Source: World Development Indicators, World Bank.

railheads) to be a key factor as well for stagnant output of the collieries. The bigger issue, however, is to ensure that the transport system which had hitherto focused exclusively on moving domestic coal rapidly expands the coal handling capacities at ports and provides requisite rail connectivity to the demand locations. The strategic questions that arise naturally are 'which ports?' and 'how much?' in terms of their capacity.

Difficult as the questions may be, their complexity pales before the more profound issue of locating the power plants especially when two-thirds if not three-quarters of the electricity generation capacity that will exist in 2031-32 is yet to be put in place. An obvious question then arises: Would it not be better to transport energy over long distances as electricity over transmission lines instead of moving coal by rail (or gas by pipeline)?

The choice, involving a combination of economic, financial, technical and environmental considerations, is not as straightforward as comparing unit costs of transmission versus rail or pipeline transport. In addition to network effects and geographic constraints, additional complexities arise due to major differences in the properties (calorific value, ash and sulphur content) of domestic and imported coal, choice of technology and fuel type, and patterns of demand (e.g., peaking), to list a few. Yet, given the massive scale of expansion and the high costs involved, combined with the scarcity of financial resources and even more, the limited capacity to execute, it is imperative that the choices made minimise the aggregate cost to the nation of producing and delivering electricity.

Accordingly, a conceptually-simple linear programming model has been employed for the analysis. Annex I outlines this model. As a first approximation, intra-state movement has been ignored and each state constitutes both a demand centre as well as an electricity supply node. The supply options include, in principle, all forms of power generation including nuclear and renewable (solar and wind). These are pre-set at exogenously-determined maximum capacity which even at the most ambitious account for a small, almost negligible proportion. While hydroelectric facilities are also included, the focus is on thermal power generation, using domestic and imported coal as well as natural gas which differ in cost. The current costs of transport options—surface transport of coal, pipeline for gas and transmission line for electricity—once again differ significantly. Average fuel costs also differ. Domestic coal is the cheapest, imported coal and domestic gas (the price of which is regulated) are almost competitive while imported gas, at internationally-traded prices, is the dearest.

PLAUSIBLE DEMAND SCENARIOS FOR ELECTRICITY

The study used a set of three scenarios (base, high and low cases) that provided reasonable estimates of potential upper and lower bounds on demand that would be meaningful for evaluating infrastructure requirements.

BASE CASE

The Central Electricity Authority (CEA) produces electricity demand forecasts every five years under the Electric Power Survey of India (EPS). These forecasts are released to coincide with the national Five-Year Plans. EPS is one of the key electricity demand forecasts in the country. It is widely used across the industry and by the states and union territories as one of the most credible reference points. The forecasts are granular and provide details by state/union territory, and by end-use category. The EPS is developed using the partial end-use method, with inputs from the states and a wide range of stakeholders. The initial data feed is subjected to a high level of additional analysis and quality assurance before the EPS is released.

CEA's draft 18th EPS is used as the basis for the base case scenario. The EPS does not typically include captive generation, capturing only utility-level demand. However, for this analysis, the base case uses the draft 18th EPS adjusted to include captive generation. The base case in this scenario, thus, represents total electricity demand. Peak demand is derived by retaining the same energy to peak ratio provided in the draft 18th EPS.

HIGH CASE

The high electricity demand scenario is derived through a normative approach. It is important that this demand scenario is understood in the context and limitation for what it was developed: to provide an approximate upper bound for a high growth scenario.

The high electricity demand reflects aspiration goals for future per capita electricity consumption based on current observed patterns of consumption across countries. It implies that the Indian economy will have to grow in order to realise this demand. But such a normative approach avoids having to make a series of intermediate assumptions on economic growth and the electricity intensity of that growth.

Drawing on the internal and external risks, and to the energy system in particular, it can be inferred that energy delivery may not be able to keep up with the requirements of 8-9 per cent annual economic growth. An iterative process lends credence to consider the possibility of growth grinding down to 6 per cent.

Electricity use within any country represents a wide variety of underlying interrelated factors: income level, the level and composition of economic activity, electricity intensity, availability of energy resources, energy costs and supply infrastructure. One of the most visible relationships with electricity use is income level. A country's per capita electricity consumption exhibits strong correlation with its national income level as illustrated in Figure 8.15.

The relationship between electricity per capita and GDP per capita were econometrically derived using panel data that included a cross sectional of all countries (with available data for all years), covering 28 years between 1980 and 2008.

For the high demand scenario, the following annual per capita electricity assumption is used: 1700 kWh by 2020 and 3,000 kWh by 2030. In contrast, India's per capita electricity consumption for 2011-12 was approximately 880 kWh and is projected to reach approximately 1,500 by 2020-21 according to the draft 18th EPS.

The per capita electricity consumption in the high demand scenario might suggest that by 2020 India would achieve an income level of a middle income country, and by 2030, that of a high middle income country. Both these inferences assume a continued relationship between income and electricity demand.

The high electricity demand scenario is developed at the national level. However, the spatial distribution was modified to describe a future where the variation in the per capita electricity consumption across the states and union territories reduces over time, reflecting our aspiration not only for higher but also more inclusive economic growth. Low levels of per capita electricity consumption reflect a number of factors: lower income levels, low levels of industrialisation, poor access, poor electricity infrastructure and high energy cost.

Although each of these factors may play out differently across states, in totality, low levels of per capita electricity consumption is a strong indicator of low levels on the human development index. This scenario essentially represents a view of the future where government programmes and other targeted investments may move electricity demand to regions with lower level of human development indicators.

Like the base case, this scenario is derived using the regional distribution in the draft 18th EPS. Here, the standard deviation distribution of per capita electricity consumption in the draft 18th EPS is reduced by 25 per cent in 2021-22 and by 50 per cent in 2031-32. This has the effect of bringing the states at either end of the distribution closer to the centre without changing the mean of that distribution. The revised distribution is then used to parse the all-India demand of the high demand scenario to the state/union territory.

LOW CASE

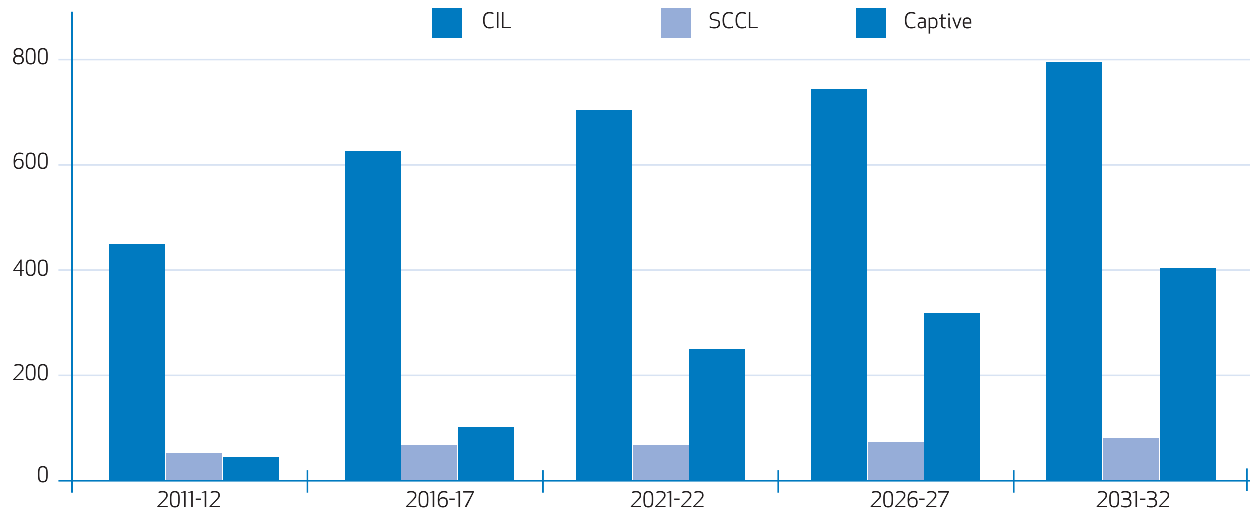
Drawing on the internal and external risks, and to the energy system in particular, it can be inferred that energy delivery may not be able to keep up with the requirements of 8-9 per cent annual economic growth. An iterative process lends credence to consider the possibility of growth grinding down to

Table 8. 7
National Annual Aggregate Demand by Scenario
[Terra Watt Hour]

CASE	2016-17	2021-22	2026-27	2031-32
Base	1,516	2,118	2,938	3,857
Low	1,329	1,736	2,228	2,808
Aspiration	1,591	2,422	3,334	4,603

Source: Working Group Report (2013).

Figure 8. 15
Total Domestic Coal Production
[Million Tonne]



Source: ICF International (Model Runs for Working Group Report 2013).

6 per cent. This is still far from a worst-case economic scenario, but is suitable for illuminating some of the strategic choices that need to be made. Accordingly, a low-case consumption scenario, closely corresponding to the 6 per cent case, was chosen. This is close to the consensus forecasts for Indian GDP growth in the near-term.

Table 8.7 shows the national aggregate electricity demand forecast for the three scenarios.

PARAMETERS AND ASSUMPTIONS

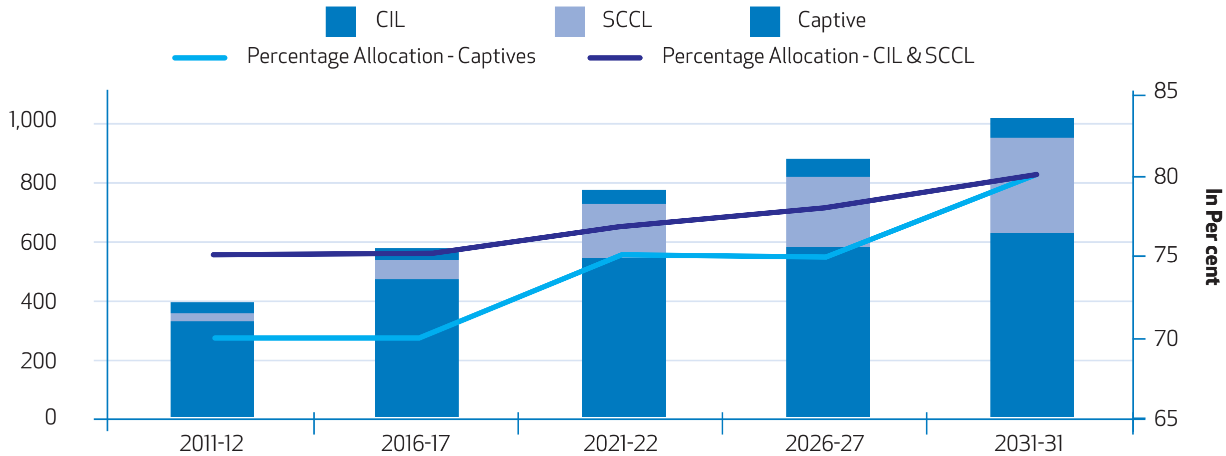
In order to focus on the strategic issues going forward and provide easiest traction for policy making, every effort has been made to ensure consistency with the work done in preparation for the 12th Five Year Plan by the various ministries and departments of the Government of India.

Capacity Additions: For the 12th Five Year Plan, capacity additions have been considered as per the latest CEA and MoP plan. This consists of approximately 66 GW of coal-based plants plus 1.7 GW of nuclear, 4 GW of gas and 11.5 GW of hydro capacity additions. Renewable capacity is over and above the conventional capacity. State level constraints for capacity additions have been modelled as per CEA for the Plans beyond 12th Plan.

Coal Supply: The percentage of coal allocated from CIL and SCCL to the power sector is projected to reach 80 per cent by 2031-32 from the current allocation of 75 per cent of the total coal production. Allocation to the power sector from captive mines is also projected to reach 80 per cent by 2031-32. Lignite is also supplied to the power sector.

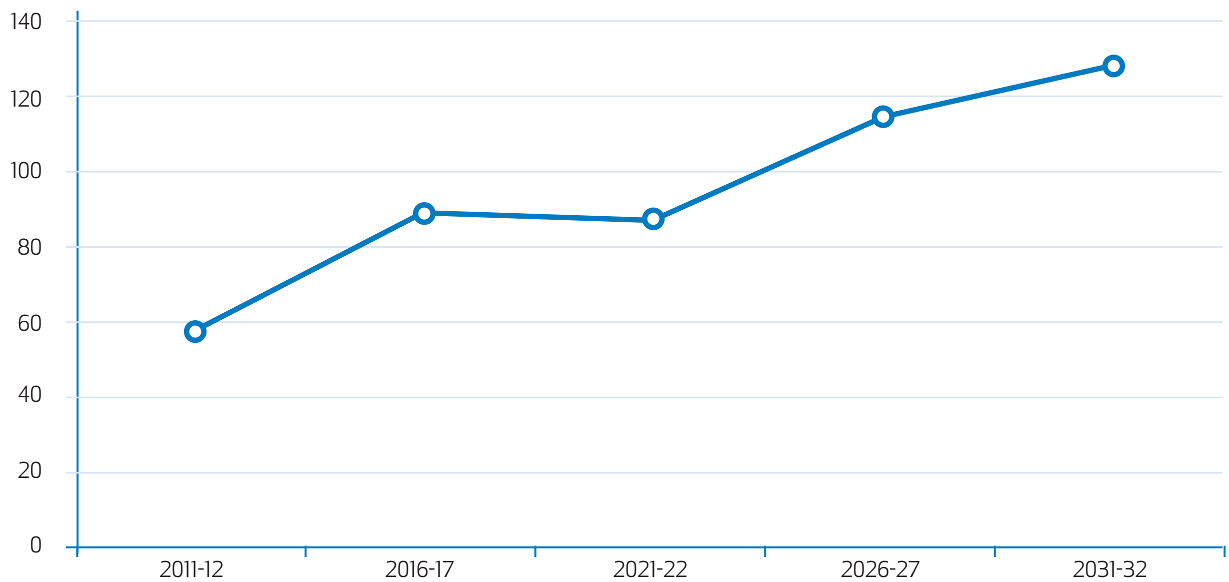
Fuel Prices: Coal prices from various subsidiaries are taken as per CIL's notified prices. Imported coal

Figure 8.17
Coal Allocated to Power Sector
[Million Tonne]



Source: ICF International (Model Runs for Working Group Report 2013).

Figure 8.18
Gas Demand by Power Sector
[MMSCMD]



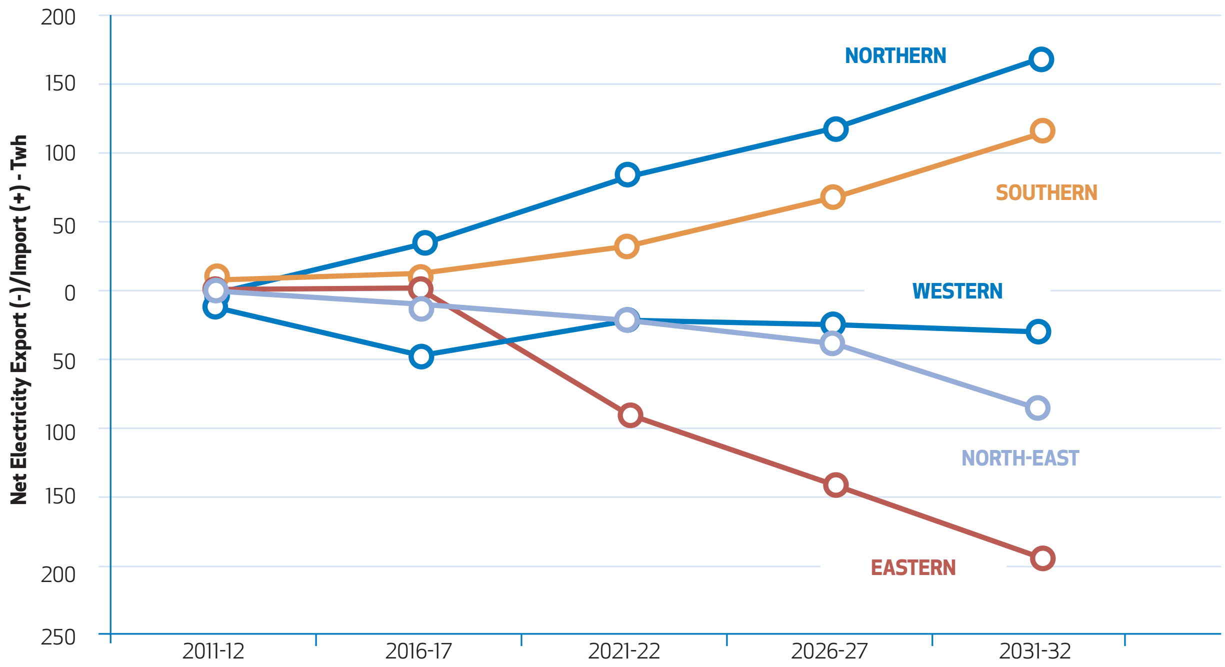
Source: ICF International (Model Runs for Working Group Report 2013).

price forecasts are as per the World Energy Outlook 2011 global coal price forecast and analysis shared by ICF International. Domestic gas prices are as per the prevailing market prices from the various sources (APM, NELP, JVs). LNG prices are based on IEA's WEO forecast for Asian deliveries after adjustment, corresponding to the actual contractual arrangements available for Indian buyers.

Gas Supply: The basis for gas production is the DGH-approved gas production plans for various existing and upcoming gas fields. It also reflects analyses commissioned for various stake holders including Petroleum Planning and Analysis Cell (PPAC), Ministry of Petroleum and Natural Gas (MoPNG), DGH, GAIL and others. The longer- term projections for the business as usual (BAU) and other gas supply cases (including conventional and unconventional gas) as well as supply to the power sector is based on international consultants' analysis of gas utilisation policy and expectations around supply in the longer term. More specifically, the gas supply share to the power sector is expected to be in the range of 45-50 per cent of the total production.

Renewable Potential: These assumptions are driven mainly by the requirement as per renewable portfolio obligations (RPOs) and the generation potential for various renewable energy technologies. As per the National Action Plan on

Figure 8.19
Inter-Regional Electricity Transmission Flows



Source: ICF International (Model Runs for Working Group Report 2013).

Climate Change (NAPCC), 15 per cent of generation should come from renewable energy by 2022. For wind potential, we have taken the latest estimates of 109 GW made by Centre for Wind Energy Technology (CWET) for a hub height of 80 meters. Various foreign institutions such as Lawrence Berkeley National Laboratory (LBNL) in the US provide even higher estimates of 700-1,500 GW for wind potential for India. Solar potential is based on JNNSM targets of 22 GW by 2021-22. For biomass and small hydro, the potential estimated by MNRE has been used.

Cost Parameters: Average, levelised parameters, constant in real terms, have been used for costs of electricity generation, coal mining as well as commodity transport and power transmission.

LIMITS ON CAPACITY ADDITIONS AT STATE LEVEL

There are limits on the amount of capacity that can be added per year, both on the national and state level. These constraints were necessary to prevent excessive concentration of power plants in some states, to reflect limits due to limited land and water availability, and to prevent further environmental degradation in areas that are already critically polluted.

More importantly, political economy considerations suggested that at least half of the incremental power consumption in each state in each Plan period must be supplied by generation capacity within that state. Without such a constraint, it was found, not surprisingly, that imported coal would go to coastal states such as Andhra Pradesh, Gujarat and Maharashtra as this would minimise the cost of imports given the overall levels of availability of domestic coal. The patterns of use of domestic and imported coal that emerged pointed to a likelihood of political wrangling as well as issues of inter-state equity with some fiscal ramifications owing primarily to the large differentials in price of domestic and imported coal. One recent signal of times to come is news reports of protectionist noises from resource-rich states.

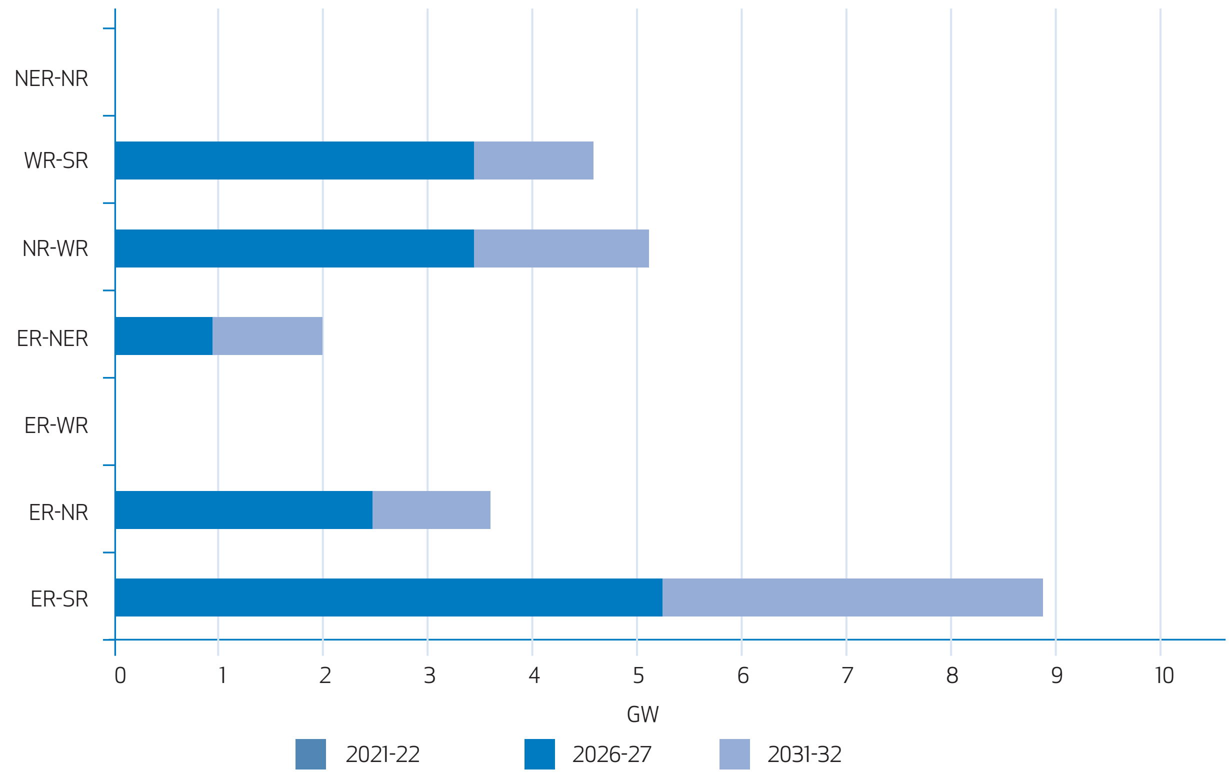
FINDINGS AND INSIGHTS FROM THE ANALYSIS

The key outputs from the modeling and analytical effort comprise the state-wise generation of electricity and the associated sources of primary energy. Since our focus is on transportation, particularly of coal, the presentation below is confined to flow of electricity and movement of both domestic and imported coal.

BASE CASE

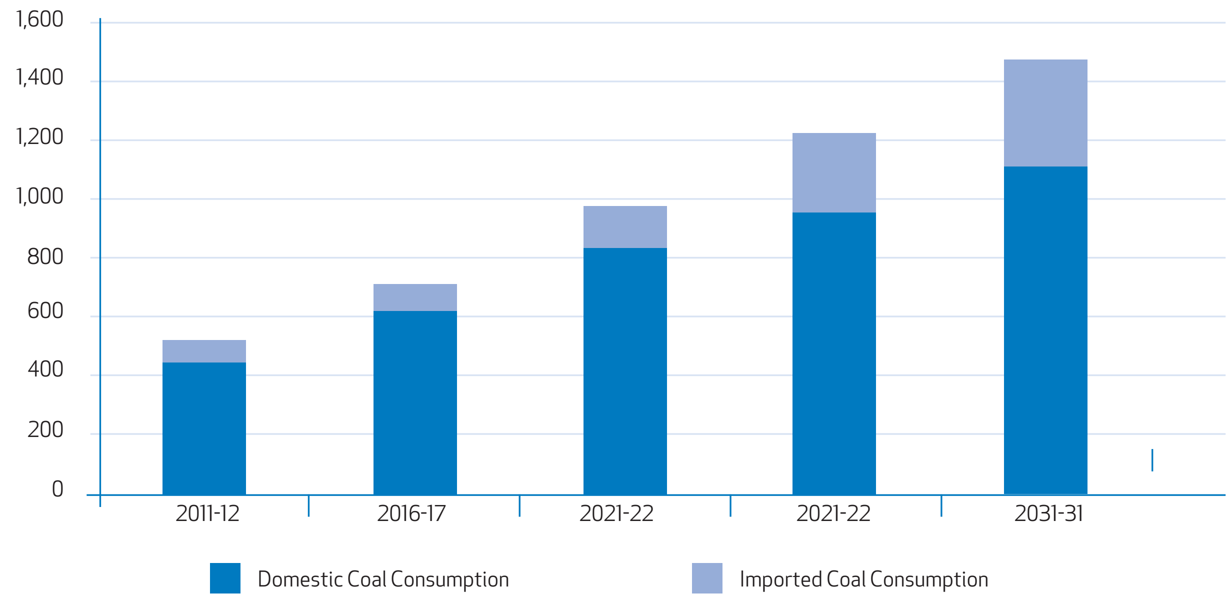
In this scenario, the Northern and Southern regions, with their burgeoning demand, become major importers of power, while the Eastern region emerges both as a supplier of coal and an exporter of electricity as power generation plants are located

Figure 8. 20
Transmission Capacity Additions



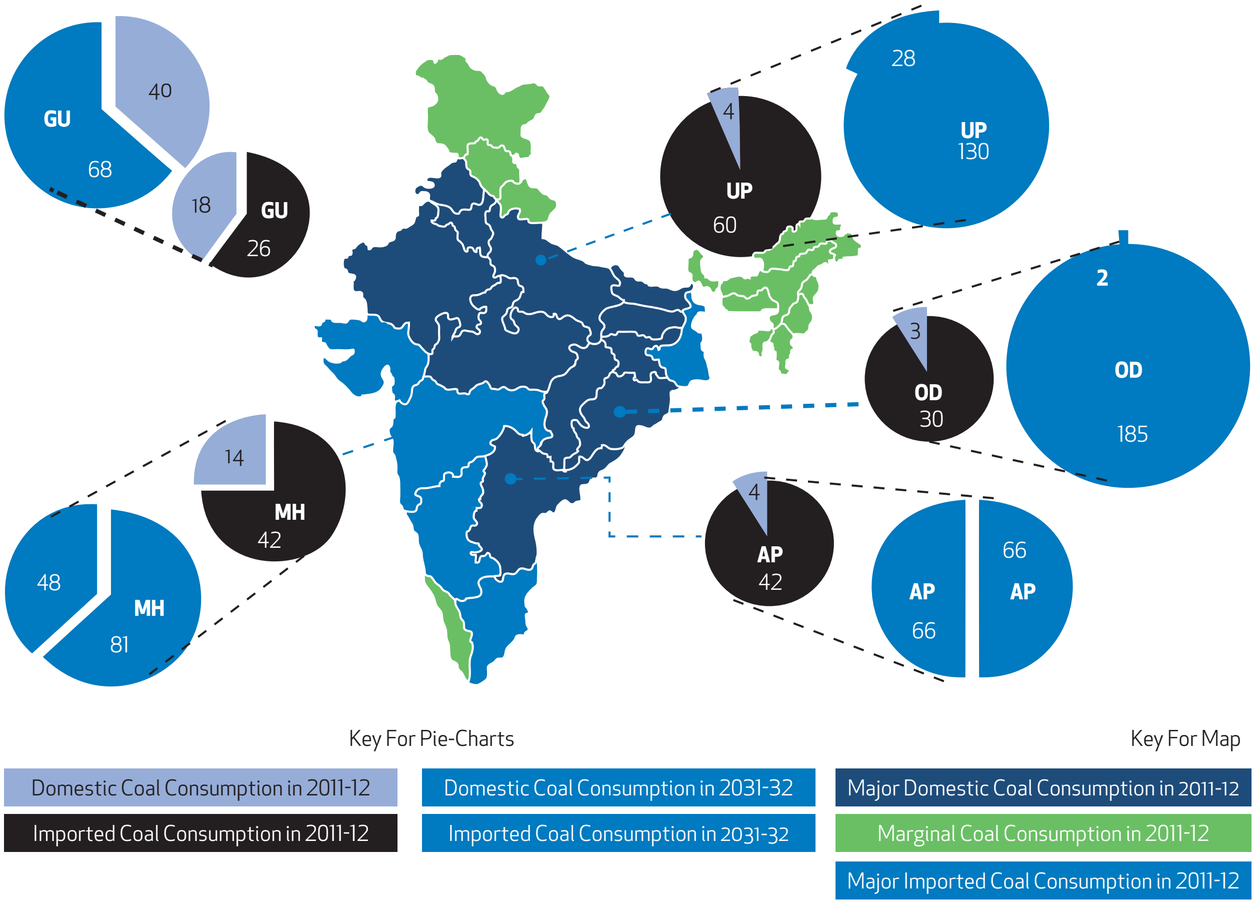
Source : ICF International (Model Runs for Working Group Report 2013).

Figure 8. 21
Consumption of Coal
[Million Tonne]



Source: ICF International (Model Runs for Working Group Report 2013).

Figure 8. 22
Base Case, State-Wise Coal Consumption, 2011-12 and 2031-32
[Million Tonne]



Source: ICF International (Model Runs for Working Group Report 2013).

near the mines. Odisha, for example, is expected to see a massive increase in electricity generation. The North-Eastern (in light of its hydropower potential) and Western regions also export electricity but much less than the major Eastern states.

The expected pattern of electricity flows in the base case scenario point to a major need to expand transmission capacity not only from the Eastern region but also from the Western to the South and North as shown in Figure 8.20. As discussed subsequently, however, the patterns change substantially under the other scenarios. So a robust risk analysis could help prioritise and programme transmission capacity investments, more so, to also maintain grid balance.

INCREASING RELIANCE ON IMPORTED COAL

Domestic coal supply growth (including coal from captive mines and lignite) is not sufficient to meet the increasing demand. Imported coal makes up for the shortages in domestic supply. Demand for imported coal will rise from 74 Mt in 2011-12 to 355 Mt by 2031-32.

The changing mix between imported and domestic coal varies considerably for the states as depicted in Figure 8.22. In addition to Gujarat and Maharashtra, which are already importing coal for power generation, Andhra Pradesh emerges as a major destination of imported coal with for half the total coal consumed in the state being imported. The logic is straightforward: importing coal directly to coastal states minimises transport costs by avoiding land transport over long distances.

States such as UP which are far away from the coast also need imported coal because domestic suppliers are unable to meet the large increase in demand. Thus, not only is there a need to dramatically expand the capacity of ports to handle the massive increases in coal imports but also to ensure rail connectivity to deliver in the hinterland.

The large volume flow of coal to the Eastern coastal states indicates a need for coastal shipping, which can expand more rapidly than rail links, as the preferred mode of transport.

MOVEMENT OF DOMESTIC COAL BY SURFACE TRANSPORT

The analysis also yields considerable insight in terms of planning priorities. Figure 8.23 for the base case depicts the volumes of coal movement required over the next two decades. It shows the dramatic increase in the volume of coal transported, mainly in the Eastern states. In addition, the volumes for some routes fluctuate. For example, the volume of coal transported to Rajasthan from the East decreases in 2021-22 and then increases by 2031-32. The volume for states like Gujarat and Maharashtra remains fairly constant, their growth being fired by increased imports of coal.

Some salient implications of the transport pattern for coal emerge. One, high priority to address the infrastructure requirements to enable flows depicted in 2021-22. Given the gestation periods in constructing rail links, these projects need to be undertaken now. In particular, the Eastern Freight Corridor and the links to it from the mining areas need urgent action.

Two, the differences between the requirements over the two decadal periods suggest some caution and suitable risk analysis to guard against the possibility of stranded assets due to major shifts in patterns of supply. The coal movement patterns under the other two scenarios discussed later, elucidates this point. Such risks can be hedged through choice of alternative routes.

Three, the large volume flow to the Eastern coastal states indicates a need for coastal shipping, which can expand more rapidly than rail links, as the preferred mode of transport. Moreover, there may be efficiency gains in coordinating the investments with the expansion in capacity of dedicated coal terminals to handle imports. Of course, this may not be possible if separate ports and/or terminals are set up for coastal shipping.

LOW CASE

In this scenario, a preliminary iterative and investigative analysis suggested that if the imports of coal were constrained to the present level, the electricity requirements compatible with a lower rate of economic growth of around 6 per cent, could be met. Here, domestic coal almost meets the overall increase in coal requirement in the country. Southern states will need to rely on domestic, coal-based generation from Eastern and Western states and hence their dependence on other states for electricity will be higher than in the base case.

The dependence of Northern states on other states for supply of electricity is expected to be low compared to the base case. Accordingly, most of the transmission capacity required has to be built towards the Southern region.

A significant and counter-intuitive result emerges from the analysis. Under the low growth scenario the movement of domestic coal actually is larger and puts even more pressure on the rail freight system. Reason: The decrease in coal use is mainly that of imports which would typically land near the demand centres in the coastal states. Domestic coal is utilised in the same volumes as in the other cases but in the low case has to move longer distances to more far-flung locations, thus increasing the surface transport burden. The economic salience of this phenomenon increases further when one considers that the low growth scenario most probably corresponds to constrained public resources and more severe infrastructure bottlenecks.

HIGH CASE

This scenario recognises that the base case itself involves considerable stretch on the supply of infrastructure as well as availability of financial resources. So, to maintain a healthy realism and to also factor in the tremendous and hitherto under-tapped potential of new technologies to increase efficiency and increase the market penetration of renewable energy, certain assumptions on the supply side of the system were also modified. Specifically, the share of renewable energy is projected to rise to 18 per cent in 2031-32. An additional increase of one percentage point in efficiency of power generation every five years is incorporated. Gas supply is also projected to be larger.

Nevertheless, in this scenario, coal imports grow more dramatically and go to coastal states. The Southern region also becomes an exporter of electricity while the Northern region alone remains an importer of electricity. Figure 8.28 depicts the highlights of coal consumption in different states, electricity transmission flows and finally the movement of coal by surface transport. A major implication is the need to expand port capacities even faster, to handle coal imports.

OVERALL OBSERVATIONS

A review of the modeling results in greater detail, yields the following conclusions:

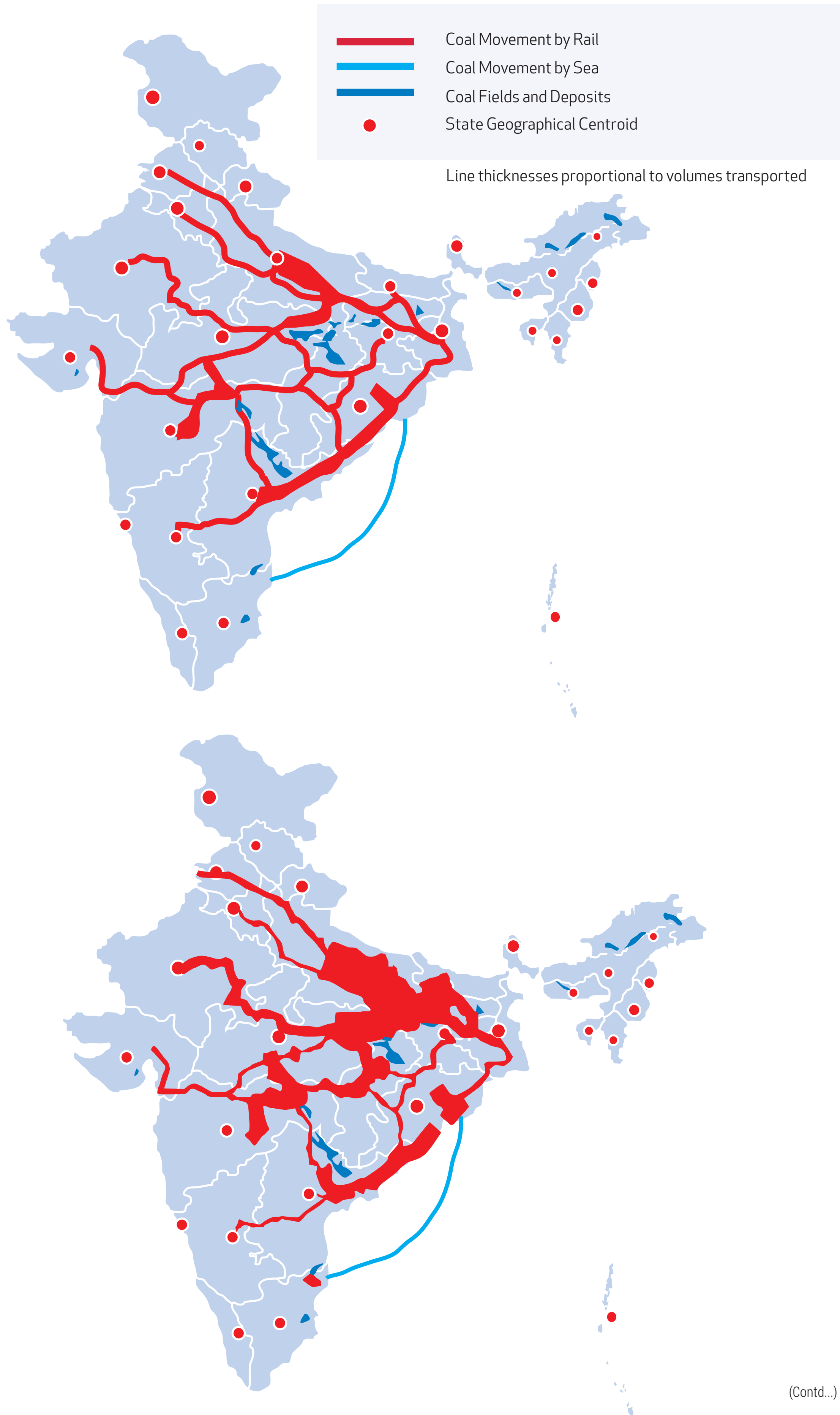
- Coal continues to dominate the energy mix. Its share declines slightly from 68 per cent currently to 65 per cent, 62 per cent and 60 per cent in 2031-32 in the base, low and high cases respectively.
- Coal continues to dominate the capacity mix also. However, its share in the capacity mix declines more rapidly than its share of the generation mix. Currently it is about 55 per cent

Figure 8.23

Comparison of Coal Movement: Base Case

2011-22

2021-22



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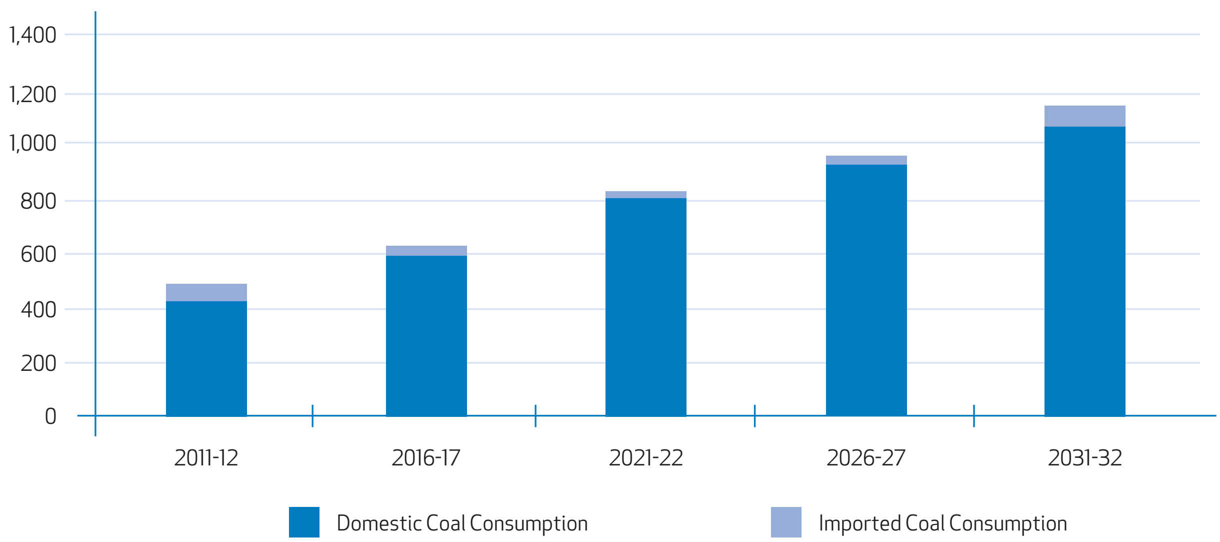
2031-32

(Contd...)

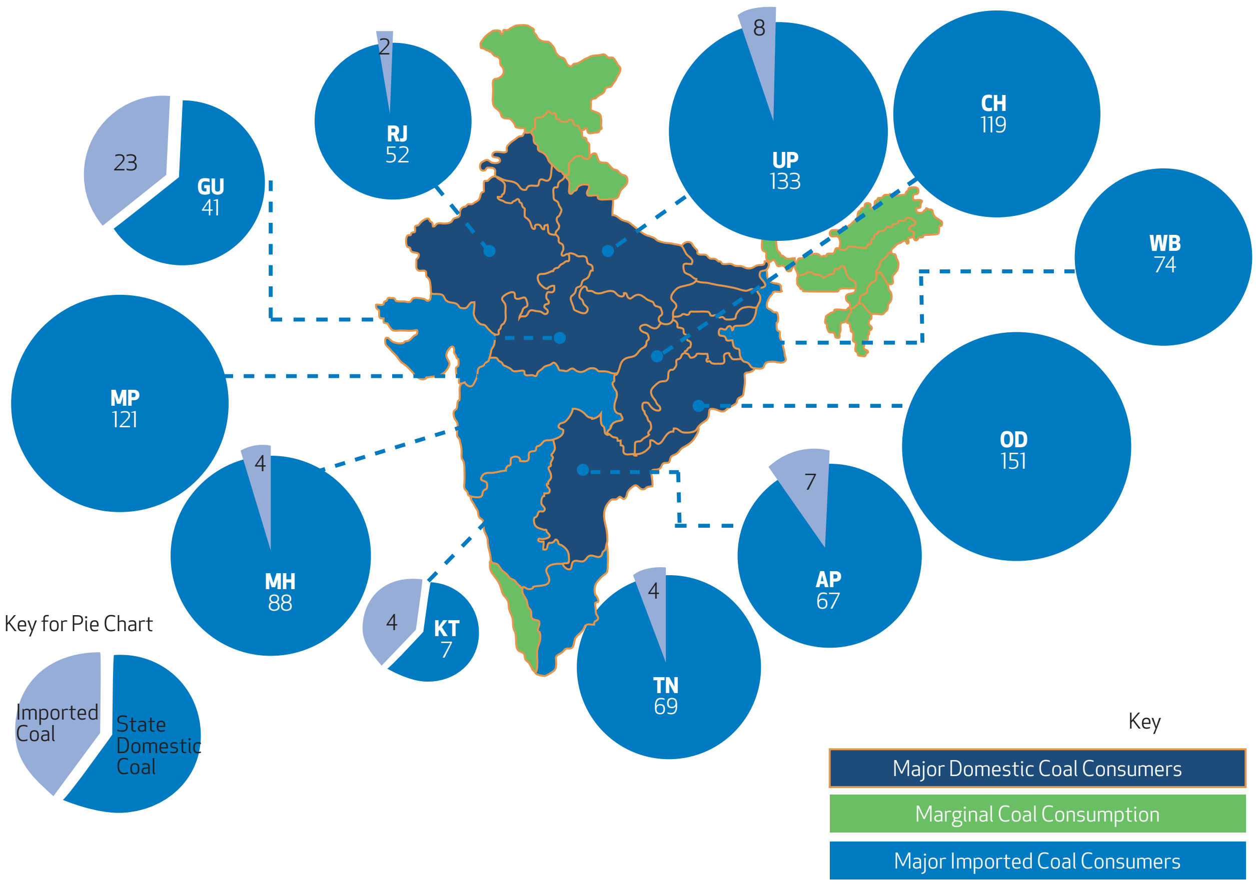
Source: Working Group Report (2013).

Figure 8.24
Coal Consumption: Low Case



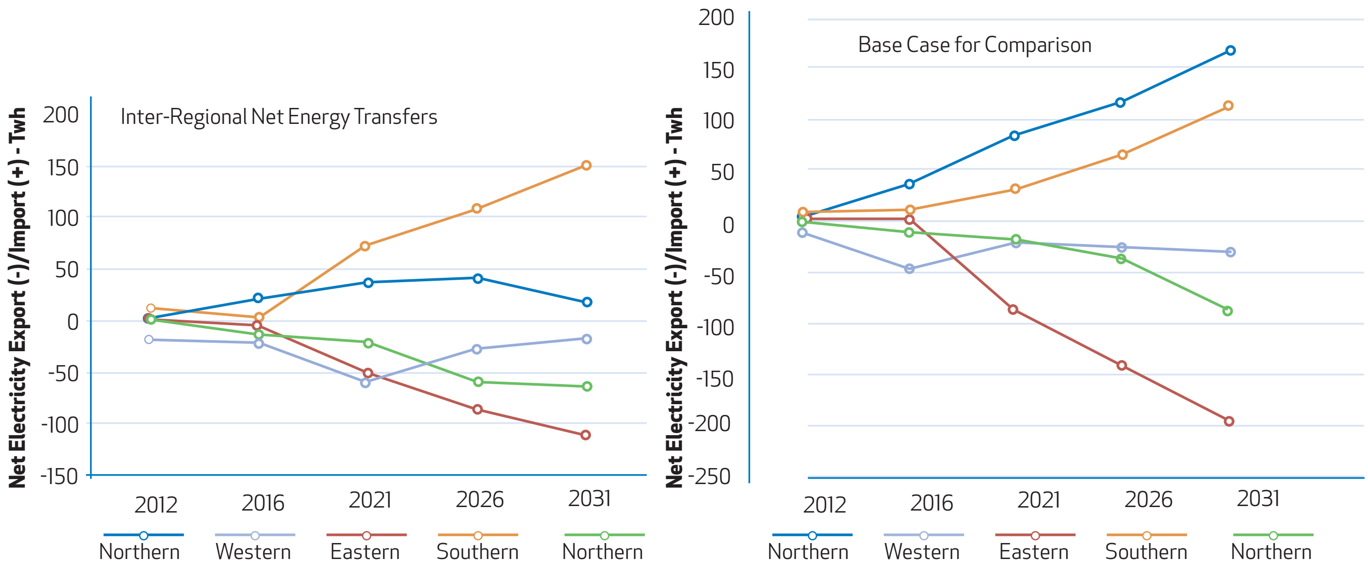
Source: ICF International (Model Runs for Working Group Report 2013).

Figure 8.25
State-wise Coal Consumption, 2031-32: Low Case
[Million Tonne]



Source: ICF International (Model Runs for Working Group Report 2013).

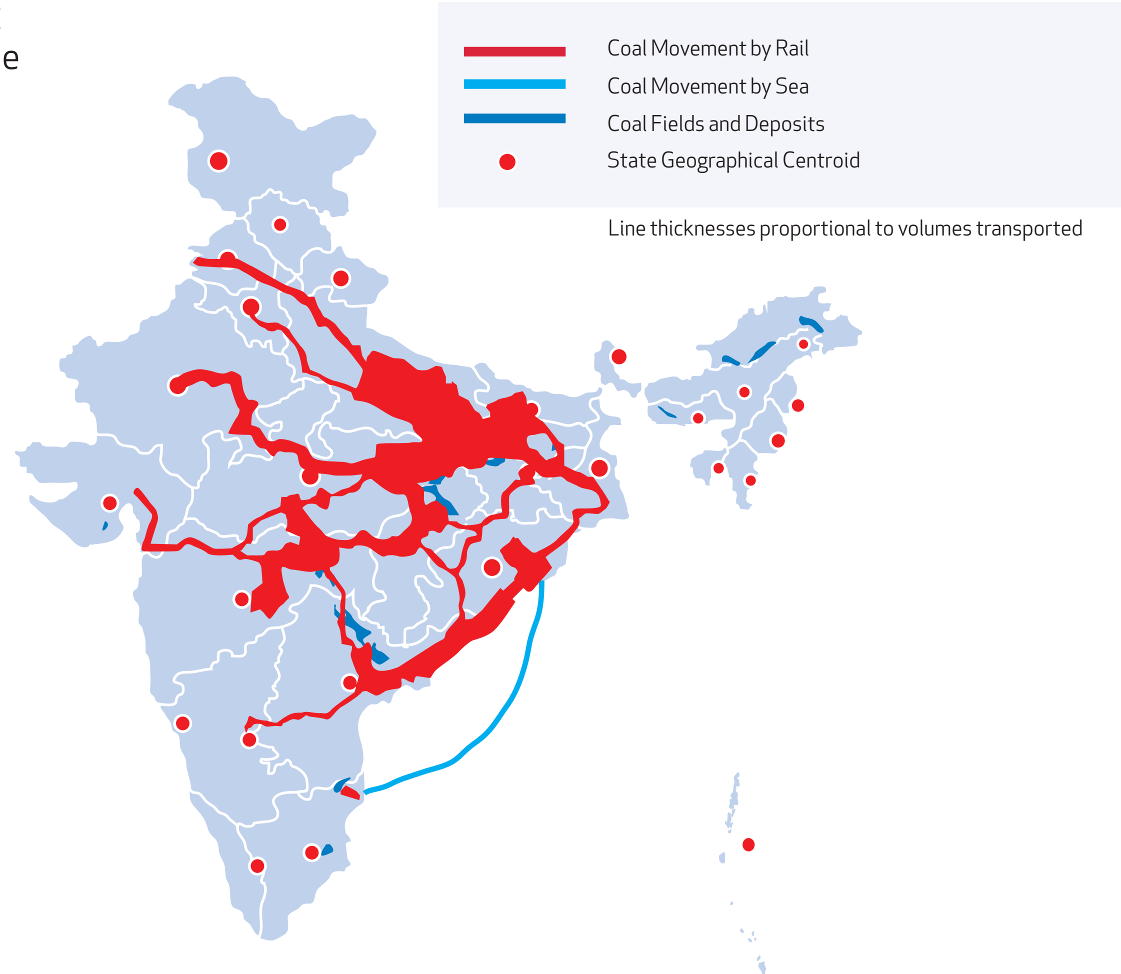
Figure 8.26
Transmission: Low Case



Source: ICF International (Model Runs for Working Group Report 2013).

Figure 8.27
Comparison of Coal Movement in 2031-32 in the Three Scenarios

2031-32
Low Case



2031-32
Base Case

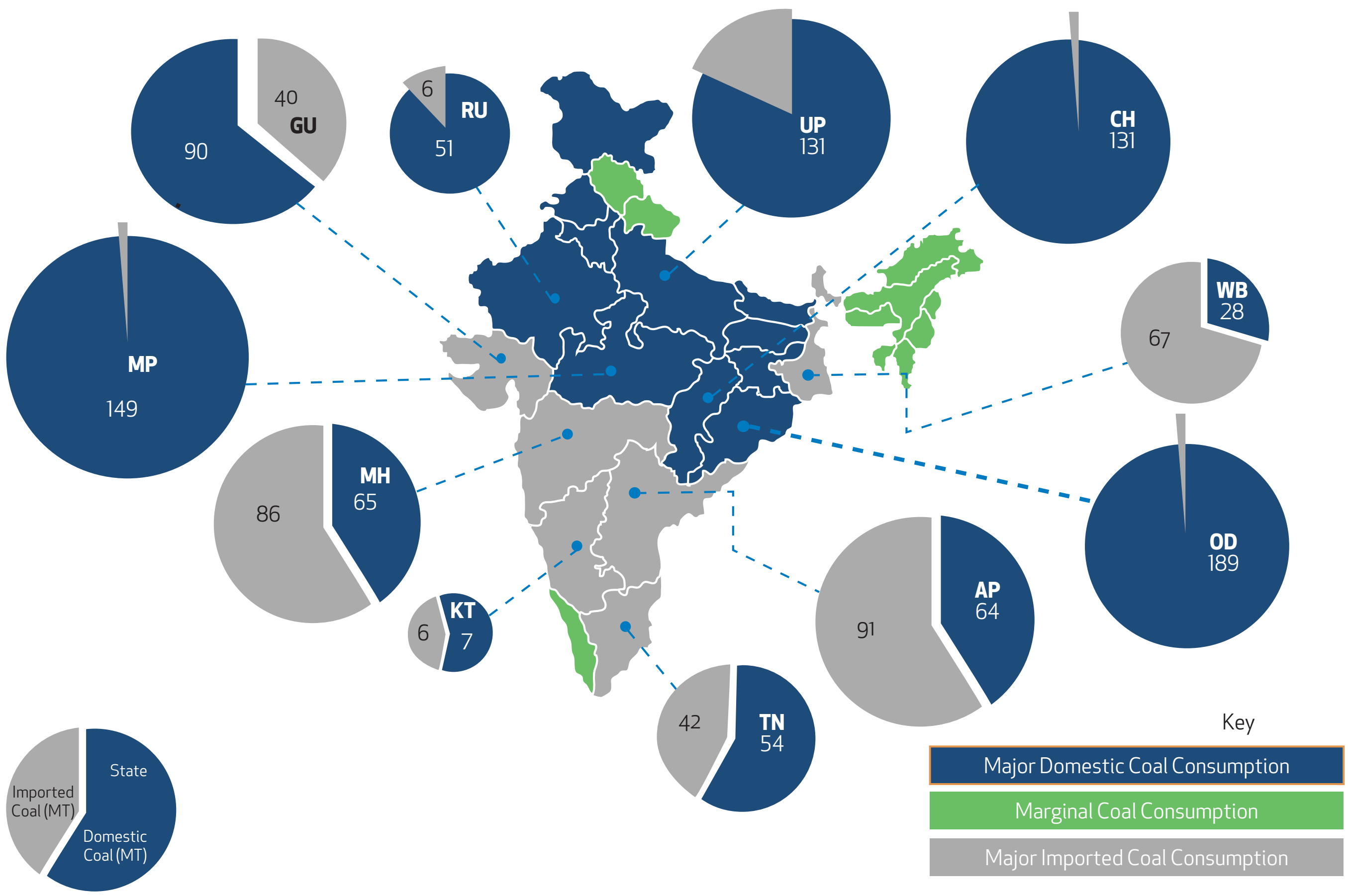
(Contd...)

2031-32
High Case

(Contd...)

Source: Working Group Report (2013).

Figure 8.28
State-Wise Coal Consumption, 2031-32: High Case



Source: ICF International (Model Runs for Working Group Report 2013).

Table 8. 8
Consumption of Domestic Coal for the Power Sector
[Million Tonne]

2011-12	2016-17	2021-22	2026-27	2031-32
442	614	828	951	1,112

Source: ICF International (Model Runs for Working Group Report 2013).

Box 8.1
Coal Beneficiation

The intrinsic quality of Indian coal and the way it is mined, results in poor-quality coal. It has high ash content and contains extraneous material such as shale and sandstone. Transport of run-of-mine (ROM) coal is wasteful because the extraneous material and ash are also transported with the coal. Coal Beneficiation (or coal washing) is a process by which the quality of coal can be improved, by either reducing the extraneous material or reducing the ash content or both.

Coal beneficiation is usually done by crushing the coal and putting it in a liquid to separate the lighter coal (low ash content) from the heavier coal (high ash content) and the extraneous material. Because beneficiated coal has a higher calorific value, transport costs are reduced. In addition, there are many benefits for power plants:

- Reduction in the required size of the power plant because less coal is required to produce the same electrical output.
- Better performance because of greater uniformity in the coal that is used.
- Reduction in wear and tear because extraneous material has been removed.
- Reduction in the amount of fly ash that is produced.

The Ministry of Environment and Forests (MoEF) issued a notification that the following power plants use coal with an ash content of 34 per cent or less with effect from June 2001. This was later extended to June 2002:

- Power plants at a distance greater than 1,000 km from the pit head; MoEF has proposed an amendment to reduce the distance to 500 km. CIL has to ensure that there are enough washeries to meet this stipulation[8].
- Power plants located in critically-polluted areas, urban areas and ecologically sensitive areas;
- Power plants using fluidised bed combustion (CFBC, AFBC and PFBC) and integrated gas combined cycle (IGCC) technologies are exempted from this requirement.

Beneficiation results in some loss of coal. The yield decreases as the level of washing is increased. The optimum level of beneficiation depends on several factors: cost of beneficiation; yield; price of unbeneficiated (ROM) coal; economics of the power plant; distance to the power plant and transportation costs. It is difficult to give a single number for the savings in transportation costs. However, for typical Indian coal, the estimated savings in transportation costs for moving coal 1,000 km are about 10-12 per cent[9].

While beneficiation of coal provides many benefits, it also imposes severe stress on the environment. Beneficiation usually uses a lot of water which can be a problem in water-scarce areas. More troubling, the used water gets polluted with coal dust and harms the local environment. The use of dry processes is being explored, and they may provide better performance but at a higher cost. There is not much experience with them yet.

Rejects from beneficiation are often not properly disposed off, and they degrade fertile land and are susceptible to spontaneous combustion. Earlier efforts to burn rejects using fluidised bed combustion

(Contd...)

8. MoP (2012: 45).
9. MoC (2012); Anderson and Nowling (2012).

(FBC) were not very successful. More recently though, private sector FBC plants are reported to be operating successfully[10].

There is about 44 GW of capacity at a distance of more than 1,000 km and it would require about 175 Mtpa of beneficiated coal to comply with MoEF's notification. If the distance is reduced to 500 km, about 90 GW of capacity would require about 360 Mtpa of washed coal. Existing capacity for coal beneficiation is insufficient. Currently it is 96 Mtpa for non-coking coa[11], although only half is being utilised (based on CCO, Coal Directory, 2010-11). Coal India Ltd (CIL) has plans for adding 20 new washeries with a total capacity of 111 Mtpa, of which 19 Mtpa will be for coking coal and the remaining 92 Mtpa for non-coking coal. Together, this capacity could theoretically be just sufficient to fulfill the requirements of MoEF.

Beneficiated coal is not being used by power plants due to both supply and demand factors. Suppliers of washed coal see very little incentive in producing washed coal. There have been conflicts between CIL and its customers over who should bear the costs of washing. On the other hand power plants do not demand washed coal because there is no penalty for not complying with MoEF's directive.

and declines in 2031-32 to 45 per cent for the base and low case and 37 per cent in the high case scenario.

- The share of natural gas in the energy mix declines for all three scenarios because it is increasingly used as an intermediate resource in the dispatch order instead of as a base load resource as done currently.

Annexes of the WG report give state-wise and region-wise details for the terminal years for each of the next four Five-Year Plans for consumption of domestic coal; consumption of imported coal; consumption of natural gas; conventional generation capacity; renewable energy capacity; and net transmission.

DOMESTIC COAL USAGE

Table 8.8 shows domestic coal usage. It remains the same in all three scenarios because domestic coal is the least expensive fuel for electricity generation and is used first to meet the nation's electricity requirements. After the domestic coal available in a particular year is exhausted, other fuels are considered by the model.

The amount of coal needed for the power sector even today is large and it will grow about threefold by 2031-32. Moving it will require increasing rail infrastructure for transportation which poses great challenges for the already-strained Railways. Coal beneficiation (also known as coal washing) is one way to reduce transportation requirements. However, this comes at a cost. Box 8.1 on coal beneficiation describes the benefits and some of the environmental costs of coal beneficiation.

IMPORTS OF COAL

Table 8.9 shows consumption of imported coal for states that consume more than 3 Mt in any year and under any of the three scenarios. The amount for the entire country is also shown in the last row. Total imports are expected to grow dramatically; almost five-fold over the next two decades in the base case, and six-fold in the high case. As can be seen from Table 8.9, most of the imported coal is expected to be used in the coastal states: AP, Gujarat, Maharashtra, Karnataka, Tamil Nadu and West Bengal. However, there are other states such as Haryana, Punjab, Rajasthan and UP that are also likely to be significant consumers of imported coal.

CLIMATE CHANGE AND USE OF COAL

No study of the power sector can ignore concerns about climate change and the detrimental effects on the global environment from power generation, particularly from the burning of coal. India must do what is reasonably possible to limit emissions of green-house gases (GHGs).

The scenarios were therefore modeled to reflect significant efforts to make the energy mix cleaner through the use of increasing amounts of renewable resources and gas. In particular, renewable resources have been pushed aggressively. In the base case, the capacity from renewable resources increases almost nine times over the two decades. In the high case, the introduction of renewable is even more aggressive, increasing by about twice that amount (18 times). Gas use also increases by a factor of two over the two decades, but gas use is constrained by the limited supply of gas over the next two decades.

These large increases in the use of renewable energy and natural gas were incorporated in the scenarios in spite of the very large cost advantage with coal based generation. Currently, natural gas based generation costs about 1.5 times domestic coal based generation on a per kWh basis. In the case of renewable energy,

10. MoC (2012).
11. SG-2 (2011).

Table 8.9
Consumption of Imported Coal for Select States
[Million Tonne]

	BASE CASE					LOW CASE					HIGH CASE				
STATES	**2011-12**	**2016-17**	**2021-22**	**2026-27**	**2031-32**	**2011-12**	**2016-17**	**2021-22**	**2026-27**	**2031-32**	**2011-12**	**2016-17**	**2021-22**	**2026-27**	**2031-32**
AP	4	11	27	49	66	4	5	5	5	7	4	12	28	54	91
BI	1	3	1	1	1	0	0	0	1	1	1	3	1	9	15
CH	2	0	0	0	0	0	0	0	0	0	3	11	0	0	0
GU	18	22	43	59	68	18	16	14	16	23	19	31	47	60	90
HY	4	2	6	13	17	4	0	0	0	5	04	2	9	12	18
KT	7	7	6	6	15	7	3	2	2	4	7	7	5	5	6
MH	14	20	17	35	48	12	2	3	3	4	14	20	17	43	86
PB	0	2	2	7	9	0	0	0	0	3	0	2	3	7	8
RJ	2	4	6	15	5	2	1	1	1	2	2	4	6	6	6
TN	4	5	24	37	47	4	0	1	1	4	4	8	15	35	42
UP	4	0	4	28	28	2	0	0	0	8	4	0	7	32	28
WB	6	1	1	14	48	6	0	0	0	0	6	2	18	29	67
INDIA	**73**	**88**	**138**	**266**	**355**	**61**	**28**	**27**	**28**	**61**	**76**	**106**	**158**	**295**	**460**

Note: Only states that consume more than 3 Mt in any year under any of the three scenarios are shown in this table. Therefore, the total of these states will be less than the amount shown for the entire country in the last row.
Source: ICF International (Model Runs for Working Group Report 2013).

the cost penalty is even higher with wind energy costing about twice as much and solar PV three times as much as domestic coal based generation.

Further as discussed earlier, the high case recognises that the higher growth that is postulated will also allow a greater focus on greener but more expensive options. That is why almost twice the amount of renewable resources as the base case are added. In addition, generation efficiency is assumed to increase by one percentage point every five years, and a greater availability of natural gas was assumed.

However, in spite of these initiatives, coal continues to dominate the energy mix, although its share drops to some extent to 65 per cent in the base case from its current level of 68 per cent. The decrease is greater for both the low case (62 per cent) and the high case (60 per cent). One reason for the continued dominance of coal is that there is a large increase in the projected requirement for electricity. While the contribution from renewable energy increases dramatically, in absolute numbers there is still a large gap in electricity requirements which must be filled by coal.

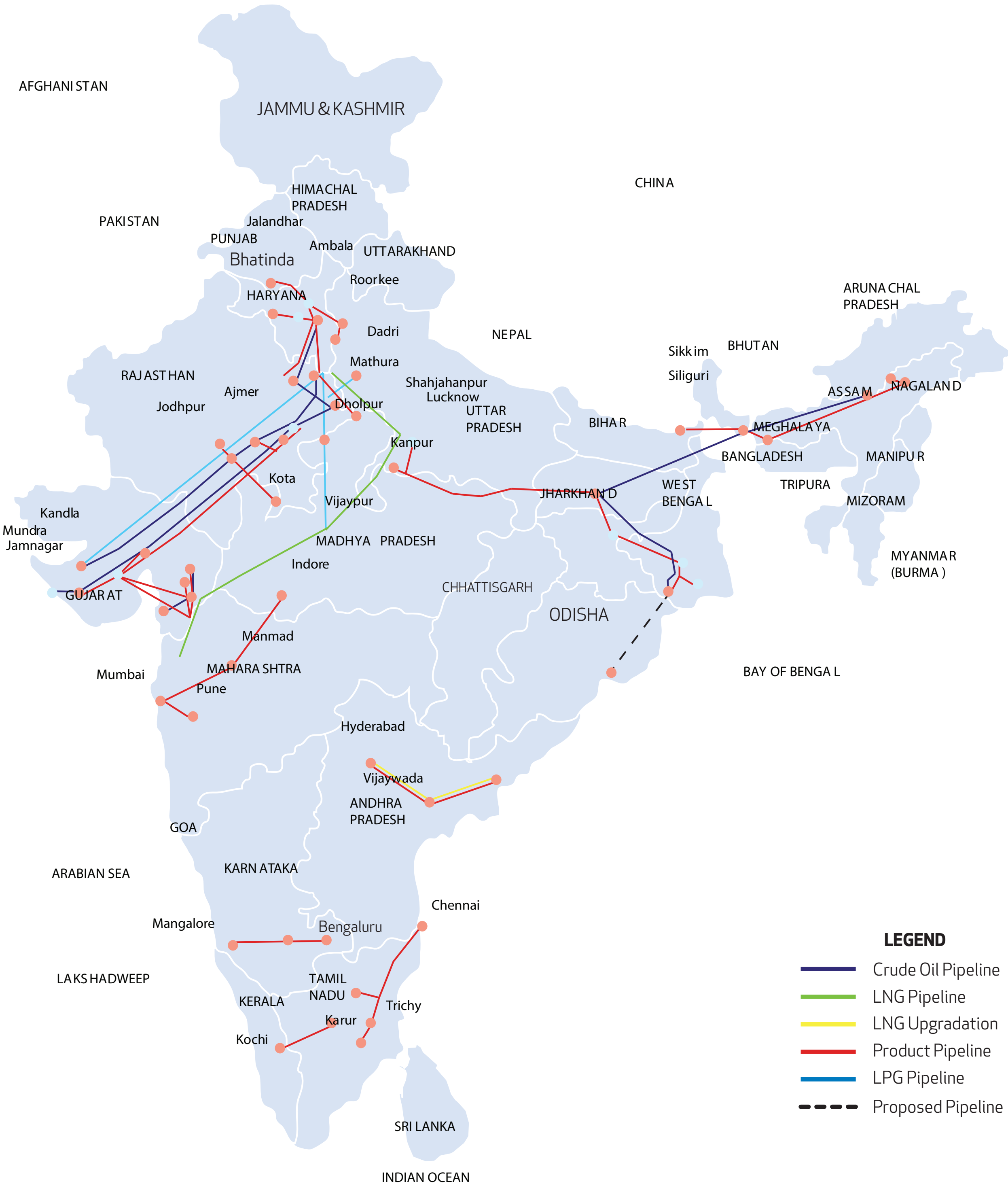
HANDLING UNCERTAINTIES

As we have seen in the three scenarios, there can be great variation in both the amount of coal to be transported and the pattern of the movement. This could be triggered by changes in the rate at which the economy is growing, greater use of renewables, increased availability of gas or higher energy efficiency.

Given this uncertainty, it is important that planning for bulk transport of energy commodities be adaptive. A strategic bulk transport planning group that monitors developments and potential developments in coal and other fuel markets, renewable energy technologies, and domestic fuel supply, should be established. In response to changing conditions, it should periodically, say every five years, direct changes in the plans for transport of fuels so that adequate fuel supplies are available to power plants without delay and at low cost. The group should include all major stakeholders and representatives from power, railways and natural gas sectors.

Chapter 5, Volume II on Institutions for Transport System Governance, proposes an Office of Transport Strategy (OTS) that would integrate transport planning across modes and coordinate between the ministries and other levels of government. The strategic bulk transport planning group could be established under the OTS, and the OTS could extend coordination to non-transport ministries such as power, petroleum and natural gas, and steel, on issues related to transport of bulk commodities.

Figure 8. 29
Oil and Gas Pipelines in India



Source: NTDPC Research.

TRANSPORT REQUIREMENTS FOR PETROLEUM AND NATURAL GAS

In India, all the natural gas and a major part of the petroleum and petroleum products are transported by pipelines. Even though a fraction of petroleum products is transported by rail, the amounts are insignificant compared to the amount of coal that needs to be moved, and therefore do not have much of an impact on the railway infrastructure required for movement of bulk commodities. The main intention of looking at the transport requirements for the petroleum and gas industry is to check the adequacy of the infrastructure, particularly for gas, to ensure that sufficient transport capacity is available for the power sector. Transportation for the petroleum industry covers

Table 8.10
Modes of Transport for Crude Oil
[Million Tonne]

	PSUS			PRIVATE COMPANIES		
YEAR	PIPELINES	COASTAL SHIPPING	TOTAL	PIPELINES	COASTAL SHIPPING	TOTAL
2011-12	70.2(52)	64.8(48)	135	8.25(11)	66.75(89)	75
2016-17	84.6(45)	103.4(55)	188	8.82(9)	89.18(91)	98
2021-22	97.99(41)	141.01(59)	239	10.26(9)	103.74(91)	114
2026-27	116.66(38)	190.34(62)	307	12.24(9)	123.76(91)	136
2030-31	146.68(38)	239.32(62)	386	15.3(9)	154.7(91)	170

Note: The figures in parentheses are percentage shares.
Source: MoP&NG (2012a).

the movement of crude oil from oil wells or ports to refineries, and the movement of petroleum products from refineries to the retail outlets.

CRUDE OIL

Crude oil is moved either by pipeline or coastal shipping to the refinery. Crude from onshore oil fields is mainly transported through pipelines, while coastal ships primarily move crude oil from offshore oil fields. Road and rail are not used. At present, there are 16 crude oil pipelines in the country, with a length of 8,560 km and capacity of 107 Mtpa (Figure 8.29). The pipelines are in the North-West and East, mostly carrying PSU crude. The PSUs transport roughly half their crude through pipelines while private companies use coastal shipping (Table 8.10).

The demand for crude oil is expected to increase from 210 Mt in 2011-12 to 286 Mt at the end of the 12th Plan and 353 Mt at the end of the 13th Plan (2021-22) with new refineries at Gujarat, Maharashtra and Tamil Nadu in the next decade, and expansion of 55 Mtpa at existing refineries proposed during the 13th Plan. In order to optimise the crude mix and product pattern to ensure adequate profitability of the companies, crude oil will be sourced from various producing nations in addition to domestic fields.

The year-wise estimate for movement of crude oil through coastal and pipelines, both by PSUs and private companies, is shown in Table 8.10.

With a number of refineries coming up at ports, the share of movement of crude oil by coastal shipping is expected to increase from 65 per cent in 2010-11 to 73 per cent by 2031-32.

PETROLEUM PRODUCTS

Petroleum products include petrol, diesel, ATF, naphtha, fuel oil, bitumen, LPG, lubricants, paraffin wax, petroleum coke, etc. The movement of these products from the refineries to the retail outlets is carried out using the least cost mix of rail, coastal shipping, roads and pipelines. The primary movement of petroleum products, from refineries to depots is through pipelines, rail or coastal shipping. The secondary movement of petroleum products, i.e., from the depot to the retail outlet, viz. last mile, is necessarily by road.

In comparison with rail and road, pipelines are considered much more economical. IOCL estimates for 2010-11 that the cost of movement was Rs 0.34 per Mt-km for movement through pipelines, Rs 1.39 per Mt-km by rail and Rs 2.86 per Mt-km by road. In addition to their safety and environmental-friendly approach, the per-unit cost advantage explains the economic importance of investment in pipelines for movement of oil and gas. Consequently, since 2008-09, there has been substantial investment in pipeline infrastructure. At present, there are 31 product pipelines, 11,274 km long and with a capacity of about 70 Mt. In addition, there are LPG pipelines of 2,313 km with a capacity of about 4 Mt. Table 8.11 gives the inter-modal mix of transport, for only primary movement of petroleum products in 2010-11 and the next two decades. As shown, the share of the pipelines is about 30 per cent. This is considerably less than in countries like the USA and China. In the US,

Table 8.11
Movement of Petroleum Products
[Million Tonne]

YEAR	PSUs					PRIVATE COMPANIES				
	PIPELINE	COASTAL	RAIL	ROAD	TOTAL	PIPELINE	COASTAL	RAIL	ROAD	TOTAL
2011-12	56.76(46)	18.51(15)	40.72(33)	7.40(6)	123.39	2.86(4)	60.87(85)	3.58(5)	3.58(5)	71.61
2016-17	90.14(53)	23.81(14)	45.92(27)	10.20(6)	170.08	2.88(3)	81.53(85)	5.76(6)	5.76(6)	95.92
2021-22	118.56(54)	30.74(14)	57.08(26)	13.17(6)	219.55	3.25(3)	87.84(81)	7.59(7)	9.76(9)	108.45
2026-27	157.64(54)	46.71(16)	75.90(26)	14.60(5)	291.92	4.80(4)	88.86(74)	12.01(10)	15.61(13)	120.08
2030-31	203.92(55)	55.61(15)	88.98(24)	18.54(5)	370.76	5.85(4)	103.83(71)	16.09(11)	20.47(14)	146.24

Note: The figures in parentheses are percentage shares.
Source: MoP&NG (2012a).

59 per cent of petroleum products were transported through pipelines, followed by coastal shipping (33 per cent), road (5 per cent) and railways (3 per cent).

Broad industry projections suggest that movement of POL products by PSUs through pipelines would be around 55 per cent, coastal shipping 15 per cent, rail 24 per cent and road 5 per cent by 2031-32.

The share of pipelines used by PSUs would increase substantially during this period, whereas the product movement by private companies would remain stable at 4 per cent. It may be inferred that, on the whole, pipelines would continue as the most preferred mode. Although railways at present transport a major share of products, their percentage contribution is expected to decline primarily due to the expansion of the pipeline network. This would ensure a balance between the ability of transport to serve economic development and to conserve energy, promote safety and sustain quality of future life.

As Table 8.11 shows, about 20 per cent (~105 Mt) of petroleum products will be transported by rail. This is small compared with movement of coal for power (~1460 Mt). Therefore, POL movement has little effect on planning for railways.

IMPORTS AND EXPORTS OF POL

Rapid growth in domestic consumption of petroleum products and refining capacity has increased the country's dependence on imports of crude oil. On the other hand, India has not only become a net exporter of petroleum products, but is now the largest exporter of petroleum products in Asia[12]. This section gives an estimate of the imports and exports of crude oil and petroleum products and the resulting liquid bulk traffic at ports.

Table 8.12 provides the details of the calculation. We first estimate the requirements for crude oil which is based on the sum of domestic demand and the net exports of petroleum products. Domestic demand has been estimated for the 12th and 13th Plan by the MoP&NG[13]. We extrapolated the results until 2031-32 using the CAGR for the 13th Plan. While in its report for the 12th Plan, the MoP&NG did estimate the exports of petroleum products for the 12th Plan, we could not find any projections for exports beyond 2016-17. As the level of exports is linked to the global requirements for petroleum products, we have assumed that India's share of exports as a percentage of global requirements would remain at the level projected for 2016-17. Global requirements were obtained from the International Energy Outlook by the Energy Information Administration (EIA) of the US. Imports of petroleum products, which consist mostly of LPG, have remained stable at about 11 Mtpa. We have assumed that imports remain at this level throughout the study period.

The total amount of petroleum products that need to be produced in the country is equal to the domestic demand plus net exports. In Table 8.12, this amount is shown as 'Total to be Produced'. The 12th Plan data indicates that a tonne of crude oil yields about 0.93 tonne of petroleum products[14]. We use this estimate to calculate the requirements for crude oil in the country.

12. MoP&NG (2011).
13. Ibid.: 49-50.
14. Ibid.: 163.

Table 8.12

Estimation of POL Traffic at Ports

[Million Tonne]

	PIPELINE	2011-12	2016-17	2021-22	2026-27	2031-32
1	Domestic Demand for Petroleum Products	147	186	245	322	424
2	Gross Exports of Petroleum Products	58	91	94	100	104
3	Gross Imports of Petroleum Products	10	11	11	11	11
4	Net Exports of Petroleum Products (2-3)	48	80	83	89	93
5	Petroleum Products to be Produced in India (1+4)	195	266	328	412	517
6	Requirements for Crude Oil (5/0.93)	210	286	353	443	556
7	Domestic Production of Crude Oil	38	41	41	41	41
8	Required Imports of Crude Oil (6-7)	172	245	312	401	515
9	Total Imports and Exports of POL (2+3+8)	240	347	417	513	631
10	**TOTAL POL TRAFFIC AT PORTS (9 X 1.37)**	**329**	**475**	**572**	**702**	**864**

Source: Working Group Report (2013).

By 2031-32, it is estimated to reach 556 Mt. Some of it will be met by domestic production. Recent projections for the 12th Plan period show a small decline in production[15]. Therefore, we have assumed that domestic production will remain at current levels. Subtracting domestic production from total requirements for crude oil give us the amount of crude oil that needs to be imported. It is expected to reach 515 Mt by 2031-32. The sum of POL imports (crude oil and petroleum products) and exports (petroleum products) is shown in Table 8.12 and is expected to reach 631 Mt by 2031-32.

Port traffic includes not just this amount but also some domestic crude that is produced off-shore and crude oil and petroleum products moved by coastal ships. Estimating this amount directly is very difficult. Instead, we looked at POL port traffic for the last several years and compared it with the total imports and exports of POL. We found that the ratio of POL port traffic to POL imports and exports over the last several years has varied between 1.25 to 1.53,with an average of 1.37. We have used the average of 1.37 to arrive at POL port traffic which is shown in the last line of Table 8.12.

NATURAL GAS

Natural gas constitutes 24 per cent of the total energy mix in the world. Its share in the Indian energy basket was around 11 per cent in 2010. It is projected that the growth of natural gas demand in India in the next two decades will alter the primary energy mix of India, by way of substitution from oil to gas, and reach up to 20 per cent. MoP&NG estimates that demand for gas will increase to 473 MMSCMD by 2016-17 and 606 MMSCMD by 2021-22, and would be about 790 MMSCMD by 2031-32[16].

The production of natural gas has increased from 89 MMSCMD to 143 MMSCMD at an annual growth rate of 17 per cent in the period 2007-08 to 2010-11. More discoveries of natural gas are expected in the coming years. Demand for natural gas has increased by 24 per cent during this period. Demand for natural gas up to 2031-32 is estimated based on the domestic production estimates as provided by the Directorate General of Hydrocarbons (DGH) and expected demand for natural gas by various sectors—power, fertiliser, city gas, industry, petrochemicals/refinery/internal consumption and sponge iron/steel. It is assumed that from 2017-18 onwards, additional gas would be available domestically from CBM Blocks and other future discoveries. Accordingly, a growth rate of 6 per cent is assumed from 2017-18 onwards and the availability is expected to stabilise thereafter at an annual growth rate of 3 per cent till 2031-32.

The remaining gap in demand is expected to be met through imports using existing facilities at Dahej, Kochi, Dabhol, Hazira and other LNG terminals

15. PetStats (2011: 12:42).
16. MoP&NG (2011a); MoP&NG (2011b).

Table 8.13
Estimates of Demand for Gas
[MMSCMD]

YEAR	GAS DEMAND
2010-11	170
2011-12	193
2016-17	473
2021-22	606
2026-27	703
2031-32	791

Note: Figures are based on the expectations that IPI/TAPI will be operational from 2018-19 onwards.
Source: MoP&NG (2012a).

proposed at places like Mangalore, Ennore, Mundra, Paradip, etc. Besides, certain Floating Storage Regassification Units (FSRUs) are being planned at port locations like Dighi, Mumbai, Paradip, Vizag, Mangalore, Cuddalore, etc.

The availability of transport infrastructure for gas needs to keep pace with availability of gas and commissioning of user industries. Gas transportation needs have been accordingly estimated until 2031-32 (including regional and trunk pipelines) as shown in Table 8.13.

Gas transportation estimates are related to the demand projections for gas, expected to increase substantially with the increase in demand projected by sectors like power and fertiliser. Given the present domestic availability, demand from other sectors like city gas, industrial, petrochemicals, refineries, internal consumption and sponge iron would be met mostly through imported LNG. However, the estimates have not considered the role of price elasticity in relatively price-elastic sectors like power and fertiliser. In this scenario, the actual demand could be much lower than the projected demand.

Pipelines are practically the only mode of inland gas transportation from producing regions to various consumption centres. India presently has approximately 13,000 km of gas pipelines with a total design capacity of 334 MMSCMD. As shown in Figure 8.30, this comprises around 8,400 km owned and operated by GAIL, around 1,469 km of east-west pipeline operated by RGTIL and the remaining operated by regional players like GSPC, IOCL, etc. The growing gas demand and new gas fields along the East coast, emphasise the need for faster development for gas transportation infrastructure. In 2007, MoP&NG had authorised around 5,771 km of pipelines to GAIL and 2,628 km to Reliance Logistics. Besides, GAIL is also upgrading the GREP/DVPL for 1,280 km for a capacity of 54 MSMCMD.

The PNGRB has authorised 4,325 km of pipeline through a transparent bidding process. In addition, another 2,675 km of pipeline is under various stages of bidding.

Table 8.14 summarises the composition of the gas pipeline grid. The total capacity of 1,176 MMSCMD will meet the requirements given in Table 8.13.

As the table shows, additional pipelines of about 32,000 km will be needed. It is difficult to estimate the cost because the cost per km varies by a factor of four to five depending on the diameter of the pipeline and by a factor of more than two depending on the region. It should be noted that some of these new pipelines are already under construction.

TRANSPORT REQUIREMENTS OF THE IRON AND STEEL INDUSTRY

Production of a tonne of steel requires three to four tonne of raw materials. So, to estimate the transport requirements for the steel industry, we first estimate the raw material requirements.

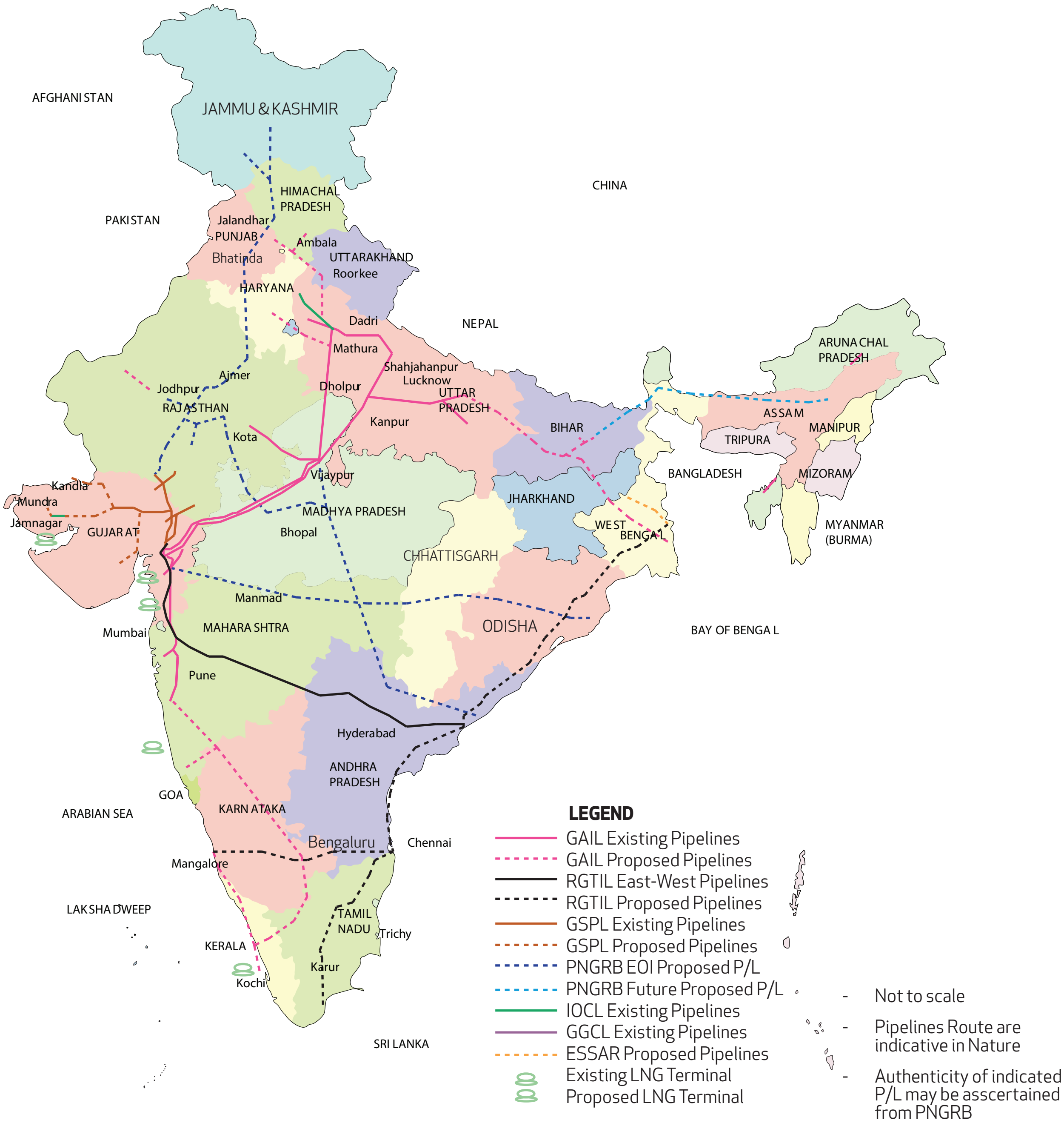
The calculations of raw material requirements have been projected on the basis of the following current norms of consumption and expected improvements in efficiency of operation[17]:

- Iron consumption is 1.6 tonne per tonne of crude steel (CS), based on BF/BOF technology.
- Coking coal use to decrease from 0.8 tonne per tonne of crude steel to 0.75 tonne, with increasing use of pulverised coal injection (PCI) and scrap in electric furnaces. (Use of

17. Ministry of Steel (2012a).

Figure 8. 30

Existing and Proposed Natural Gas Pipelines



Source: MoP&NG (2012a).

scrap expected to increase from 15 per cent in 2016-17 to 25 per cent in 2031-32.)

Input materials required to produce one tonne of crude steel will decrease from the present four tonne to three, with these efficiency improvements. This will reduce the need for transportation of raw materials.

Based on these requirements, the amount of raw material to be transported for the terminal year for each of the next four Plans has been estimated in the Table 8.15.

These transport requirements do not include those for exporting iron ore. While these exports are, and have been, quite large (~50 per cent of mined iron ore), they have declined recently because of the ban on export of iron ore. These exports will continue to decrease and will not be significant after 2016-17 as the iron ore resource needs to be conserved to ensure availability of adequate amount of steel for the country's development.

Steel production in 2011-12 was 73 Mt (provisional estimate)[18]. Assuming the same ratio of material to be moved to finished steel produc-

18. MoS (2013).

Table 8.14

Expected Composition of Gas Grid at End of 13th Plan (2021-22)

PIPELINE TYPE	LENGTH (KM)	CAPACITY (MMSCMD)	COMMENTS
Existing	13,508	334	Existing
Under Execution by GAIL/RGTIL	9,679	263	12th Plan
Under Upgradation by GSPL	1,220	30	12th Plan
PNGRB Bidding Rounds	7,000	243	12th Plan
AGCL/ OIL	350	6	12th Plan
New Greenfield Pipelines	4,000	150	13th Plan
Additional Pipelines through Augmentation	5,000	150	13th Plan
Additional Pipelines through Spurlines	4,500	0	13th Plan
TOTAL	**45,257**	**1,176**	

Source: MoP&NG (2012a).

Table 8.15

Estimates of Amounts of Raw Material and Steel to be Transported

[Million Tonne]

	MATERIAL	2016-17	2021-22	2026-27	2031-32
1.	Iron Ore	217	346	526	736
2.	Coking Coal	86	135	203	280
3.	PCI	11	17	41	56
4.	Non-coking Coal	39	67	82	122
5.	Scrap	15	36	78	145
6.	Others	118	188	284	398
7.	**TOTAL STEEL MAKING RAW MATERIAL (1+2+3+4+5+6)**	**486**	**790**	**1,213**	**1,737**
8.	Total Finished Steel	113	199	325	495
9.	**TOTAL RAW MATERIAL AND FINISHED STEEL (7+8)**	**599**	**989**	**1,538**	**2,232**

Source: Ministry of Steel (2012a).

Table 8.16

Modal Distribution of Raw Material Traffic between Road and Rail

[Per cent]

	RAIL		ROAD	
	RAW MATERIALS	FINISHED STEEL	RAW MATERIALS	FINISHED STEEL
Mega/Large Projects	90	70	10	30
Small & Medium Units	30	30	70	70

Source: Ministry of Steel (2012a).

Table 8.17
Average Lead Distances for Steel and Raw Material
[Km]

IRON ORE	COAL	OTHER RAW MATERIALS	PIG IRON AND FINISHED STEEL
325	405	763	988

Source: Ministry of Steel (2012a).

Table 8.18
Estimated Railway Traffic Due to the Steel Sector

TOTAL (INDIA)	2016-17		2021-22		2026-27		2031-32	
	MT	MT-KM	MT	MT-KM	MT	MT-KM	MT	MT-KM
Iron Ore	164	53,320	262	85,142	398	129,354	557	180,978
Coking Coal	65	26,330	102	41,260	154	62,168	212	85,721
PCI	8	3,291	13	5,517	31	12,434	42	17,144
Non-coking Coal	30	12,062	51	20,633	62	24,998	92	37,323
Scrap	11	10,804	27	26,965	59	58,080	110	108,392
Others	89	68,102	143	108,736	213	162,476	301	229,663
TOTAL STEEL MAKING RAW MATERIALS (1+2+3+4+5+6)	**367**	**173,908**	**597**	**287,895**	**916**	**449,509**	**1,314**	**659,222**
TOTAL FINISHED STEEL	**68**	**67,463**	**120**	**118,806**	**196**	**194,030**	**299**	**295,522**

Source: Ministry of Steel (2012a).
Note: MT = Million Tonne; MT-KM = Million Tonne Km.

Table 8.19
Estimated Road Traffic Due to the Steel Sector
[Million Tonne]

TOTAL INDIA	2016-17	2021-22	2026-27	2031-32
Iron Ore	53	84	128	179
Coking Coal	21	33	49	68
PCI	3	4	10	14
Non-coking Coal	10	16	20	30
Scrap	4	9	19	35
Others	29	46	69	97
TOTAL STEEL MAKING RAW MATERIALS (1+2+3+4+5+6)	**118**	**192**	**295**	**423**
Total Finished Steel	45	79	128	196
TOTAL RAW MATERIALS AND STEEL (7+8)	**163**	**271**	**424**	**619**

Source: Ministry of Steel (2012a).

Table 8. 20
Imports of Coking Coal for Steel Industry by State
[Million Tonne]

STATE	2011-12	2016-17	2021-22	2026-27	2031-32
Odisha	7.8	15.8	26.4	42.2	58.2
Chhattisgarh	4.2	8.5	14.1	22.6	31.2
Jharkhand	4.5	9.2	15.3	24.6	33.9
West Bengal	2.2	4.4	7.4	11.9	16.4
Karnataka	2.9	5.8	9.7	15.5	21.4
Tamil Nadu	1.0	2.1	3.5	5.5	7.6
Maharashtra	1.7	3.5	5.9	9.5	13.1
Andhra Pradesh	2.0	4.1	6.8	10.9	15.0
Gujarat	2.4	4.9	8.2	13.1	18.1
Other Locations	3.1	6.2	10.4	16.7	23.0
Total India	**31.8**	**64.5**	**107.7**	**172.5**	**237.8**

Source: Ministry of Steel (2012a).

tion as for 2016-17, the total raw material and steel that was moved in 2011-12 was about 390 Mt. This amount is projected to increase to 2232 Mt in 2031-32; almost a six-fold increase over the next 20 years (Table 8.15).

Currently, most of the material for large steel plants is moved by rail, and for small and medium units, by road. We have assumed this pattern holds throughout the study period (Table 8.16).

Current lead distances for raw materials and finished steel are shown in Table 8.17. While lead distances for iron ore are short, reflecting the proximity of steel plants to mines, the lead distances for finished steel are large (~1000 km) because finished steel is transported across the country. Consequently the transport requirements for finished steel in tonne-km are much higher than for raw materials. Using these numbers for lead distances, projected rail traffic for the steel industry is shown in the Table 8.18.

We have also estimated the road traffic for the steel sector in Table 8.19. As expected, road traffic is much less than rail.

IMPORTS OF COKING COAL

Much of the coking coal reserves in the country have high ash content, rendering them unsuitable for steel-making. Consequently, about 70 per cent of the coking coal required by the steel industry is currently imported. As the domestic production of coking coal is expected to remain stagnant or even decline, the share of imported coal is expected to increase to 75, 80 and 85 per cent in 2016-17, 2021-22 and 2026-27 respectively, and remain at that level for the rest of the study period[19]. Using these assumptions, the imports of coking coal have been estimated in Table 8.20.

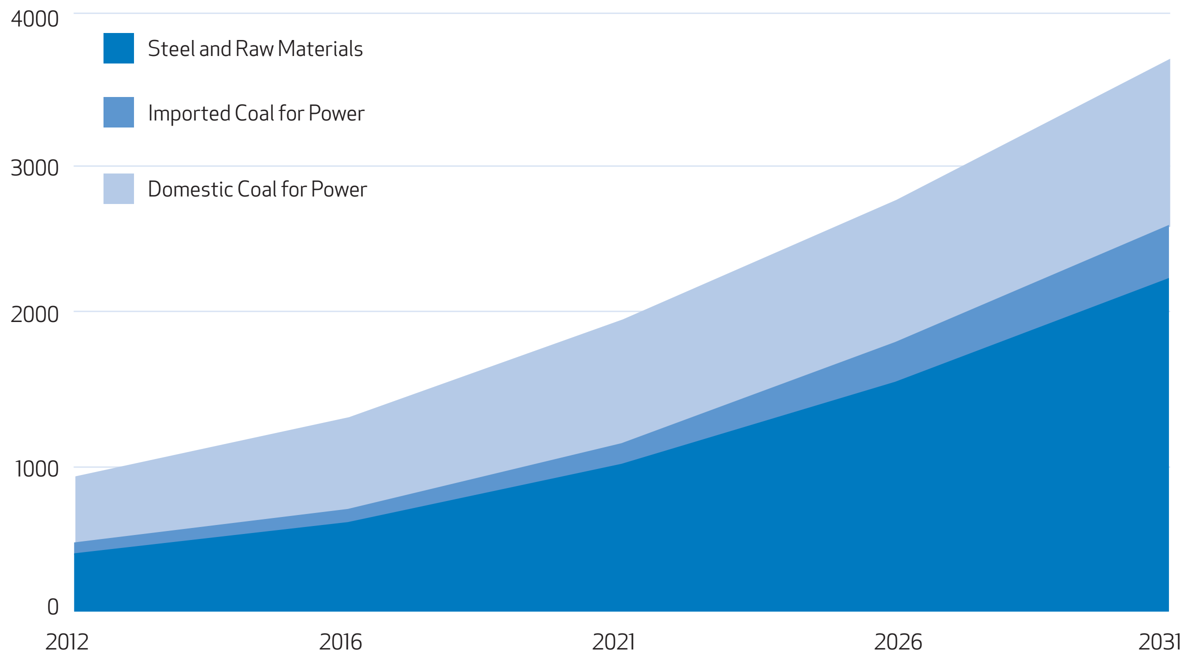
INFRASTRUCTURE REQUIREMENTS AND INVESTMENT PLANNING FOR RAILWAYS

India's requirements for bulk commodities are expected to grow rapidly over the next two decades. For the power sector, coal will remain the dominant fuel even though its share is expected to decrease marginally. The use of domestic coal for the power industry will be limited by the amount that will be produced and is expected to grow by about 2.5 times. Imports of coal for the power sector however, will grow much faster; by almost five times by 2031-32.

As the intensity of steel in the economy is expected to increase, steel requirements will grow faster than the economy. By current projections, requirements for steel will grow by almost seven times. As a tonne of finished steel requires three to four tonne of raw materials, the transport requirements for steel industry will be huge. The transport requirements for the power and steel industry are expected to grow from about 900 Mt now to 3,700 Mt in 2031-32 (Figure 8.31).

19. MoS (2012).

Figure 8. 31
Amount of Bulk Material to be Transported for Power and Steel Industries
[Million tonne]



Source: Working Group Report (2013).

Railways is one of the main modes of transport for dry bulk commodities. The rail network is already stretched to capacity with almost all the major trunk routes bearing traffic well above their designed capacity. This section assesses the additional requirements for transport of bulk commodities that will be imposed on the rail network and the upgradation required.

Transport of coal and iron ore by rail can be broadly broken up into five segments:

1. **First Mile Connectivity** where coal/iron ore is transported from the mine to the rail siding
2. **Feeder Routes at the Source End** which carry the coal/iron ore from the rail siding to the trunk route
3. **Trunk Routes** which carry the material long distances, usually between states
4. **Feeder Routes at the Destination** which move the material from the trunk route connection point to the rail siding at the destination power or steel plant
5. **Last Mile Connectivity** where the material is moved from the rail siding to the power or steel plant

It is important to ensure that each link in the transport chain from mine to power/steel plant functions effectively because the overall transport chain will be only as effective as its weakest link. Hence, we consider here all segments of the rail transport chain.

Of course, not all coal or iron ore shipments will traverse all five segments. For example, coal for power plants within a coal-producing state may be carried by a single feeder route that connects the rail siding at the mine to the power plant. First and last-mile connectivity are not usually provided by rail but are included because they are important in ensuring that coal or iron ore moves in an efficient and effective way. Poor first and last-mile connectivity can be a bottleneck in the transport of bulk material.

PATTERN OF MOVEMENT OF BULK COMMODITIES FOR THE POWER AND STEEL INDUSTRY

MOVEMENT OF COAL FOR THE POWER INDUSTRY

As transport requirements can be quite different, depending on the types of rail segments traversed, it will be useful to divide transport of domestic coal for the power sector into three categories:

1. Transport within the coal-producing states which relies mostly on road transport, MGR, conveyor belts/ropes and short rail routes
2. Transport to states neighbouring coal-producing states which takes place either on non-DFC routes or on short sections of high-density trunk routes that will later be covered by dedicated freight corridors (DFCs)
3. Transport to distant states which makes extensive use of high density trunk routes that will later be covered by DFCs

Table 8. 21
Movement of Domestic Coal

YEAR	CONSUMPTION WITHIN SUPPLY STATES (MILLION TONNE)	CONSUMPTION IN NEIGHBOURING STATES (MILLION TONNE)	LONG-DISTANCE TRANSPORT—(EXTENSIVE USE OF DFCs) (MILLION TONNE)	TOTAL (MILLION TONNE)	SHARE OF IN-STATE CONSUMPTION (PER CENT)	IN-STATE CONSUMPTION AND NEIGHBOURING STATES (PER CENT SHARE)
Base Case						
2011-12	194	64	156	442	44	58
2021-22	429	152	212	828	52	70
2031-32	664	110	260	1112	60	70
Low Case						
2011-12	194	64	156	442	44	58
2021-22	396	140	222	828	48	65
2031-32	602	114	288	1,112	54	64
High Case						
2011-12	194	64	156	442	44	58
2021-22	443	150	184	828	54	72
2031-32	693	117	222	1,112	62	73

Source: Working Group Report (2013).
Note: For transport to neighbouring states and for long-distance transport, only the major coal-consuming states were considered. Therefore, the total in column 5 will be slightly higher than the sum of columns 2, 3 and 4.

Using the outputs of the model described earlier, Table 8.21 shows the amount of domestic coal likely to be transported in each of these categories for the three scenarios[20]. The share of in-state consumption, already at 44 per cent, could increase to 60 per cent by 2031-32 in the base case. In the low case in 2031-32, it is slightly lower at 54 per cent and in the high case it is at 62 per cent.

If we include transport to neighbouring states to get an estimate of the share of transport within the coal-producing regions, we find that the share of these categories grows to 64-73 per cent by 2031-32. These trends are consistent with our earlier finding that as the economy grows, domestic coal is used 'closer to home'. While in some cases, the regional or in-state movement may be on a short part of a dedicated freight corridor (DFC)[21], a very large portion of domestic coal will not make extensive use of DFCs.

This finding is reinforced by an analysis of how much coal is transported by the various modes. A report by PriceWaterhouse Coopers states that the share of rail is about 49 per cent, MGR is 19 per cent and road is about 26 per cent (Figure 8.32).

A similar pattern emerges when we examine the movement of imported coal. As Table 8.22 shows, the share of consumption by the coastal states reaches over 80 per cent in 2031-32 for the base and high case. It is slightly lower at 71 per cent for the low case. In such a scenario, where most of the imported coal is expected to be used close to the coast, short rail routes or conveyor belts are likely to be important.

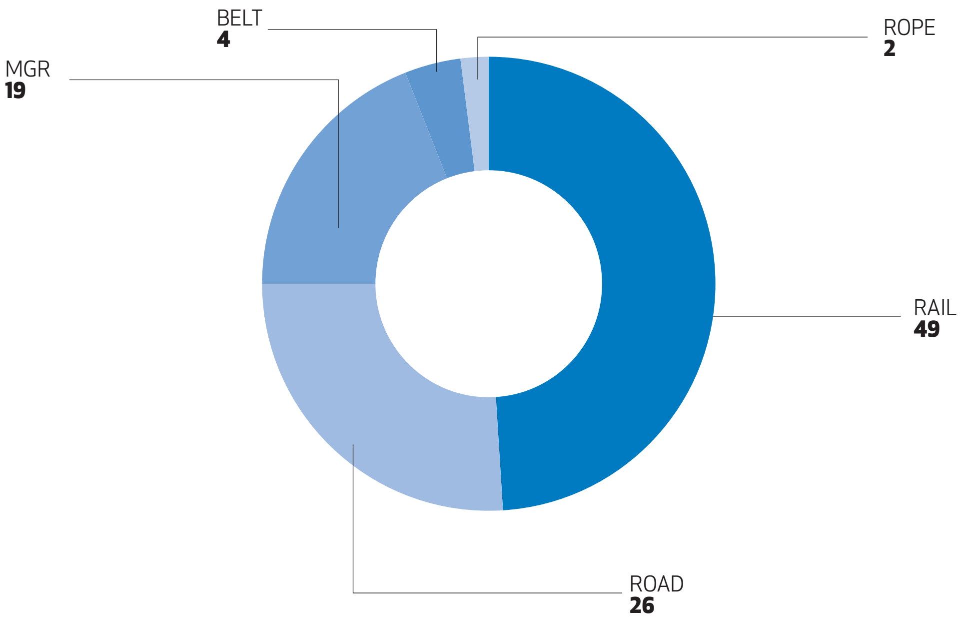
Thus we see that a progressively greater share of coal will be used within the source and coastal states, and hence the share of shorter rail routes, road, MGR and belts/ropes will grow.

MOVEMENT OF BULK MATERIALS FOR THE STEEL INDUSTRY

The steel industry requires transport of iron ore, coking coal, non-coking coal, other raw materials such as limestone, and finished steel. Lead distances for non-coking coal and iron ore are short because of proximity of steel plants to iron ore and coal mines. Consequently, much of the movement of iron ore and non-coking coal is on short rail routes for large steel plants and by road for the smaller plants. Similarly, because of the proximity

20. These estimates are indicative. Specifying an exact route for transport of coal would require a precise origin and destination. Because the modeling exercise treated an entire state as a node, such precise identification of origins and destinations was not possible in this study. A much more detailed modeling exercise with a much higher resolution for locating power plants would be required.
21. Indian Railways has proposed the construction of six DFCs. These are discussed in more detail later in the sub-section, 'Indian Railways Plans High Density Corridors'.
22. PwC (2009).

Figure 8. 32
Share of Different Modes for Transport of Domestic Coal
[Per Cent]



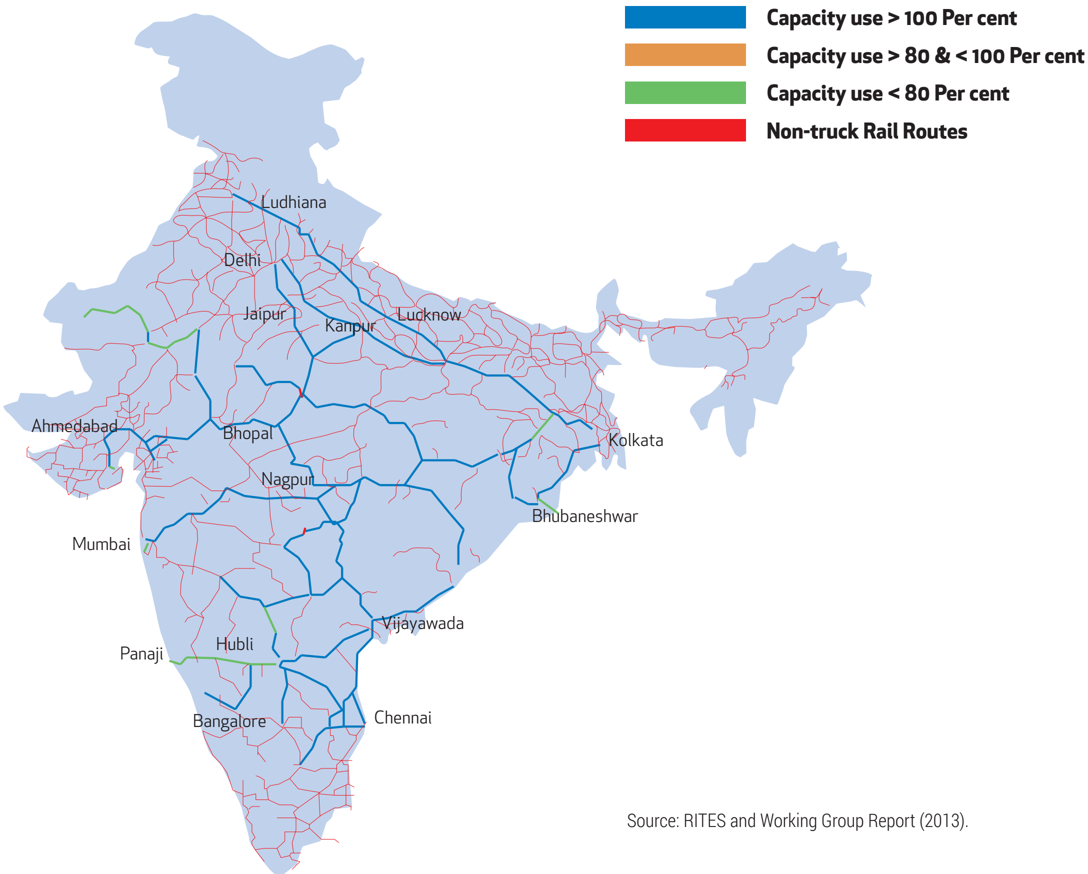
Source: PwC (2009).

Table 8. 22
Movement of Imported Coal

YEAR	CONSUMPTION WITHIN COASTAL STATES (MILLION TONNE)	ON NON-DFC ROUTES (MILLION TONNE)	LONG-DISTANCE TRANSPORT—EXTENSIVE USE OF DFCS (MILLION TONNE)	TOTAL (MILLION TONNE)	COASTAL STATES CONSUMPTION (PER CENT SHARE)
BASE CASE					
2011-12	53	0	14	73	73
2021-22	119	0	19	138	86
2031-32	293	0	59	355	82
Low Case					
2011-12	50	0	8	61	83
2021-22	26	0	1	27	96
2031-32	43	0	18	61	71
High Case					
2011-12	54	0	15	76	72
2021-22	131	0	25	158	83
2031-32	382	0	75	460	83

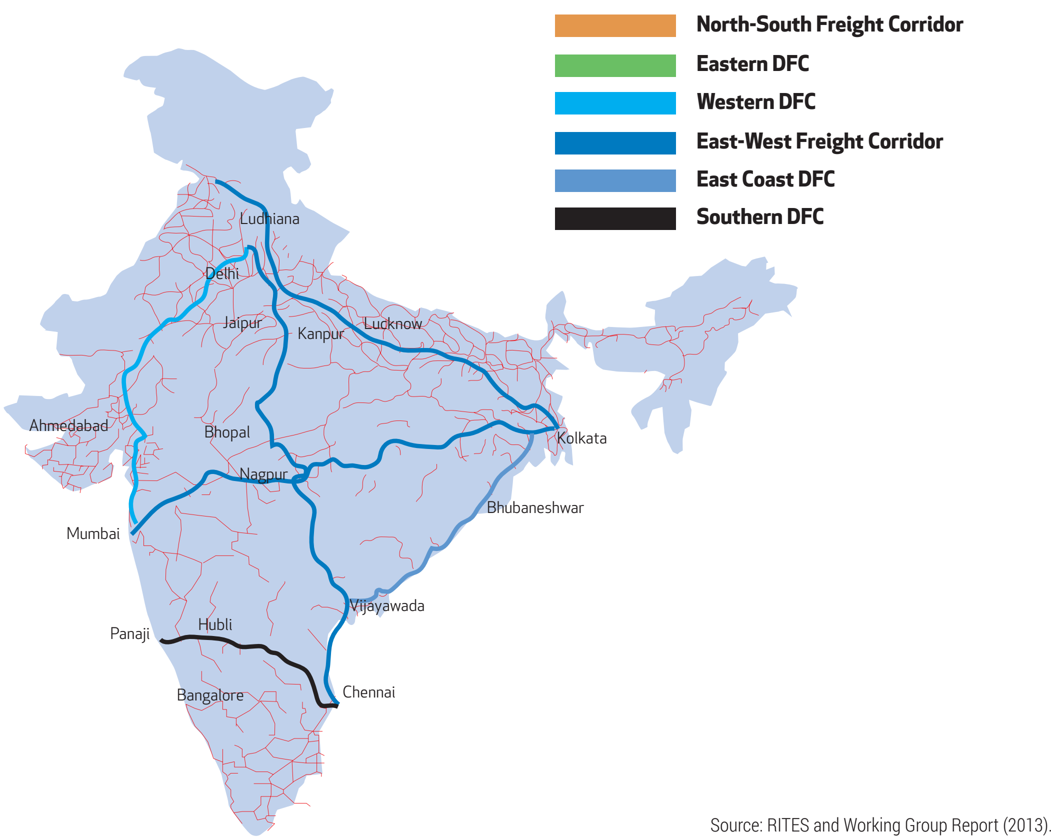
Source: Working Group Report (2013).
Note: For the routes covered by DFCs and non-DFC routes, only states which consumed more than 3 Mtpa of imported coal were considered. Therefore, the total in column 5 will be slightly higher than the sum of columns 2, 3 and 4.

Figure 8. 33
Major Rail Routes for Transport of Bulk Commodities



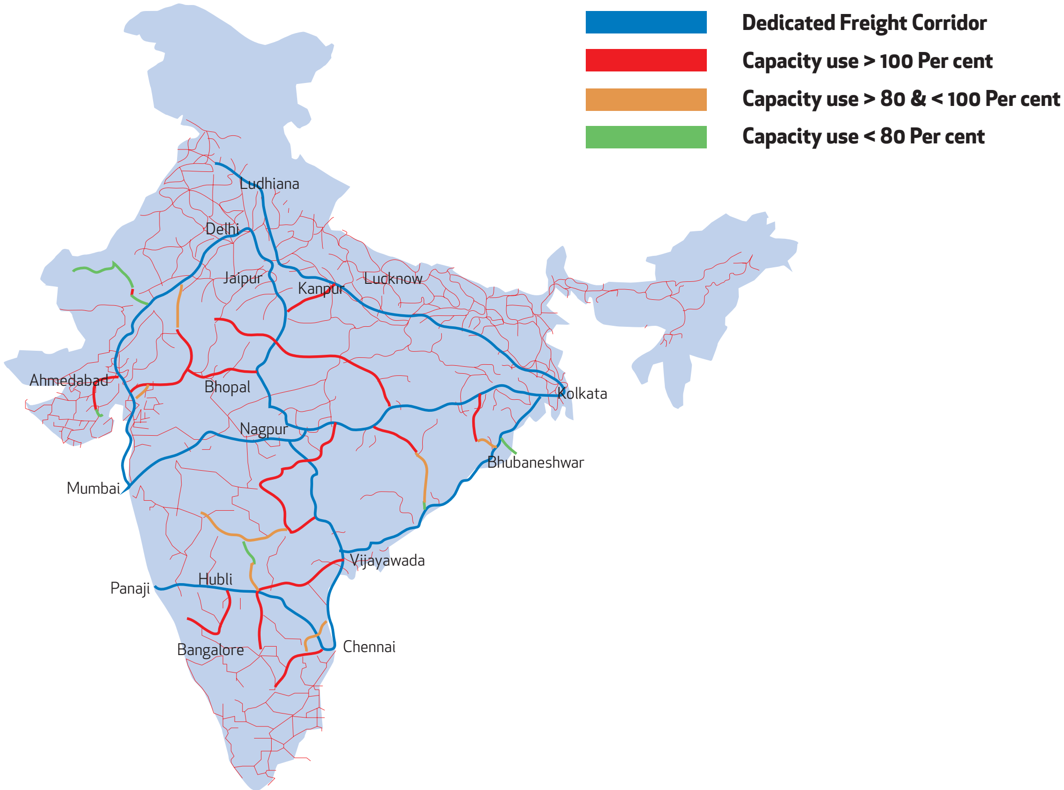
Source: RITES and Working Group Report (2013).

Figure 8. 34
DFC Routes



Source: RITES and Working Group Report (2013).

Figure 8.35
Impact of DFCs on Trunk Routes



Source: RITES and Working Group Report (2013).

of the ports which receive coking coal imports, the lead distances for imported coking coal are short and transport is on short rail routes for large steel plants and by road for smaller steel plants. Finished steel is transported across the country and its effect is diffused throughout the network. So, its effect on specific routes may not be so significant, and hence is not covered here.

TRUNK RAILWAY ROUTES

STATUS OF RAIL ROUTES

Figure 8.33 shows the main rail routes that transport over 80 per cent of coal, iron ore, iron, steel, limestone and dolomite. We also examined the level of capacity utilisation for the sections of the routes. A section reaches 'saturation' if the capacity utilisation is greater than 80 per cent. Therefore, we have divided the sections that comprise these routes into three categories: where the capacity utilisation is (1) less than 80 per cent (green); (2) between 80 per cent and 100 per cent (yellow); and (3) greater than 100 per cent (red).

Almost all the sections on the map in Figure 8.33 are blue, implying that almost all sections on the major routes are operating at capacity utilisation greater than 100 per cent. So, almost all bulk commodity routes face major delays due to congestion. This is particularly relevant for transport of coal over long distances which makes extensive use of the high density network, and for transport within coal-bearing states and to neighbouring states, as some of this transport may occur over short sections of these trunk routes.

INDIAN RAILWAYS PLANS HIGH DENSITY CORRIDORS

Indian Railways recognised the problem several years back and has proposed construction of dedicated freight corridors (DFCs), shown in Figure 8.34. Six DFCs totaling 9,538 km have been proposed:

(a) Western DFC (Delhi-Mumbai) 1,534 km.
(b) Eastern DFC (Ludhiana-Kolkata) 1,839 km.
(c) East West DFC (Howrah-Mumbai) 1,976 km.
(d) East-Coast DFC (Kharagpur-Vijaywada) 1,097 km.
(e) South DFC (Chennai-Goa) 902km.
(f) North South DFC (Delhi-Chennai) 2,190 km.

Of these, the first two are already under construction and pre-feasibility studies have been carried out for the others. Figure 8.35 shows the impact of the DFCs on the trunk routes for the transport of bulk commodities. While many of the sections will no longer be congested (blue), there will still be some, shown in red and yellow, that will be congested and will require capacity augmentation.

Table 8. 23

Expected Long Distance Movement of Domestic and Imported Coal on DFCs for the Power Sector

[Million Tonne]

YEAR	EASTERN	WESTERN	EAST-WEST	NORTH-SOUTH	EAST COAST	SOUTHERN	TOTAL—ON ROUTES COVERED BY DFCs
Base Case							
2012	88	6	23	30	22	0	170
2021	124	14	57	23	13	0	231
2031	211	30	30	33	15	0	319
Low Case							
2012	88	6	23	30	22	0	170
2021	99	1	62	36	25	0	223
2031	207	9	78	0	12	0	306
High Case							
2012	88	6	24	30	22	0	171
2021	105	18	60	23	3	0	209
2031	212	31	37	8	8	0	297

Source: Working Group Report (2013).

SCHEDULE FOR DFCs

The Western DFC and Eastern DFC are under construction and scheduled to be completed by 2017. The other four DFCs have been proposed. Not yet approved, they could be completed earliest by 2023.

Table 8.23 shows the approximate volumes of domestic and imported coal likely to be transported over long distances on DFCs. Movement of coking coal is not included because most of it occurs within iron ore-rich states.

In the next decade, about half the long-distance transport of coal will take place on the Eastern DFC. By 2031-32, it will account for two-thirds. The Western DFC will carry imported coal mostly from Gujarat to the Northern and North-Western states. The East-West, East Coast and North-South DFCs will carry about the same amount of coal as one another but much less than the Eastern DFC. The Southern DFC is expected to carry almost no coal.

Therefore, for long distance transport of coal the Eastern DFC is far more important than the others and it should be given the highest priority. The traffic on the Eastern DFC will be highest closest to the coal-fields and will decrease as coal is unloaded at successive states on the route to the farthest state. This would also apply to the other DFCs. Another reason for focusing on the Eastern end of the DFCs is that transport of coal within coal-producing states and to neighbouring states is likely to use sections of DFCs that are short but the volume of traffic can be high. Almost all the use of short sections of DFCs will occur in the eastern part of the country.

Given the size of the DFC projects and the associated challenges, delays are possible, particularly in the remaining four which await approval. Given the time it will take to make the DFCs operational, even if there are no delays, the traffic will grow and some short-term augmentation will be required. Otherwise, the existing infrastructure will be strained to breaking point. This situation doubles the challenge because short-term measures are needed along with long-term. Given the limited resources, creative solutions will need to be found to ensure that there is no unnecessary duplication of efforts and expenditure. It could be that the augmentation will support increase in passenger traffic on these corridors once freight shifts to the DFCs.

RAIL FEEDER ROUTES AT MINES AND PLANTS

Feeder routes are critically important for the effectiveness of the bulk transport system, particularly at the source end, because they bring the material (coal or iron ore) up to the trunk route that then carries it to its destination. Inadequate transport capacity on these routes will have wide repercussions for the power and steel industry.

Table 8. 24
Critical Feeder Routes for Coal

RAIL LINK	DISTANCE (KM)	COST (MILLION RS)	START YEAR	INITIAL PROJECTED END-DATE
North Karanpura Coalfield – JH, Tori-Shivpur-Hazaribagh, New BG line	92	6,210	2000	31 DECEMBER 2012
North Karanpura Coalfield – JH, McCluski-ganj-Piparwar New BG line	30.5	1,420	1990	SEPTEMBER 2011
Mand-Raigarh Coalfields – CH, Bhupde-opur-Baroud-Durgapur	91	31,,00	Approved	MARCH 2018
Ib Valley Coalfield – Odisha, Barpali-Jhar-suguda-Gopalpur- Manoharpur Tract	52.4	4700	2006	31 MARCH 2012
Talcher Coalfield – Odisha, Jarpada-Angul - Talcher Rail Corridor	87	To be estimated	To be approved	NA
Talcher Coalfield – Odisha, Radhikapur West Block – Angul Rail Corridor	50	To be estimated	To be approved	NA
Talcher Coalfield – Odisha, Talcher – Dhamra Port via Bhadrak[23]	150	To be estimated	To be approved	NA
Singareni Coalfield – AP, Bhadrachalan Rd – Sattupalli	52	3,600	To be done on PPP basis	NA
TOTAL	**605**	**35,100**		

Note: For the purpose of calculating total costs for routes where costs are yet to be estimated, it was assumed that the cost would be the average cost of the other routes in Rs million/km.
Source: Ministry of Coal (2012).

Feeder routes at the destination end bring the material from the trunk route to the destination plant. They are not much of a problem because the transportation capacity required for a single plant is comparatively low. However, power plants in coal-producing states are likely to come up in clusters of about 4000 MW at locations not yet known, and are likely to require new rail lines directly from mines.

FEEDER ROUTES AT MINES

Most of the increase in coal production is expected to come from three regions: (1) Talcher and Ib Valley coalfields in Odisha with a potential increase of 110 Mtpa by 2031-32; (2) North Karanpura coalfields in Jharkhand with a potential increase of 75 Mtpa; and (3) Mand-Raigad coalfields in Chhattisgarh with a potential increase of 90 Mtpa. Table 8.24 gives a list of the critical routes in these areas. Early implementation and completion of these rail connectivity projects is important if the need for domestic coal for power is to be met in the coming two decades. As the table shows, some action has been taken by the Railways on several of these projects but much more needs to be done.

For example, the project to construct a new broad gauge line for the North Karanpura coalfield from McCluskiganj to Piparwar was started way back in 1990. IRCON was awarded the contract but it left the job in 2002. Another five years went by before RITES was hired to complete the work. The new completion date was September 2011 but the work is still on. The Tori-Shivpur-Hazaribagh line, also in North Karanpura coalfield, was started in 2000 and had a scheduled completion date of end of 2012 but only 410 million of the Rs 1,500 million payment made to the Railways has been utilised. The 40-km single line rail corridor between Angul and Talcher is mostly complete but has been held up because of land acquisition issues for a 4-km stretch.

On the other hand, there are several projects such as the extension of the Bhupdeopur-Baroud-Bijari-Durgapur double line which have not even been started. For some of them, even cost estimates have yet to be made.

As Table 8.24 shows, the combined length of these links is about 600 km, estimated to cost Rs 35 billion.

23. The new line, Angul-Sukinde, has been sanctioned. The Sukinde-Bhadrak line exists but if a new line is required, then approval will be needed.

Table 8. 25

Critical Feeder Routes for the Iron and Steel Industry

STATE	NAME OF THE PROJECT	DISTANCE (KM)	COST IN RS MILLION (2011-12)
	NEW LINE		
Odisha	Angul-Sukinda Road (Suppl.)	99	6,390
Jharkhand	Hansdiha-Godda	30	2,670
Andhra Pradesh	Bhadrachalam Road-Sattupalli	56	3,380
Chhattisgarh	Dallirajahara-Jagdalpur	235	11,050
Tamil Nadu	Attipattu-Puttur	88	4,470
Karnataka	Kottur-Harihar via Harpanhalli	65	3,540
Karnataka	Hubli-Ankola (Suppl.)	167	3,380
	DOUBLING		
Odisha	Sambalpur-Titlagarh	182	9,510
Odisha	Sambalpur-Talcher	174	6,790
Odisha	Banspani-Daitari-Tomka-Jakhapura (Suppl.)	180	9,430
Odisha	Barbil- Barajamda	10	525
Odisha	Bimalgarh- Dumitra	18.3	1,157
Odisha	Banspani-Jaruri	09	910
Odisha	Champajharan- Bimalgarh	21	1,511
Odisha	Brundamal-Jharsuguda flyover connection to join DN Line (Suppl.)	-	880
Andhra Pradesh	Vizianagram-Kottavalasa 3rd line	35	1,950
Chhattisgarh	Sailari-Urkura	25	730
Chhattisgarh	Kirandul-Jagdalpur	150	8,270
	Raipur-Titlagarh incl. NL Mandi Hasaud-Naya Raipur (20 km) and new MM for conversion of Raipur (Kendri)- Dhamtari & Abhnapur-Rajim branch line(67.20 km)	270	6,920
Maharashtra	Chandrapura-Rajabera-Chandrapura-Bhandaridah	11	350
Bihar	Kajra-Kiul (Suppl.)	16	480
Jharkhand	Barharwa-Tinpahar	17	750
Jharkhand	Rajkharsawan- Sini- 3rd line	15	916

(Contd...)

STATE	NAME OF THE PROJECT	DISTANCE (KM)	COST IN RS MILLION (2011-12)
Jharkhand	Sini- Adityapur 3rd line	22.5	953
Jharkhand	Bhojudih- Mohuda	23	1,342
Jharkhand	Goelkera- Manoharpur 3rd line (Chakradhpur- Bondamunda Section)	40	2,717
Jharkhand	Dongaposi- Rajkharsawan 3rd line (Suppl.)	75	3,094
Jharkhand	Tinpahar-Sahibganj as PH-I of doubling of Tinpahar-Bhagalpur	38	1,680
Jharkhand	Sahibganj-Pirpaniti	11	1,300
Jharkhand	Padapahar- Banspani	32	1,553
West Bengal	Rajgoda-Tamluk-Phase-II of Panskura-Haldia Doubling	13.5	869
West Bengal	Panskura-Kharagpur 3rd line (44.7km) with new MM Panskura - Ghatal(32.8 km) NL 11-12	77.5	5,292
West Bengal	Chinpai-Sainthia, Prantik-Siuri	32	5,960
West Bengal	Gokulpur- Midnapur New Bridge on diversion alignment with substructure & steel super structure on Bridge No,143	2	521
Chhattisgarh	Salkar Road-Khongsara Patch Doubling	26	1,439
Chhattisgarh	Khodri- Anuppur with flyover at Bilaspur	61.6	3,855
Chhattisgarh	Bypass at Champa	14	376
TOTAL		**2,341.4**	**117,413**

Source: Ministry of Coal (2012).
Note: For the purpose of calculating total costs for routes where costs are yet to be estimated, it was assumed that the cost would be the average cost of the other routes in Rs million/km.

The Railway Plan in the 12th Plan has been estimated at Rs 5,200 billion[24]. The amount required for these critical feeder routes for coal is about 0.7 per cent of the total Railway Plan. Given that these links are essential for the transport of the most of the additional coal that is going to be produced in the coming two decades and the relatively low investment required, these links must be given top priority and be completed within this Plan.

Listed in Table 8.25 are rail connectivity or capacity augmentation projects for the iron and steel industry that are awaiting completion.

The combined length of these links is about 2,340 km and the total cost is estimated at Rs 117 billion, about 1.7 per cent of the total Railway Plan for the 12th Plan. As with the critical feeder routes for coal, these links are essential for the transport of iron ore. They must be given top priority and be completed within this Plan for the unhindered growth of the iron and steel industry. They should be designed to handle 25-30-tonne axle load so that the capacity of the lines is effectively increased.

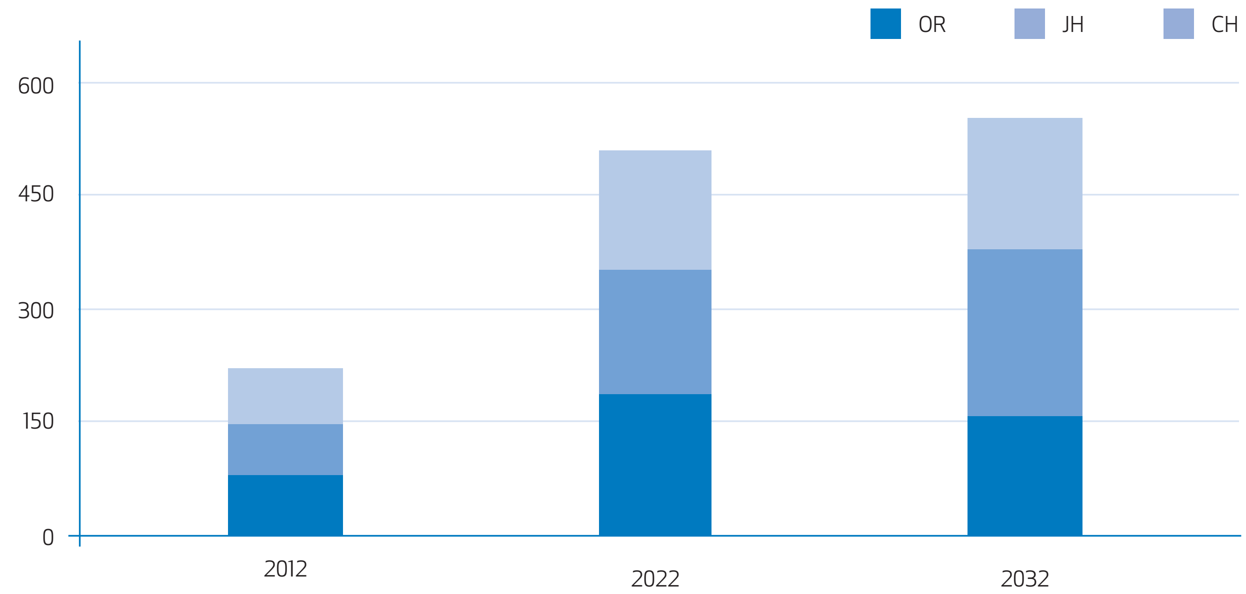
The major reasons for the delays in providing these links are[25]:

- Difficulties in acquiring land and delays in clearances
- Projects are initiated only if they meet stringent requirements of guaranteed minimum traffic to enable Railways to earn a minimum return on its investments. Private participation by steel plant owners may be one way to solve this problem.
- Rail projects have a long gestation period and more advance planning needs to be done so that railway infrastructure grows as there is economic growth in the region.

These critical feeder routes should be completed as soon as possible.

24. Bansal (2013).
25. MoS (2012: 15).

Figure 8. 36
Coal Production from Tri-State Region
[Million Tonne]



Source: Working Group Report (2013).

FEEDER ROUTES TO POWER PLANTS

In-state consumption of coal for power is likely to increase and much of this new capacity will come up in clusters of about 3000-4000 MW each. Such power plants will need to be located not only near coal mines but also near sources of water. It is difficult to predict where these clusters of power plants will come up. In any case, feeder routes from the mines to the power plants will need to be provided. These links will be 70-100 km long and will be required to carry about 20 Mtpa[26]. They should be designed for heavy-haul technology where a rake per day carries 4 Mtpa. Some of these feeder routes may overlap, to some extent, with each other or the feeder routes that bring coal from the mine to the trunk route.

Consumption of domestic coal within coal-producing states is expected to grow at about 24 Mt per year. Assuming that half of this will be used in power plant clusters and the other half in pit-head plants, roughly one such feeder route to a cluster of power plants will be required every other year. Given that most of the increase in production of coal is expected to occur in the tri-state region of Odisha, Jharkhand and Chhattisgarh, about one such feeder route will be required in each of the three states every six years.

NEED TO FOCUS ON TRI-STATE REGION OF ODISHA, JHARKHAND AND CHHATTISGARH

As Tables 8.24 and 8.25 show, most of the critical feeder routes lie in Odisha, Jharkhand and Chhattisgarh as steel plants and mineral resources, particularly coal and iron ore, are concentrated in these states. In spite of the importance of these states, the development of the rail network has been inadequate.

These states produce more than half of the domestic coal used in the country and are expected to produce about two-thirds of it by 2032 (Figures 8.36 and 8.37). In addition, a quarter of the country's steel production is going to be located in Odisha by 2016-17, a share that will remain constant for the next two decades. Together, these states will have more than half the steel capacity of the country.

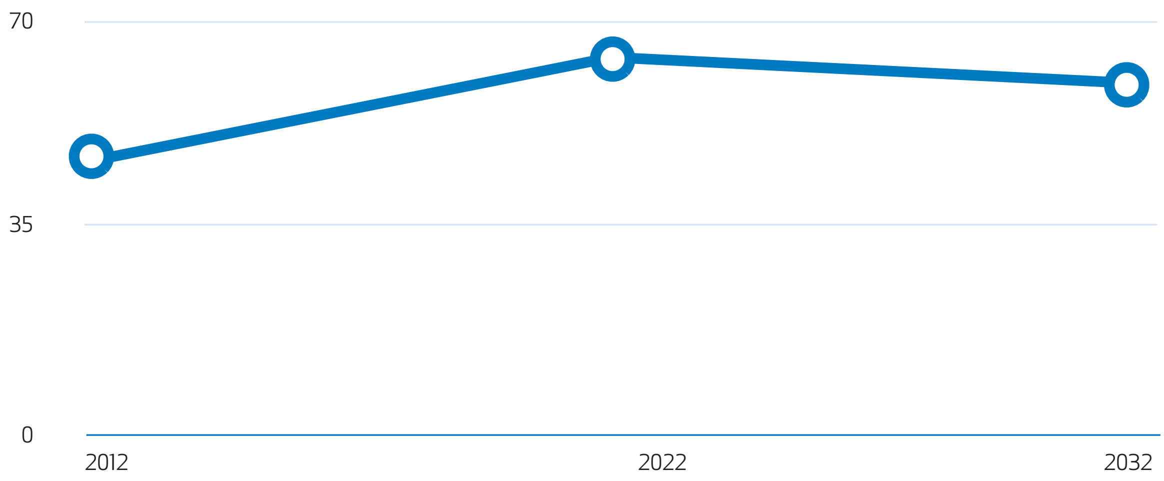
PRIVATE PARTICIPATION IN RAIL CONNECTIVITY PROJECTS

While the need for rail connectivity for previously unconnected areas is growing, Railways faces resource constraints to fulfill these demands. Therefore, Indian Railways has been working on ways to attract participation of the private sector, to provide an alternative source of funding. The first policy was Railways' Infrastructure for Industry Initiative (R3i) issued in July 2010, but it was not applicable to lines from coal and iron ore mines. In February 2011, Railways introduced a second policy, Rail Connectivity to Coal and Iron Ore Mines (R2CI). More recently, on 10 December 2012, the Cabinet Committee on Infrastructure approved a new policy on participative models for rail connectivity and capacity augmentation. This supersedes R3i and R2CI.

IR has formulated five participative investment models for its existing shelf of projects and for new projects[27]:

26. A 1000 MW power plant requires about 5 Mtpa of domestic coal.
27. MoR (2012).

Figure 8. 37
Contribution of Tri-State Region to National Coal Production
[Per Cent]



Source: Working Group Report (2013).

1. **Non-Government Railway Model** is designed for developing feeder routes at source and destination. The project developer is responsible for land acquisition, project development and construction with no financial input by IR. The project developer will be paid 95 per cent of the net income from the project.
2. **JV Model** for operationally necessary/bankable sanctioned/to be sanctioned railway projects. This model is for bankable new line or gauge conversion projects that have clearly identifiable stakeholders such as users of the line or ports, mines, exporters, plants or state governments. The JV will include the Railways and these stakeholders. The JV will get a portion of the freight revenue.
3. **Railway Projects on BOT** awarded through competitive bidding, where the viability gap funding required would be the bidding parameter. This model is designed for cases where it may not be possible to identify stakeholders who will take the lead in making investments. An example is a long rail corridor where revenue is generated from multiple streams. Here the concessionaire will provide the funding and will be paid a user fee based on 50 per cent of the apportioned freight.
4. **Capacity Augmentation with Funding Provided by Customers.** This model is for those cases where some potential beneficiaries of a capacity augmentation project (doubling, multiple lines, etc.) are willing to fund the project in order to expedite it. The funds with associated interest will be returned to the customers through rebate on freight charges.
5. **Capacity Augmentation with Annuity.** This model is for cases where it is not possible to get funding from a specific user. Here, the concessionaire would be paid through an annuity.

State governments can participate in any of these models. If they participate through the first and second models, they can bid out the projects.

The five cases cover most of the circumstances under which private investment could accelerate the development of rail infrastructure. IR will remain a key player even with private participation, carrying out the following functions. Success of the new PPP policy will depend on how well IR is able to execute these functions.

- Certification of the lines in all cases, and in some cases even supervision of the construction.
- Supervision and certification of the maintenance of the lines.
- Operation of the rail network with its rolling stock.
- Collection of freight charges and disbursal of payments to the private parites as per the terms of the specific agreement.

Large integrated producers of steel or large mining companies can enter into these PPP arrangements, but smaller parties may find it difficult to do so. Institutional mechanisms will need to be developed to facilitate coordination among SMEs and large firms in the same area to pool their resources to create common infrastructure[28].

28. MoS (2012).

FIRST MILE CONNECTIVITY

ROAD CONNECTIVITY FROM MINE TO RAIL SIDING

Coal and iron ore are generally transported from mines to the nearest rail siding by road. In many cases the evacuation of material is hampered by the following factors: (1) lack of adequate and appropriate material handling infrastructure at the mine and at the rail siding; (2) inadequate road capacity from the mine head to the railway siding; (3) occasional shortage of railway rakes.

Efforts are being made to augment material loading and unloading facilities and increase road transportation capacity. The shortage of rail rolling stock is often a seasonal issue which is exacerbated by congestion on the lines. As capacity constraints are removed, it will also mitigate the shortage of rolling stock to some extent. Creation of road infrastructure takes time. Advance planning, though rarely done, is essential to develop the required roads for movement of coal from mine-heads to rail-heads. It has also been suggested that the existing fair-weather roads in high-growth coal fields, particularly where captive coal blocks are expected to become operative, be converted into all-weather express coal corridors[29].

Due to the poor quality of road transportation, the loading at rail sidings shows an annual pattern: it peaks during winter and declines during summer and monsoon. The mine company is unable to utilise the rail capacity optimally, and the unused capacity is lost. Railways estimates that the drop in loading results in a loss of about 50 rakes per day for a substantial part of the year[30].

Further, because the coal from the mines in the traditional coal fields has to be moved through heavily-populated villages, and is vulnerable to blockage and other disturbances due to socio-political events, the following suggestions have been made about transportation from mine-heads to rail-heads[31].

1. Wherever possible, long-distance conveyor belt systems should be used. This will reduce the environmental impact of road transport.
2. Siding rationalisation plans should be developed.
3. Coal mining companies should consider developing a hub-based system for transporting coal from existing mines wherever feasible.

MERRY-GO-ROUND (MGR) SYSTEMS

Most pithead plants, particularly the large ones, get their coal using merry-go-round (MGR) systems. Almost 20 per cent of the country's domestic coal is transported by MGR. As a greater percentage of coal will be used within the producing state, the share of movement by MGR will grow. Therefore, it is important that this mode of transport is also efficient.

> Evacuation of coal and iron ore is hampered by lack of adequate and appropriate material handling infrastructure at the mine and at the rail siding; inadequate road capacity from the mine head to the railway siding; occasional shortage of railway rakes.

Sometimes there is a delay in the development of the mining and the MGR system, and the power plant is completed before one of the two is functional. In such cases, as a stop-gap measure, coal is brought from another location in case of delay in the mine. Or Indian Railways is asked to transport coal from the mine in case of delay in the MGR system. Such stop-gap arrangements become difficult to get out of due to socio-political reasons. Therefore, synchronisation between the development of the pithead power plant and the mine and transport system is critical[32].

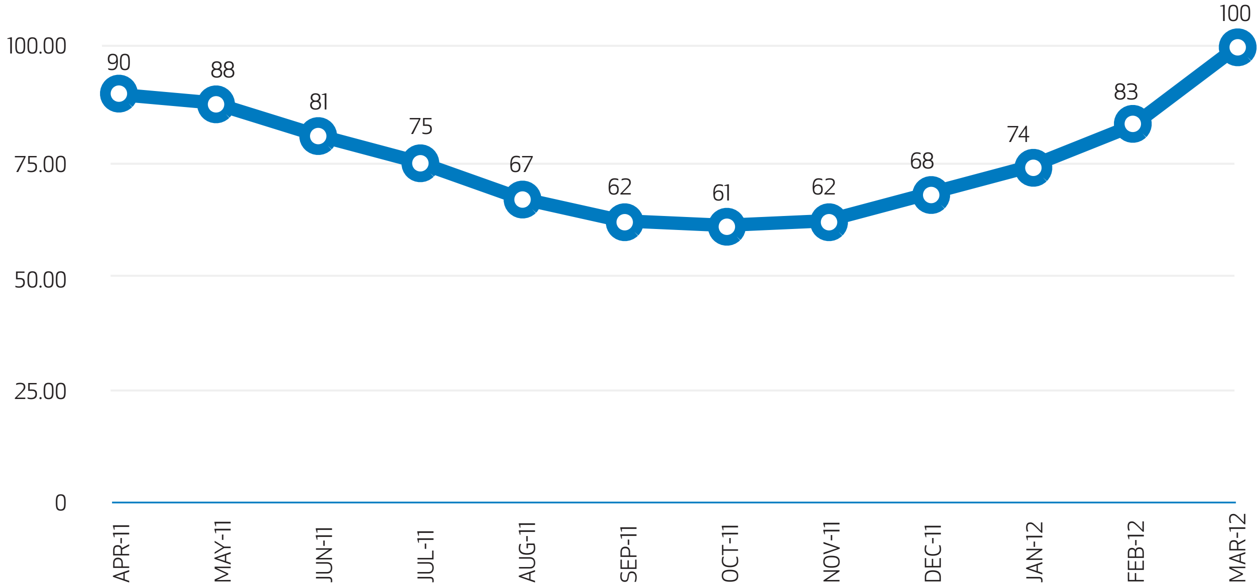
In addition, Indian Railways states that often pithead plants with MGR require augmentation of their coal supplies by Indian Railways. But often the MGR systems are not designed for handling rakes from outside[33]. This results in delays. When pithead plants are proposed in the future, the MGR systems should be designed to handle rakes from the Indian Railways. Indian Railways can operate the MGR systems at lower cost because of its expertise on rail systems[34]. Therefore, it is suggested that Indian Railways be involved as a partner in the running of MGR systems.

LAST MILE CONNECTIVITY

Transport of unsized coal sometimes results in delays in unloading, especially of bottom discharge wagons, because large pieces get stuck. Sizing of coal before dispatch would avoid this problem and ensure faster unloading of rakes. It would also increase the carrying capacity of wagons through better compaction. Sometimes there are delays in unloading because the material handling system at the receiving power plant cannot handle all types of wagons. Either a power plant should be designed to handle a particular type of wagon and only that type of wagon should be sent to that power plant, or all power plants should be capable of handling all types of wagons—bottom discharge, tippler, etc. While the first option may be more economical from the perspective of the power plant, it may not be feasible, given the limited rolling stock available with the Railways. In either case, the turnaround time of rakes at power plants would be greatly improved.

29. MoC (2011).
30. Roy (2012).
31. MoC (2011).
32. Ibid.
33. Roy (2012).
34. Ibid.

Figure 8. 38
Month-Wise Pit-Head Closing Stock of Coal in 2011-12
[Per Cent]



Source: Coal Controller's Organisation (2012a).

There is also a need to improve the bunker, conveyor belt and stacking capacities at power plants. As the tonnage per train discharged at the power plant increases, bunkers will need to be emptied and their content stored at the power plant site. Otherwise, overfull bunkers will become a bottleneck slowing down the unloading of trains. Therefore, additional stacking capacity will be required.

BUILD-UP OF COAL STOCKS AT PITHEADS

There has been concern about the build-up of coal stocks at the pitheads of mines awaiting transportation while, ironically, there is a shortage of coal at many power plants[35].

Coal production and road transportation to rail sidings follow a pattern over the year where they peak during the winter months and decline during the summer and monsoon season. Railways is unable to meet this wide variation in demand and consequently pithead stocks peak in the winter months and decline in the summer and monsoon months (Figure 8.38).

Pithead stocks are the cumulative effect of a mismatch between production and the amount transported by Railways.

About 45[36] Mt of coal is lying at pitheads[37]. Such an annual build-up indicates that there is no spare capacity in the rail transport system. It is an early warning that the rail network or the amount of rolling stock or both are operating at their full capacity.

Currently we are at a low-level equilibrium where production of coal is not increasing or is increasing very slowly and the transport system is almost able to keep up. But if the amount of coal produced at the mines increases, as would be desirable, then there may not be sufficient capacity in the transport system to move that coal to power and steel plants. The transportation system will become a bottleneck, blocking the value of increased production from benefitting the economy.

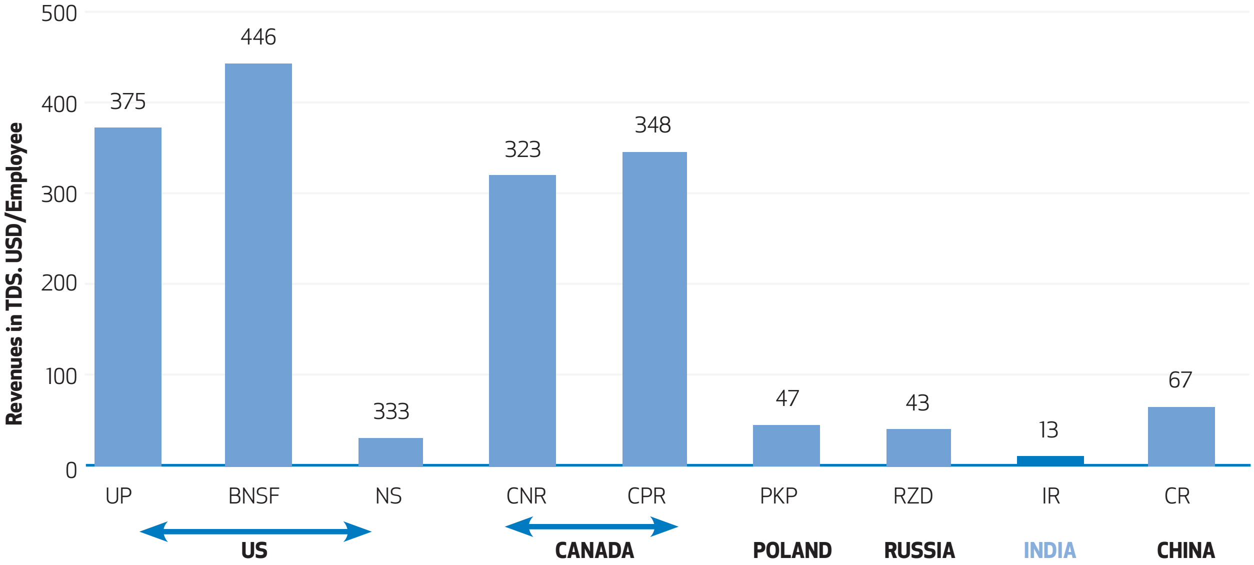
RAIL EFFICIENCY AND TECHNOLOGY IMPROVEMENTS

Freight transportation in India is far less efficient than in other countries. Figures 8.39 and 8.40 compare two indicators of efficiency of India with a peer group of countries. India's staff efficiency, measured in revenues per employee, is the lowest. It is only $13,000 per employee compared with the best of $446,000 per employee. Wagons in India provide transportation of 2.4 Mt-km per year, much lower than the best of about 12.4 Mt-km.

Transportation cost is a large fraction of the price that the customer pays. For states that are far from coal mines, rail transportation can often be more than the price of coal at the mine-mouth, effectively more than doubling the cost of fuel for power plants.

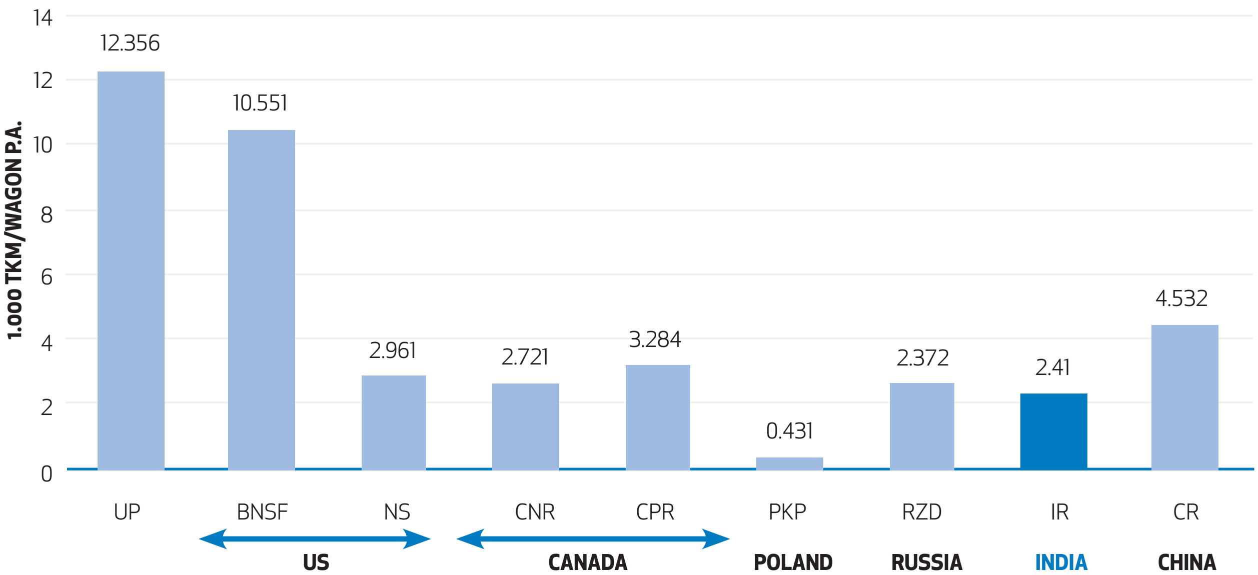
35. Business Today (2012).
36. This number is the minimum stock and is about 60 per cent of the maximum pithead stocks reported for 2011-12. For a year-by-year comparison of pithead stocks, we think that the minimum stock for the year is a more appropriate measure of the annual mismatch between transportation requirement and capacity.
37. Working Group Report (2013).

Figure 8. 39
Comparison of Staff Efficiency of Railways in Select Countries



Source: Jahncke (2012).

Figure 8. 40
Comparison of Wagon Efficiency in Select Countries

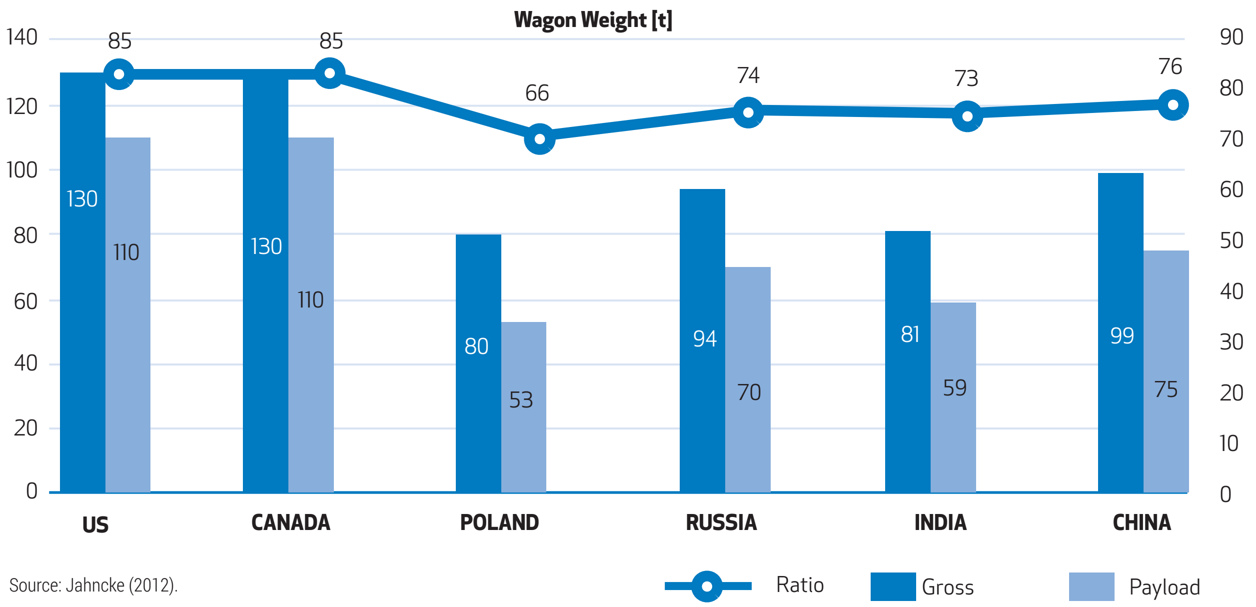


Source: Jahncke (2012).

Therefore, it is important that the transport cost be kept low. Furthermore, the Railways' main competitive advantage is its lower cost. It must keep costs low or its market share will erode even faster than it already is.

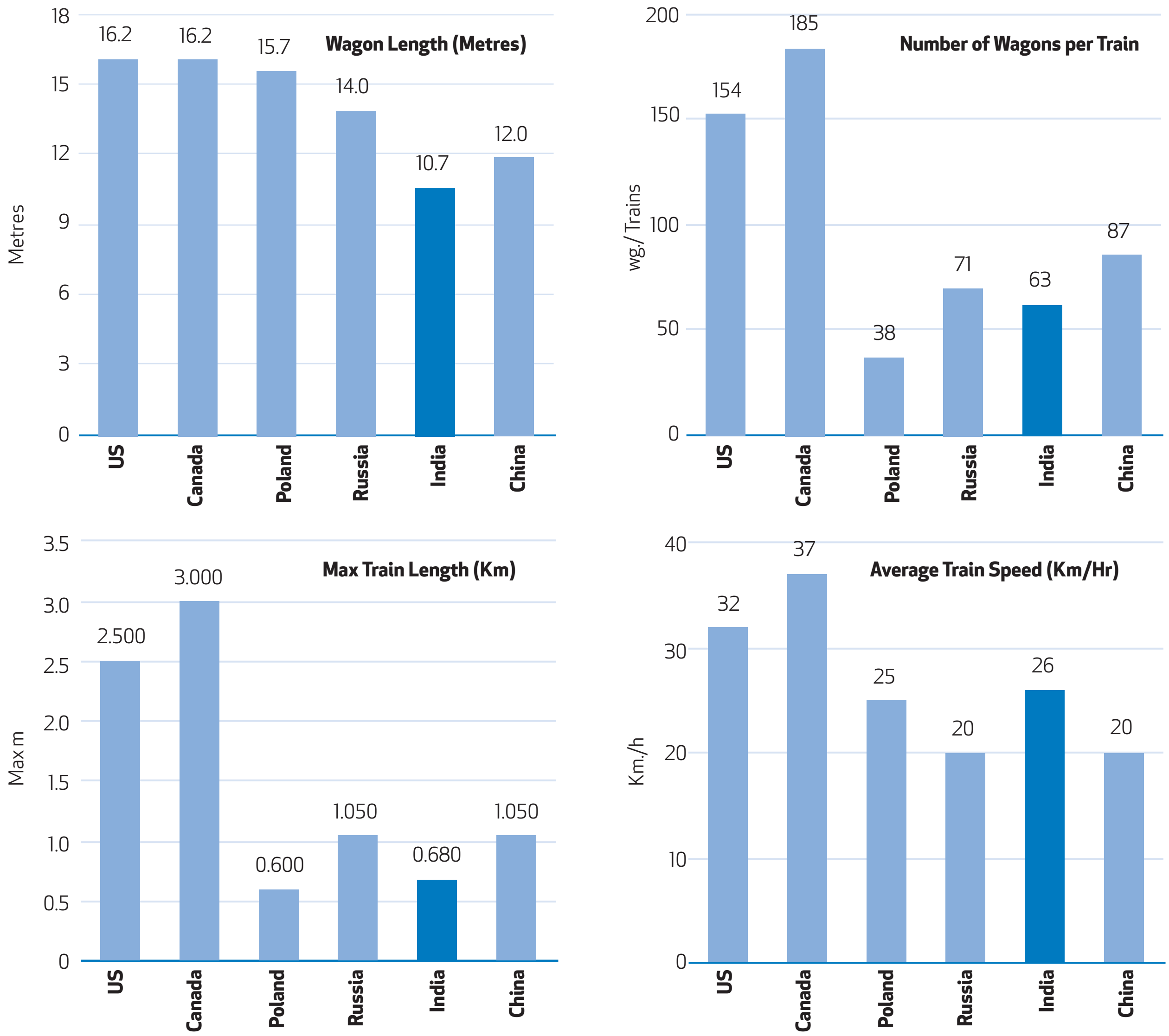
Transportation costs per tonne can be lowered by using well-loaded trains with a high net weight to gross weight ratio. Indian trains are comparable on most loading parameters with trains in Poland, Russia and China but not with trains in US and Canada. For example, Figure 8.41 shows that Indian wagons have a net to gross ratio of 73 per cent which is significantly lower than the world's best of about 85 per cent. This means that Indian wagons are spending a larger fraction of fuel to carry the weight of the wagon itself. Further, the Indian trains, with a maximum length of 680 metre, are much shorter than trains in the US and Canada which can be as long as 2.5 to 3 km (Figure 8.42). The problem is compounded by the

Figure 8. 41
Comparison of Wagon Weight and Payload to Gross Weight for Select Countries



Source: Jahncke (2012).

Figure 8. 42
Country-Wise Comparison of Components of Loading Level of Trains



Source: Jahncke (2012).

Table 8. 26
Required Investment in Rolling Stock and Terminals to Carry Additional Bulk Materials

CATEGORY OF INVESTMENT	12TH PLAN	13TH PLAN	14TH PLAN	15TH PLAN
Increase in thermal coal transported by end of each FYP (Million tonne)	187	264	251	250
Increase in iron ore transported by end of each FYP (Million tonne)	77	129	180	210
Increase in coking coal transported by end of each FYP(Million tonne)	30	49	68	77
Total increase in bulk material transported by end of each FYP (Million tonne)	294	442	499	537
Required investment in rolling stock and terminals (Rs Billion)	441	663	749	806

Note: It is assumed that each additional Mtpa to be carried will require investment of Rs 1500 million (For details see Annex III. 6.2 of the Working Group Report 2013).

lower average speed of Indian trains (26 kmph) compared to the speeds in US and Canada (32-37 kmph)[38].

Indian Railways is planning to address these issues. The report of the Working Group on Railways for the 12th Plan discusses a strategy of 'heavier, longer, faster' which includes the following measures[39]:

- Use of 25-tonne axle load wagons for iron ore, and planning for 30-tonne axle load
- Moving overall regime from 22.8 tonne to 23.5 tonne axle load.
- Greater use of long haul trains. As an interim measure, on some sections, Indian Railways is running two trains in tandem, effectively as one train to reduce the impact of capacity constraints[40].
- New rolling stock and infrastructure is being designed so that trains will run at 100 kmph empty and 75 kmph when loaded. Efforts are ongoing to make fully-loaded trains run at 100 kmph.

However, in order to carry the much higher volumes of bulk commodities over the next two decades, Indian Railways will have to take big strides in improvements of transport infrastructure. The focus should be on:

- Infrastructure enabling higher axle loads;
- Specialised wagon and loading technology;
- Longer trains.

INVESTMENT REQUIRED

PRIORITISATION OF INVESTMENTS IN RAIL NETWORK

Given the limited resources available for further development of the railway network, prioritising should be on two principles: (1) route developments that have the highest impact; and (2) urgently-required route developments over those where the requirement is expected sometime later.

Based on these two principles, we suggest the following priorities:

1. **Critical Feeder Routes for Coal and Iron & Steel.** All the additional coal or iron ore that is to be transported by rail will make use of these feeder routes. A delay in providing these routes will affect availability of coal and iron ore for the entire country.
2. **Construction of DFCs Starting from Eastern End.** Construction of DFCs must start at the end located in the coal-bearing region because (1) coal-bearing traffic will be the highest nearest to the coal region and (2) transport of coal within coal-bearing states or to neighbouring states is likely to use short sections of the DFCs.
3. **Highest Priority to the Eastern DFC.** The Eastern DFC must get very high priority because it is likely to carry 50-70 per cent of the coal traffic to distant states from the coal-source states. Therefore we suggest that the Eastern DFC be built within the 12th Plan. The Western DFC is required for container traffic (not discussed here) and is already slated for completion by the end of the 12th Plan. However, because it is not as important for movement of bulk materials, we suggest that about 80 per cent of the investment be done in the 12th Plan and the remaining 20 per cent in the 13th Plan. The E-W, East Coast and N-S DFCs, are scheduled to be operational by the end of the 13th Plan. To keep the investment in the

38. Jahncke (2012).
39. MoR (2012).
40. Roy (2012).

Table 8. 27
Suggested Plan-Wise Investment for Railways
[Rs Million]

CATEGORY OF INVESTMENT	12TH PLAN	13TH PLAN	14TH PLAN	15TH PLAN
Critical Feeder Routes-Coal	31,500			
Critical Feeder Routes-Iron and Steel	117,400			
Feeder Routes for Power Plant Clusters	25,000	25,000	25,000	25,000
Eastern DFC	459,750			
Western DFC	268,450	115,050		
E-W DFC	164,667	329,333		
East Coast DFC	91,417	182,833		
N-S DFC	182,500	365,000		
Southern DFC			112,750	112,750
Additional Augmentation		1,157,173	1,157,173	1,157,173
Rolling Stock and Terminals	441,385	663,000	748,500	805,500
TOTAL	**1,782,068**	**2,837,390**	**2,043,423**	**2,100,423**

Note: The required investment for rolling stock and terminals is for coal and iron ore only. However, the investments for DFCs and the additional augmentation are for all commodities because it is difficult to separate the investment by commodity.
Source: Working Group Report (2013).

12th Plan from becoming burdensome, we suggest that only a third of the investment be made in the 12th Plan and the remaining investment and construction take place in the 13th Plan. As the Southern DFC is not important for movement of bulk commodity, we suggest that it be shifted to the 14th and 15th Plans.

4. **Additional Augmentation.** We have removed the critical feeder routes from this list because the critical feeder routes will be covered in the 12th Plan. We suggest the remaining augmentation be spread out evenly over the 13th-15th Plans, with augmentation to routes closest to the coal and iron-ore regions getting priority.

INVESTMENT IN RAILWAYS FOR BULK TRANSPORT

Investment in the railways includes: (1) investment in rolling stock and (2) investment in the rail network. First we estimate the required investment in rolling stock and terminals. As the amount of bulk material that needs to be transported increases, the number of wagons, locomotives and terminals will have to increase. We estimate an investment of about Rs 1500 million in rolling stock and terminals for each additional Mtpa to be carried. We estimate the increase in the bulk material to be transported in the terminal years of the next four Five Year Plans as shown in Table 8.26.

Next we look at the total investment required for transporting bulk materials by rail. Based on the principles of prioritising investments described in the previous section, we suggest the Plan-wise investment for the Railways given in Table 8.27.

INFRASTRUCTURE REQUIREMENTS AND INVESTMENT PLANNING FOR PORTS

As shown in Table 8.28, the traffic at ports for thermal and coking coal and POL will grow dramatically in the next two decades. Will our ports be able to handle the traffic given that many are already stretched to capacity? Efforts are being made to improve the performance of Indian ports. However, in addition to port-wise development plans, a comprehensive strategy needs to be evolved for the port sector.

There are also issues of how poorly our ports compare with international benchmarks of performance. Perhaps, most importantly, the level of connectivity of the ports to the hinterland needs to be

Table 8. 28
Projected Port Traffic for Coal and POL[41]
[Million Tonne]

COMMODITY	2011-12	2016-17	2021-22	2026-27	2031-32
Thermal Coal	97	142	224	340	423
Coking Coal	32	65	108	173	238
POL	329	475	572	702	864
Total	**458**	**682**	**904**	**1,215**	**1,525**

Note: Port traffic includes movement by coastal shipping. Because coastal shipping adds to the traffic at both the origin and destination port, the additional traffic due to coastal shipping is twice the volume of material transported.
Source: Earlier tables in this chapter.

considered because even the most modern and best-performing port would be useless if it lacked sufficient connectivity to the destination of materials to be imported.

Before the ban by the Supreme Court, exports of iron ore were increasing dramatically. Over the nine-year period from 2000-01 to 2009-10, they increased over threefold. In 2009-10, about 53 per cent of the iron ore produced was exported. There was a decline in 2010-11 because of the Supreme Court ban. According to the Ministry of Steel, because the iron ore resources are ultimately limited, the resources should be conserved for the domestic steel industry. Therefore, development of additional mining capacity should be undertaken in a 'well-calibrated' way so that excess capacity does not result in an incentive to export, while ensuring that iron ore is available for the domestic steel industry as it expands. Keeping this in mind, we have not focused here on transportation requirements for export of iron ore.

PORT CAPACITY

India's ports are stretched to their capacity. As Figure 8.43 shows, the capacity utilisation of the major ports averages around 85 per cent, with at least four operating at a utilisation of 100 per cent or more. International norms recommend that capacity utilisation be below 70 per cent to avoid delays.

Commodity-wise capacity utilisation for coal and POL which is of greater interest here is shown in Figures 8.44 and 8.45. Unfortunately, capacity utilisation for coal is available for only four major ports, but for POL we have more complete data. These commodity-wise capacity utilisation figures reaffirm the same picture of ports stretched to capacity. For coal, three out of four ports have capacity utilisation above 80 per cent while the international norm is 70 per cent. For POL, about half the major ports have capacity utilisation above 70 per cent.

PORT PERFORMANCE

The lack of capacity at the ports and consequent congestion and delays are reflected in the poor performance of the major ports. Table 8.29 provides some measures of performance of Indian ports.

In spite of a lot of effort, we have not been able to get international benchmarks for these performance metrics that would provide a fair 'apples to apples' comparison with Indian ports. However, one indicator of the penalty that is imposed on ships at Indian ports due to lack of adequate capacity is the following observation by the Ministry of Shipping that

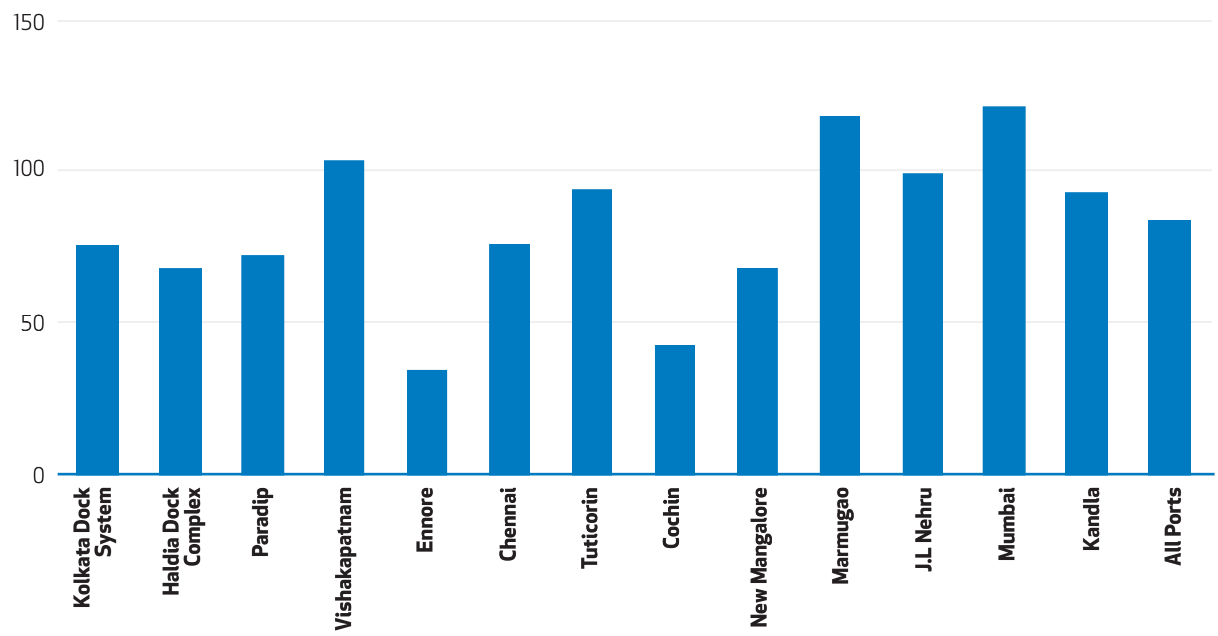
> *there is no concept of 'pre-berthing detention' as in world-class ports. The capacity is much more than the actual traffic and the planning is also done on those lines. Hence there is no question of any ship waiting at anchorage*[42].

In contrast, on average, ships have to wait for more than two days to berth at an Indian port.

While data on port performance is not available for bulk commodities, the Maritime Agenda does have a comparison of major Indian ports with Singapore for handling of container ships. The turnaround time for container vessels at major Indian ports is 1.77 days compared to just 0.50 days at Singapore port. The cargo dwell time for containers at major Indian ports is 3.78 days while it is just 0.60 days for Singapore. Even though the performance of a port on handling of bulk cargo can be different from containers, these numbers do give an idea of the gap between the performance of Indian and world-class ports.

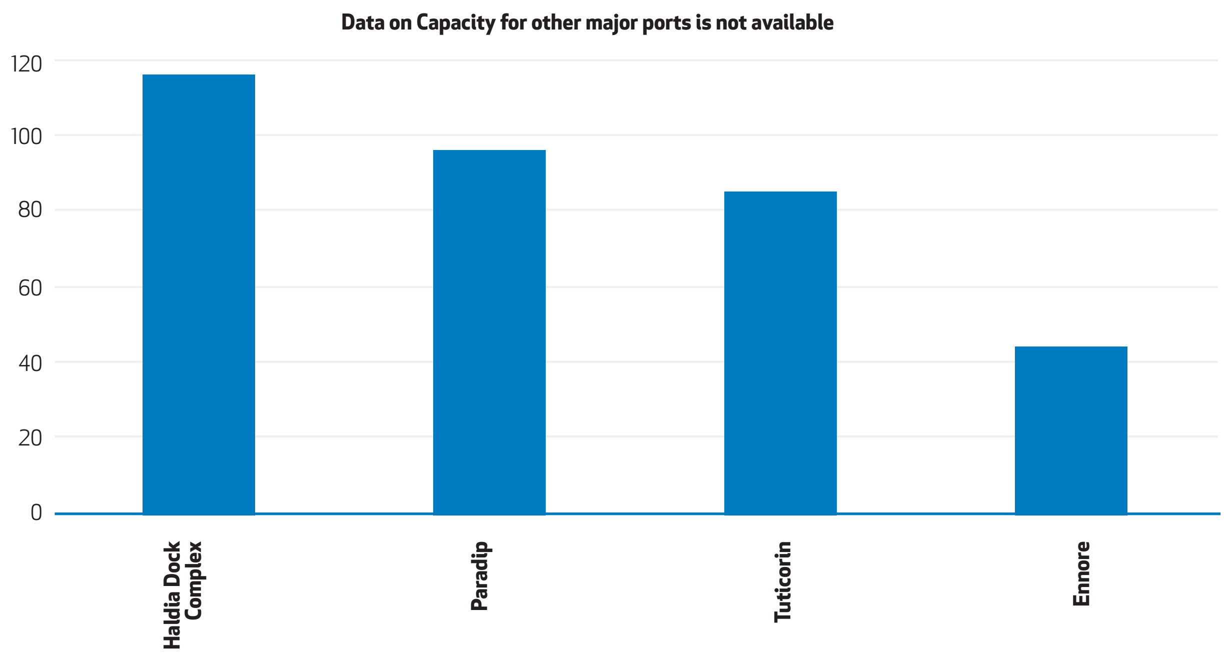
41. The traffic in this table, particularly for coal is a little lower than given in Chapter IV 4, Volume IIIon Pports and Shipping in Volume III. The projections given here are based on expected level of imports and coastal shipping with data on 2011-12 from the Directorate-General of Commercial Intelligence and Statistics (DGCIS). The projections in the chapter on ports areis based on direct projections of traffic, with data for 2011-12 from the Ministry of Shipping.
42. Ministry of Shipping (2011).

Figure 8. 43
Capacity Utilisation Percentage of Major Ports



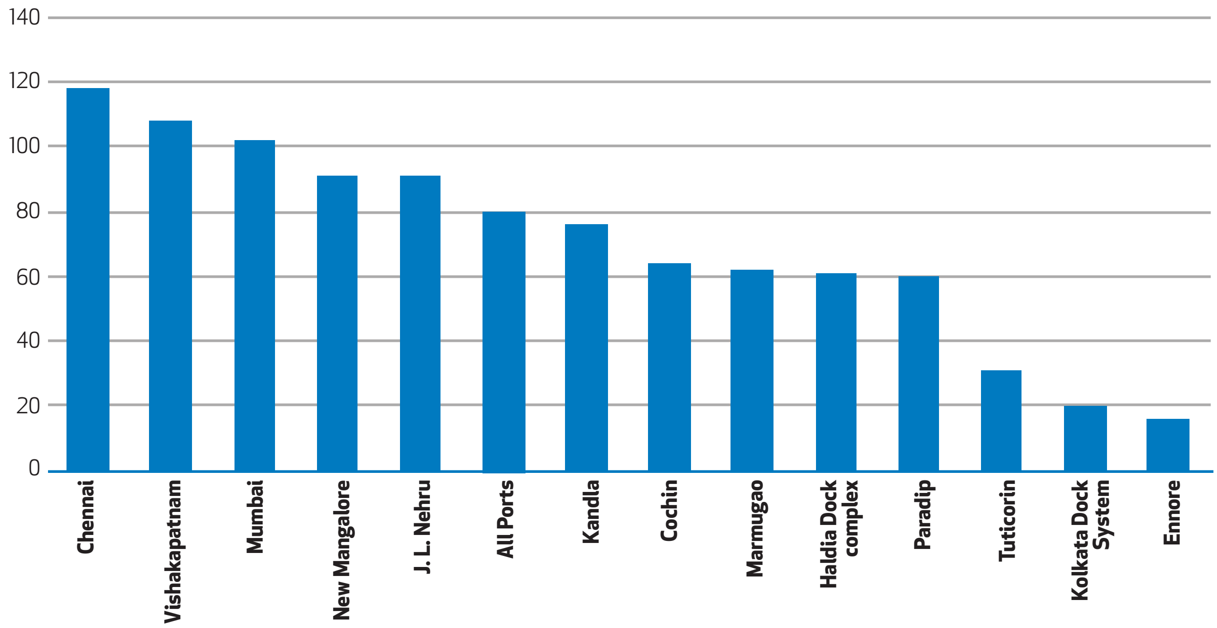
Source: Ministry of Shipping (2012).

Figure 8. 44
Capacity Utilisation Percentage for Coal at Major Ports



Source: Ministry of Shipping (2012).

Figure 8. 45
Capacity Utilisation Percentage for POL at Major Ports



Source: Ministry of Shipping (2012).

Table 8. 29
Performance of Major Ports

PERFORMANCE METRIC	AVERAGE FOR MAJOR PORTS
Pre-Berthing Dwell Time	2.1 days
Turn-Around Time	4.5 days
Output Per Ship-berth-Day	11,112 Tonne

Source: Indian Ports Association (2012).

Some of the reasons for the poor performance at ports are listed below[43]:

- **Low Level of Mechanisation.** Indian ports lack modern technology to handle coal and other bulk cargo. There are a limited number of berths available for handling bulk cargo with mechanised ore-handling capability. (Paradip Port is the only one with a dedicated berth for coal handling.) The low level of mechanisation, in combination with other factors leads to low productivity.
- **Inadequate Cargo-Handling Equipment.** Even the equipment that exists in the ports is old and breaks down frequently and takes long to be repaired. This results in long downtimes, exacerbating the problem of low productivity.
- **Inadequate Navigational Aids and Facilities.** Most of the ports are not equipped with a vessel traffic management system (VTMS). Furthermore, the number of tug-boats and launches are likely to be insufficient for the increased traffic that is expected.
- **Insufficient Use of Information Technology.** Resources and equipment at the ports are spread out and without good ERP systems, are underutilised.
- **Insufficient Drafts.** The drafts at Indian ports have been very low and not in keeping with the increase in ship sizes that is occurring around the world. The older ports have drafts as low as 7 metres while a few of the new ports go up to 16 metres. For shipping of bulk materials such as coal and iron ore, the larger the ship the better because of the economies of scale. As Table 8.30 shows, *transport costs for bulk shipping can come down by more than 40 per cent by increasing the size of the ship from Handy Size to Cape Size.*

43. PwC (2009).

Table 8. 30
Effect of Vessel Size on Transport Costs

SHIP SIZE	DEAD WEIGHT (TONNE)	DRAFT REQUIRED (METRES)	TRANSPORT COSTS (INDEXED TO HANDY SIZE AS 100)
Handy Size	35,000	10	100
Panamax	80,000	12	76
Cape Size	180,000	18	58

Source: Ecorys (2012).

However, the required draft also increases from 10 metres for a Handy Size vessel to 18 metres for a Cape Size vessel.

- **Insufficient Storage Space.** Lack of adequate stacking space results in less clear space at the port which in turn leads to higher vessel turnaround time.

COASTAL SHIPPING[44]

Coastal shipping is an important mode of transport for bulk commodities that has several advantages and can reduce the burden on other modes. Coastal shipping uses less fuel (~5 g/tonne-km) compared to road (~ 31 g/tonne-km) and rail (~ 9 g/tonne-km). Consequently, it is less expensive and has a lower environmental impact. Currently, coastal shipping carries only about 7 per cent of the freight traffic, well below its potential, given India's long coastline. In comparison, the share of coastal shipping is 15 per cent in the US and 43 per cent in the EU. Even at the current low level of penetration, about two-thirds of the total traffic carried by coastal shipping is for POL, coal and iron ore. Therefore, it can play a significant role in the bulk transport of these commodities.

COMPARISON OF TRANSPORTATION COSTS USING COASTAL SHIPPING

Table 8.31 compares the costs for transporting coal from Mahanadi Coalfields Ltd (MCL) in Odisha to the coastal states namely, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Gujarat by coastal shipping with the costs of rail transport. For coastal shipping, it is assumed that coal is transported from the mine by rail to Paradip from where it is shipped to the destination ports in the states. One destination port has been selected for each state. For estimating the costs of rail transport, it is assumed that coal is transported by rail from the mine to the geographical center of the state. For both rail and coastal shipping, we have used tariffs as proxies for the costs. Ideally, costs should be compared but it was not possible to get actual costs for transportation and handling.

In spite of the much longer distance ships would have to travel, the freight charge in all cases are lower for coastal shipping even for Kandla port where the distance travelled by a coastal ship is much greater than the distance travelled by rail which cuts across the country. For Vizag, Ennore and New Mangalore, shipping freight charges are 25-50 per cent of the rail freight charges.

But on comparing total costs, it is cost-effective to use coastal shipping only for transporting coal to Ennore. For all other destination ports in the table, the customer would pay more in total for coastal shipping, because of the other charges.

Handling charges to be paid at Paradip to load the ship and at the destination port to unload the ship, and freight charges would have to be paid to bring the coal from the mine to the port of origin (Paradip in this example) and to take the coal from the port to the power plant. Together, the additional charges are almost as much or even more than the shipping freight charges. Thus, the cost advantage of coastal shipping is not realised because of high handling charges and first and last mile connectivity.

REASONS FOR SLOW ADOPTION OF COASTAL SHIPPING

There are several factors which contribute to the high handling charge for coastal shipping and the lack of interest in it:

- Major Ports do not have separate berthing and material-handling facilties for coastal vessels which are smaller. This results in higher costs and longer turnaround times.
- Minor Ports do not have adequate material-handling facilities and the equipment is often not working.
- Lack of consolidation and the resulting large number of small players hampers economies of scale.

44. This section, except the table and analysis of costs is based on information in the report by Ernst & Young (2011).

Table 8. 31
Comparison of Rail and Coastal Shipping Costs
[in Rs/Tonne]

(COAL FROM MAHANADI COALFIELDS, ODISHA TO DESTINATION PORT VIA PARADIP FOR COASTAL SHIPPING)						
DESTINATION PORT	RAIL	COASTAL SHIPPING				
	FREIGHT	FREIGHT	HANDLING	RAIL - MINE TO ORIGIN PORT	RAIL - DEST. PORT TO POWER PLANT	TOTAL
Vizag	867	173	368	327	91	959
Ennore	1,164	243	368	327	91	1,029
New Mangalore	1,248	646	368	327	91	1,432
Mumbai	994	820	368	327	91	1,606
Kandla	1,445	1,173	368	327	91	1,959

Note: Freight charges for coastal shipping (Rs 0.23/tonne-km), and handling charges are based on TANGEDCO costs for transporting coal from Paradip to Ennore.
Source: Working Group Research and TANGEDCO (2012).

- The other modes of transport such as roads, railways and aviation enjoy subsidies and credit facilities butnot coastal shipping. Effectively, this increases costs.
- Connectivity between ports and the hinterland is inadequate.
- Qualified personnel are not available because most prefer to move to overseas ships that have better perquisites and tax benefits.
- Lack of an integrated transport policy which encourages and promotes inter-sectoral coordination

RECOMMENDATIONS FOR PROMOTING COASTAL SHIPPING

Over the years, the government has taken several initiatives to remove some of the disadvantages suffered by the coastal shipping industry. In 2004, a special cell was established for development of coastal shipping. As a result, in 2008, the manning scales for coastal ships were relaxed so that they were more consistent with the smaller size of the vessels, and did not impose an onerous staff requirement. In recognition of the fact that the vessels engaged in coastal shipping were smaller and did not require the same construction, equipment and safety requirements as ocean-going vessels, there was an exemption for coastal ships from these requirements of the Merchant Shipping Act. Now coastal ships are subject to requirements that are more appropriate for the kind of service they do. In addition, policies have been proposed for dedicated facilities for coastal shipping and to develop minor ports for this.

In spite of these initiatives, growth in coastal shipping has been sluggish relative to its potential. While appropriate policies have been formulated, there has been a lack of framework for implementation. Such a framework should include inputs from all stakeholders on barriers to effective implementation and suggestions for overcoming them; and assign responsibility and timelines for various tasks.

STRATEGIC CONSIDERATIONS FOR FURTHER DEVELOPMENT OF PORTS

As we have seen, currently Indian ports have severe limitations of capacity to handle bulk cargo traffic. Clearly considerable efforts and investment will be required to upgrade the ports to not only service the fourfold increase in traffic but also meet the performance benchmarks based on international standards. Efforts are being made to improve the performance of individual ports. However, a broader and coherent strategy needs to be developed for the overall ports sector based on a vision for the sector.

Some of the issues that need to be addressed, as the country develops its port strategy:

- Mega Ports provide very significant economies of scale and most of the world's major economies have a few Mega Ports. How many Mega Ports should there be in the country and where should they be located?
- Should ports for bulk commodities be separate from those for other cargo?
- Should ports for coastal shipping be separate from ports for international traffic?

Except for Paradip, no major port in India has dedicated berths for unloading coal. Traditionally, this was how it was in other countries too. However, now the worldwide trend is towards development of facilities dedicated to handling bulk cargo.

Consideration of these issues, particularly regarding the number and location of mega ports are discussed in the chapter on Ports and Shipping.

EXPECTED PORT TRAFFIC FOR BULK COMMODITIES

We looked at the current level of coal imports in the coastal states to determine how much was for consumption within that state and how much was destined for other states. For each landlocked state, we were also able to make an educated guess about which coastal state was importing coal for it. This allowed us to develop a picture of the approximate route taken by the imported coal. As consumption by state for POL was not known, we simply assumed that the current pattern of imports would continue. Thus as the nationwide POL port traffic is projected to increase, the relative proportion of traffic in each state is assumed to remain the same.

THERMAL COAL

Figure 8.46-52 show port traffic by state for thermal coal. It is mainly imported by Gujarat, Andhra Pradesh, Tamil Nadu and Odisha. For the coming two decades, we assume that Gujarat will import thermal coal for itself and mainly for Rajasthan, Haryana and Punjab and a small amount for Madhya Pradesh. Andhra Pradesh is expected to import for itself and Eastern Maharashtra; Tamil Nadu for itself and Karnataka. Odisha is not expected to use any imported coal but will import for Uttar Pradesh, Bihar and West Bengal. Three ports on the eastern coast—one each in Andhra Pradesh Odisha and Tamil Nadu—could serve their own needs and those of Bihar, West Bengal, Uttar Pradesh and Eastern Maharashtra. On the western coast, Gujarat will need a mega port. In addition, it seems appropriate to have a mega port near the southern part of the coast of Maharashtra. This would serve western Maharashtra and Karnataka.

COKING COAL

Figures 8.53-55 show port traffic by state for coking coal. Odisha and Andhra Pradesh are expected to be the main ports. Odisha will import for the steel plants in the state and for those in Jharkhand. Andhra will import mainly for itself and for Chhattisgarh. Gujarat is also expected to import a significant amount. Karnataka and Goa are also likely to import some. Mega ports in Andhra Pradesh and Odisha would be able to serve the needs of the east coast while those in Gujarat and the northern part of the Karnataka coast should be able to serve the needs of the west coast.

POL

Figures 8.56-58 show port traffic by state for POL. Gujarat is by far the dominant state for port traffic for POL. By 2031-32, the port traffic in Gujarat for POL is expected to reach 500 Mt. Clearly a mega port will be required in Gujarat. The other coastal states have POL traffic that is roughly equal to one another but much less than Gujarat.

COMPOSITE PORT TRAFFIC BY STATE

Figures 8.59-61 show the composite port traffic by state due to POL, thermal coal and coking coal. Gujarat is by far the state that has the most port traffic for all three commodities, and would clearly be a prime location for a mega port. On the east coast, three states have a large amount of traffic—Odisha, Andhra and Tamil Nadu, and are potential candidates for mega ports. On the west coast, in addition to Gujarat, one or two more mega ports will be required. Maharashtra has the largest amount of port traffic on the west coast after Gujarat, and it may be appropriate to have a port on the southern end of the Maharashtra coast that could also be used to serve Gujarat and Karnataka.

SUGGESTIONS FOR LOCATING MEGA PORTS

Selection of sites for locating mega ports requires extensive modeling and analysis. First and foremost, the port traffic from all commodities will need to be taken into account. In this study, we have looked at port traffic from coal and POL only. Second, detailed data are required on the cost of further development of ports at potential sites. Third, detailed modeling will be required to examine the costs and benefits of various alternative selections from a short list of potential sites.

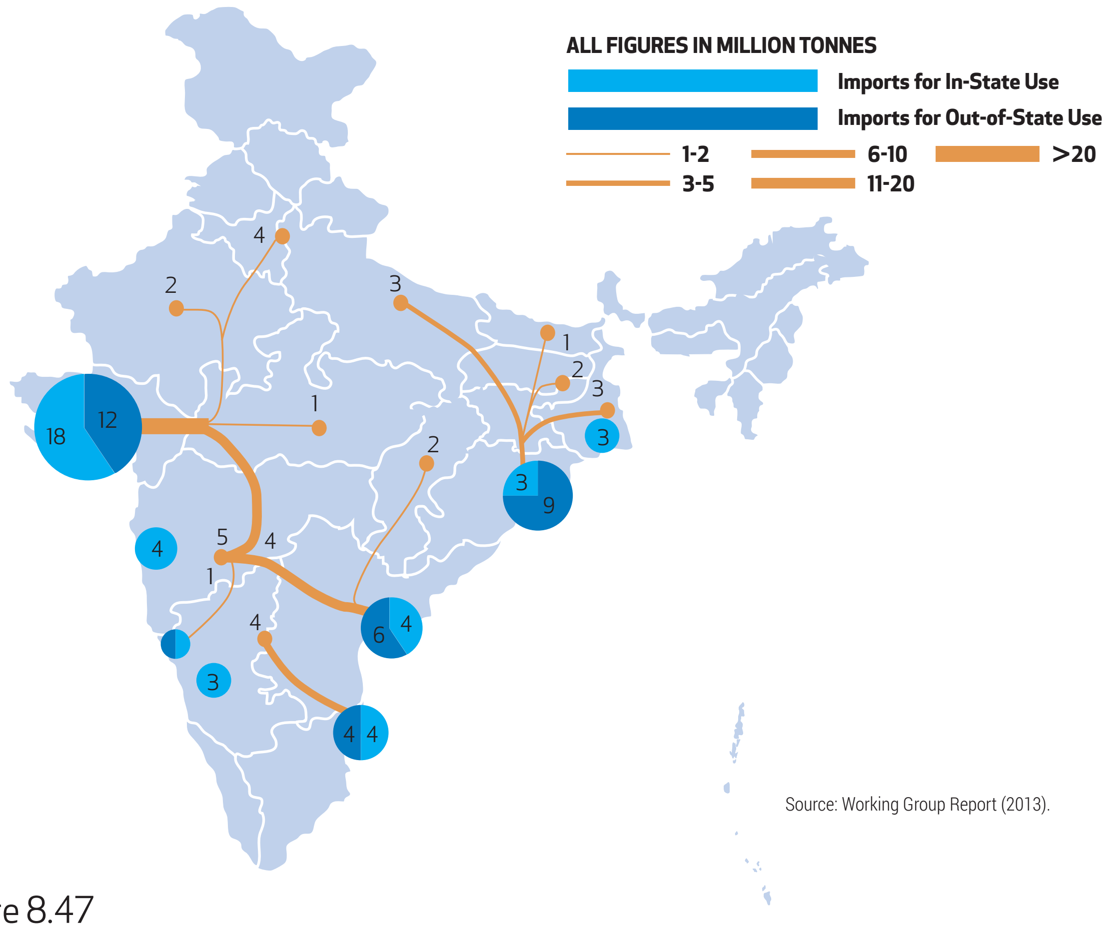
Lack of adequate draft at the port entrance is one of the main issues that need to be addressed at a macro-level for the port sector. Except for some ports such as Mundra, Kakinada, Dhamra and Gangavaram which have a natural deep draft, most other ports have shallow natural drafts and therefore require that the depth of the approach channel be artificially created and maintained[45]. Dredging is a highly capital intensive activity where the costs are very sensitive to the type of seabed that needs to be dredged. Loose sand beds are relatively cheaper to dredge but hard rock beds can be very expensive to dredge[46]. These issues need to be kept in mind in strategising about the number and location of mega ports.

The investment in breakwaters also needs to be considered. Breakwaters break the force of sea waves and thus create tranquil water conditions so that ships can be loaded and unloaded smoothly. However, they involve large investment. They also have

45. imaritime (2003); DPCL (2013).
46. imaritime (2003).

Figure 8. 46

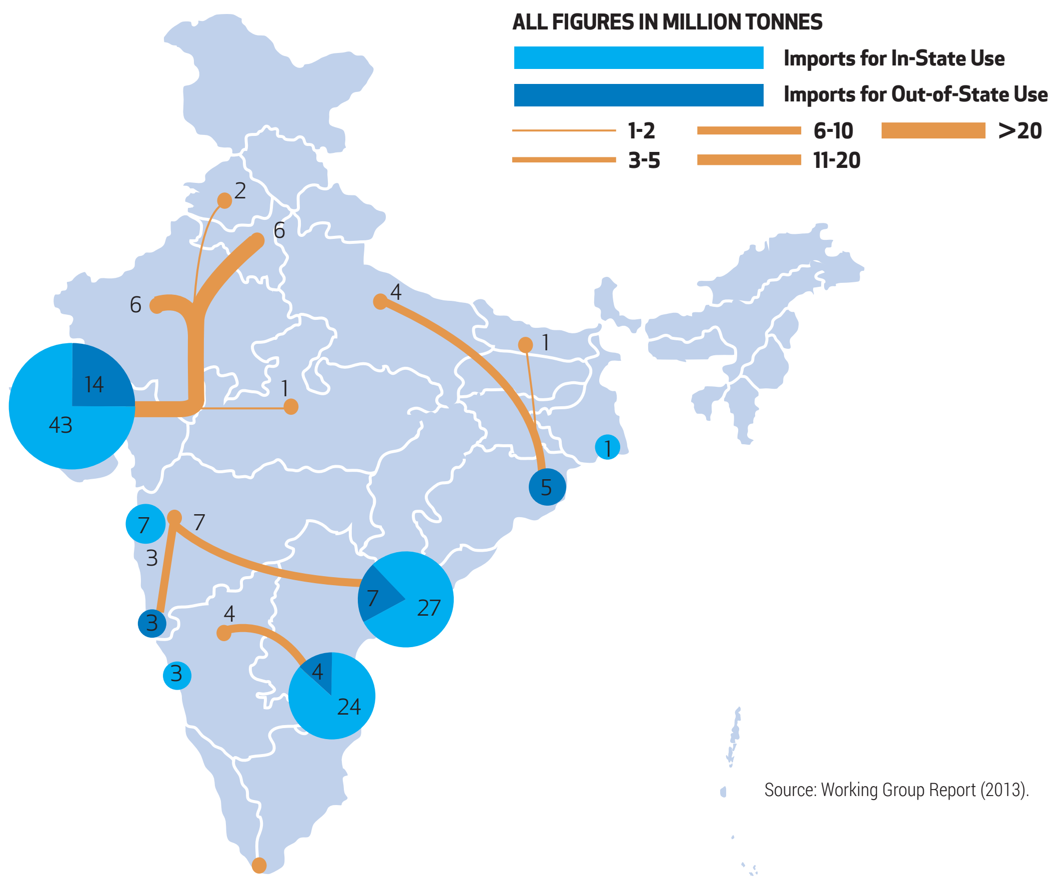
Port Traffic for Import of Thermal Coal 2011-12: Base Case



Source: Working Group Report (2013).

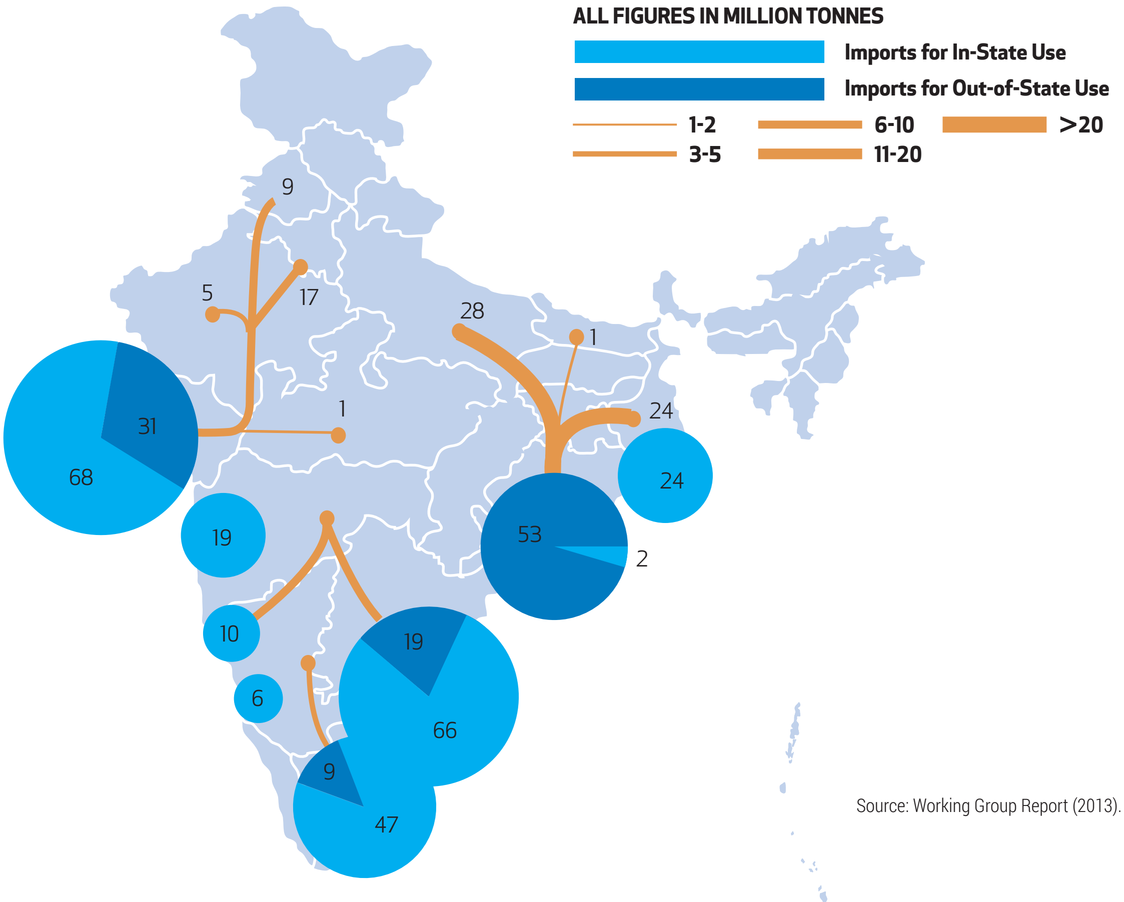
Figure 8.47

Port Traffic for Import of Thermal Coal 2021-22: Base Case



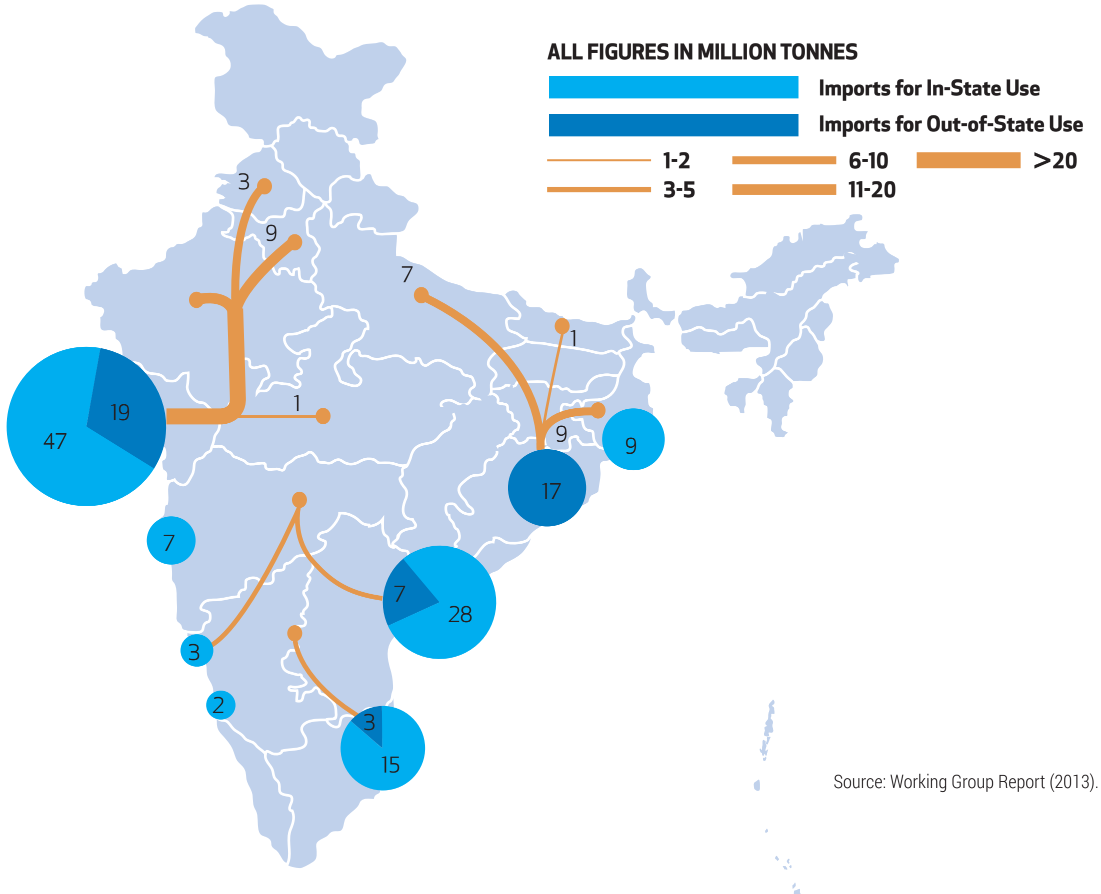
Source: Working Group Report (2013).

Figure 8.48
Port Traffic for Import of Thermal Coal 2031-32: Base Case



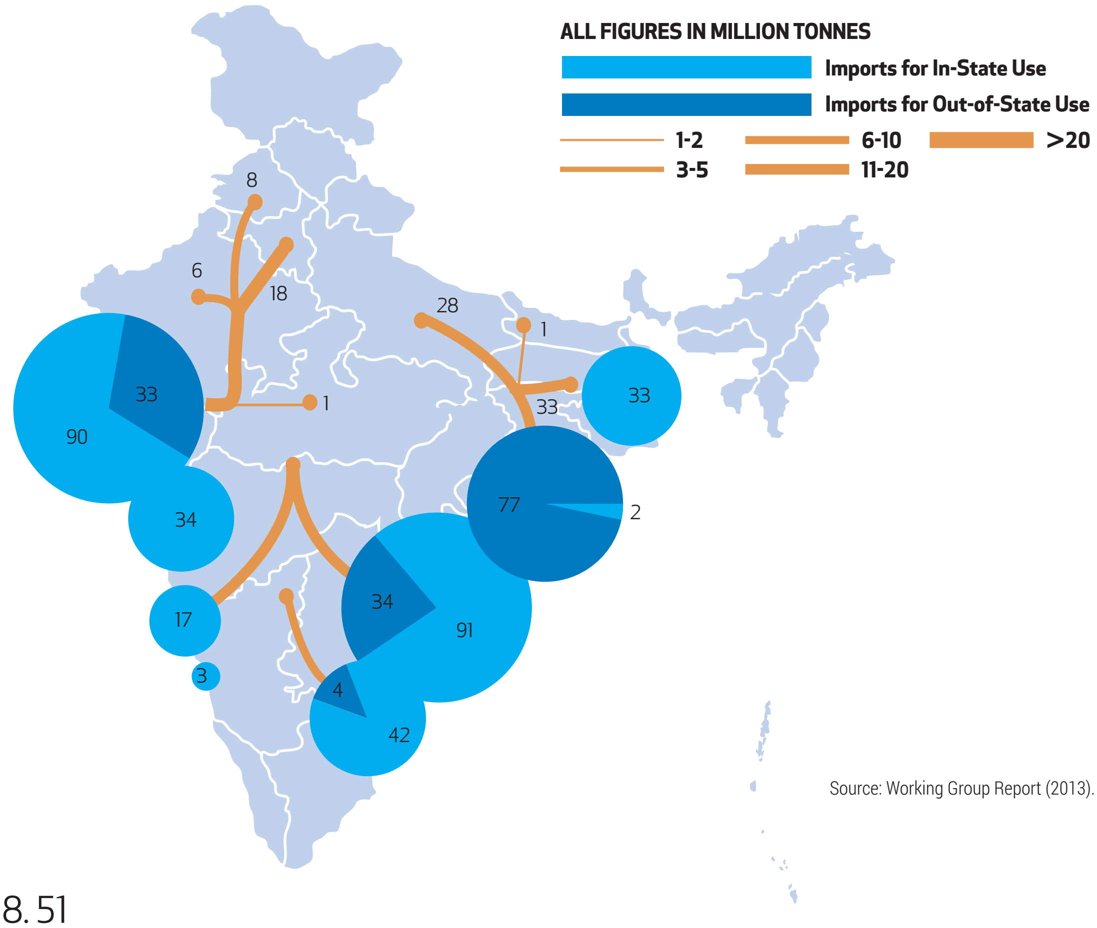
Source: Working Group Report (2013).

Figure 8. 49
Port Traffic for Import of Thermal Coal 2021-22: High Case



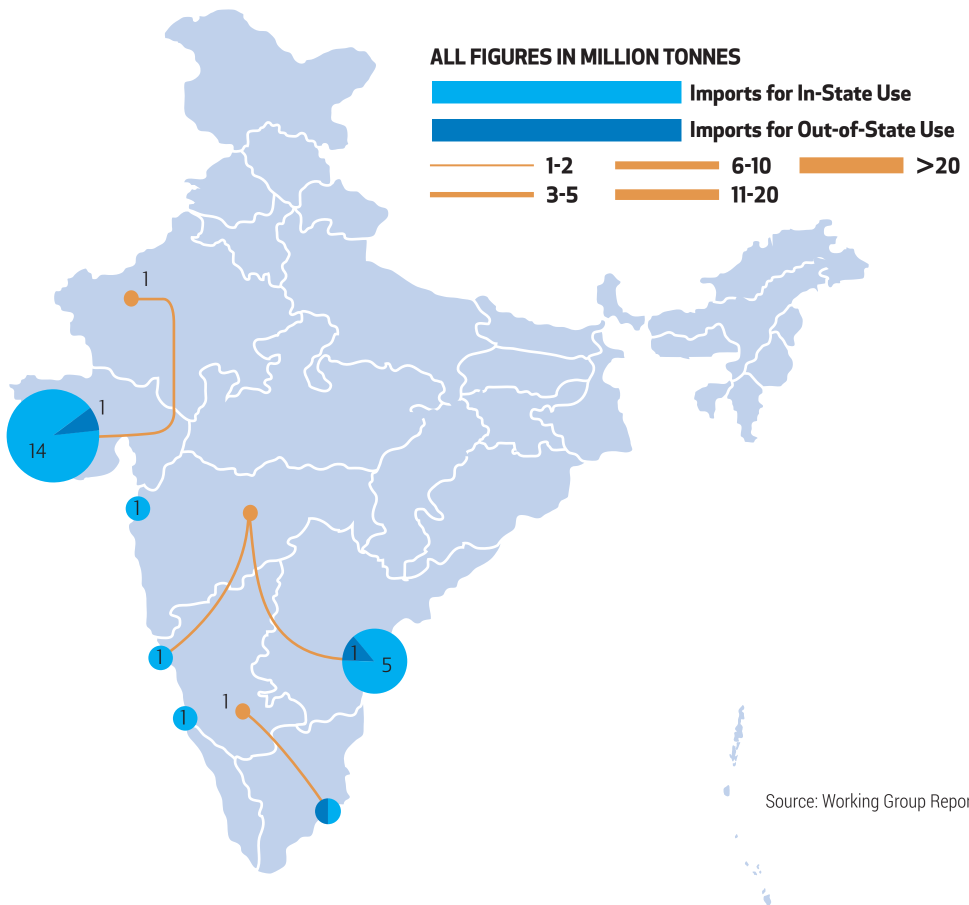
Source: Working Group Report (2013).

Figure 8. 50
Port Traffic for Import of Thermal Coal 2031-32: High Case



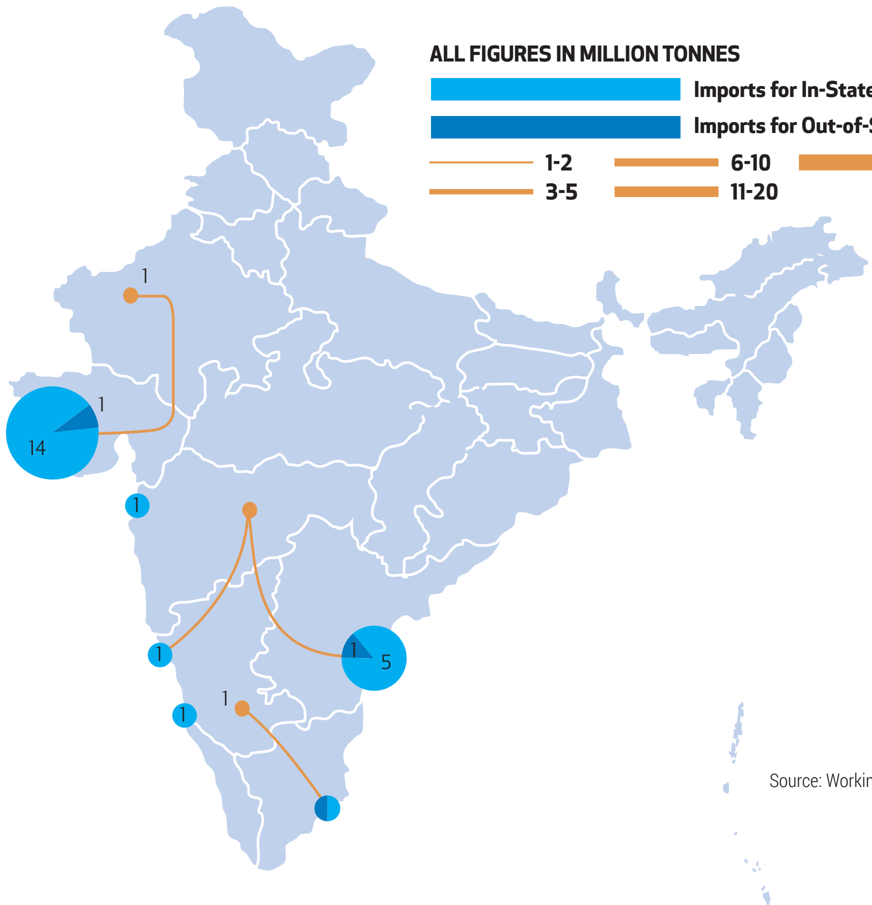
Source: Working Group Report (2013).

Figure 8. 51
Port Traffic for Import of Thermal Coal 2021-22: Low Case



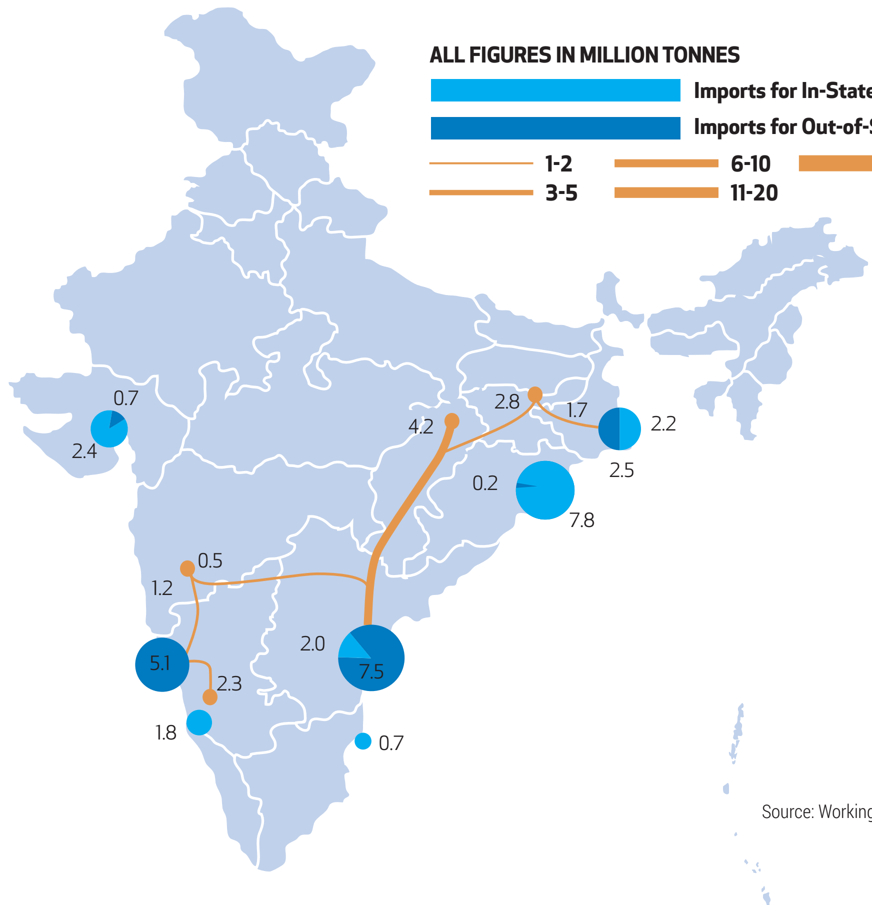
Source: Working Group Report (2013).

Figure 8. 52
Port Traffic for Import of Thermal Coal 2031-32: Low Case



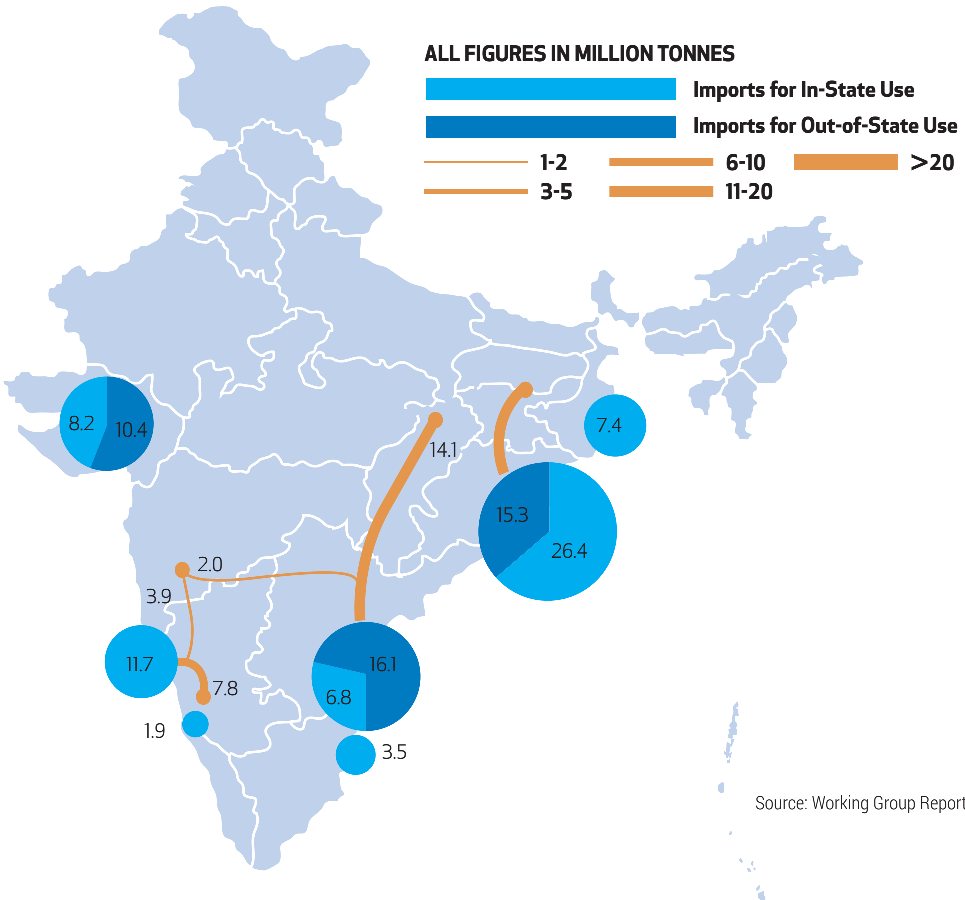
Source: Working Group Report (2013).

Figure 8. 53
Port Traffic for Imported Coking Coal 2011-12



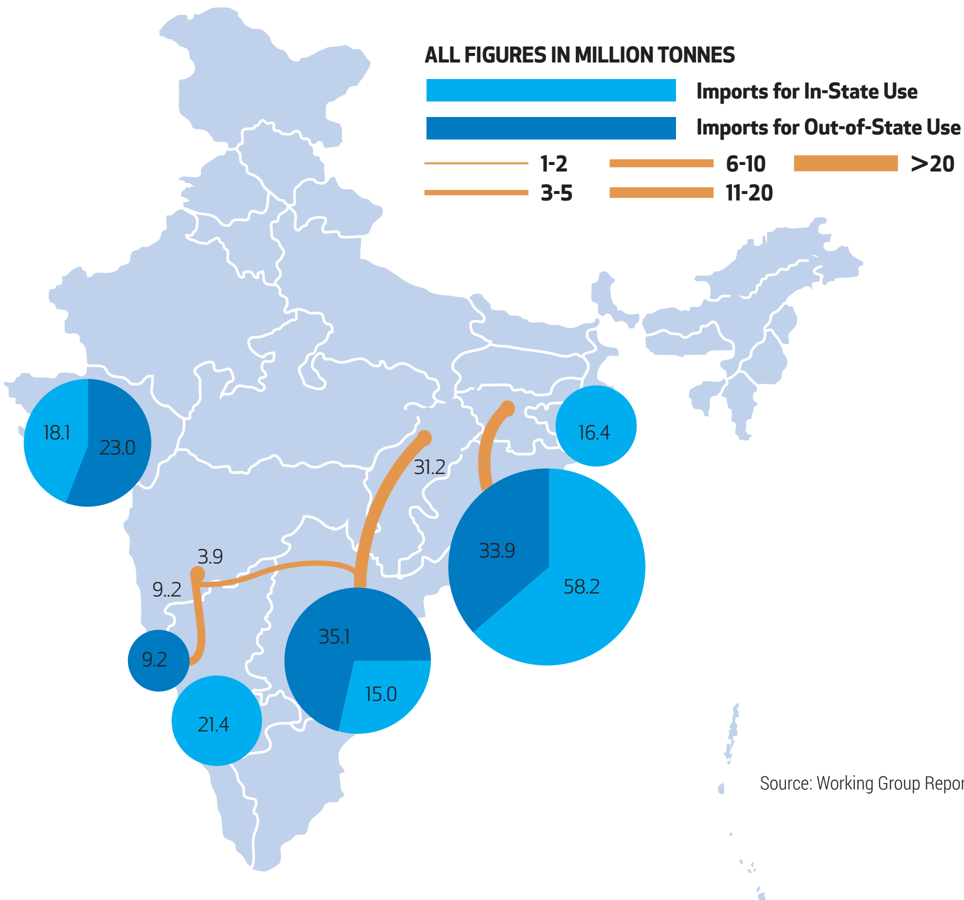
Source: Working Group Report (2013).

Figure 8. 54
Port Traffic for Imported Coking Coal 2021-22



Source: Working Group Report (2013).

Figure 8. 55
Port Traffic for Imported Coking Coal 2031-32



Source: Working Group Report (2013).

Figure 8. 56
Port Traffic for POL 2011-12

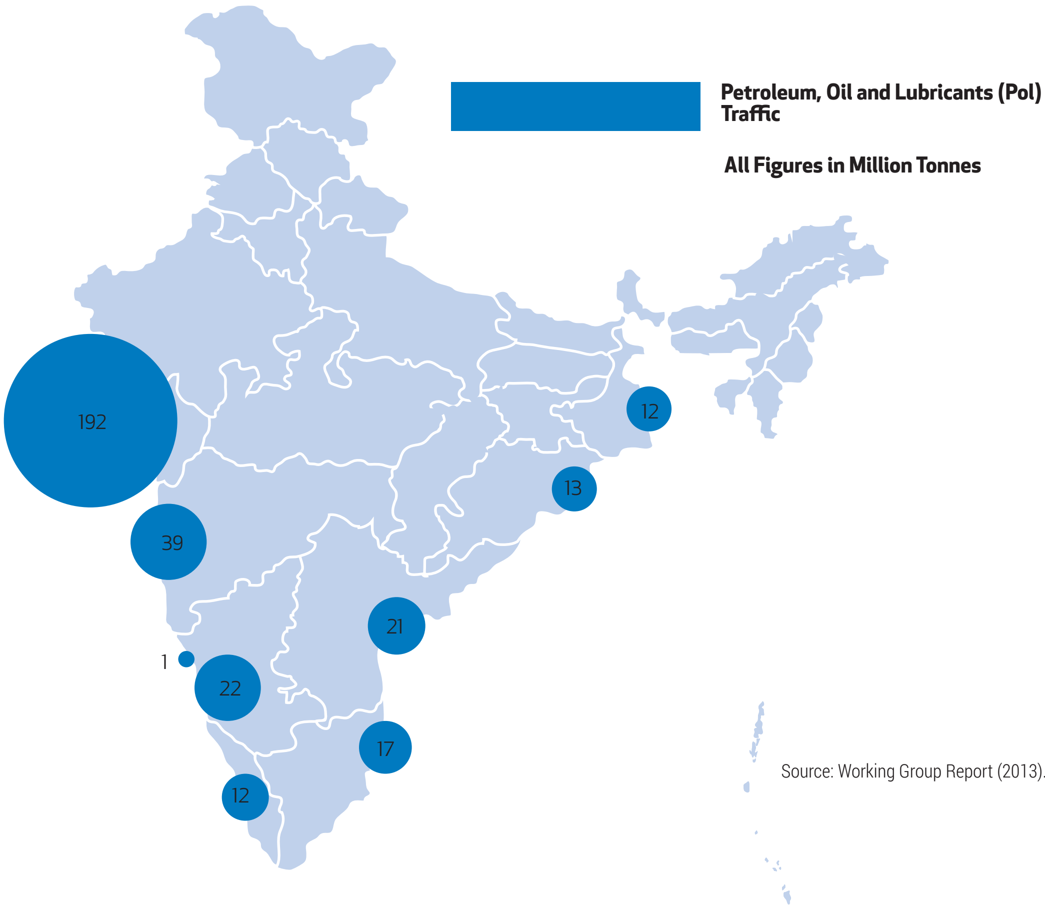


Figure 8. 57
Port Traffic for POL 2021-22

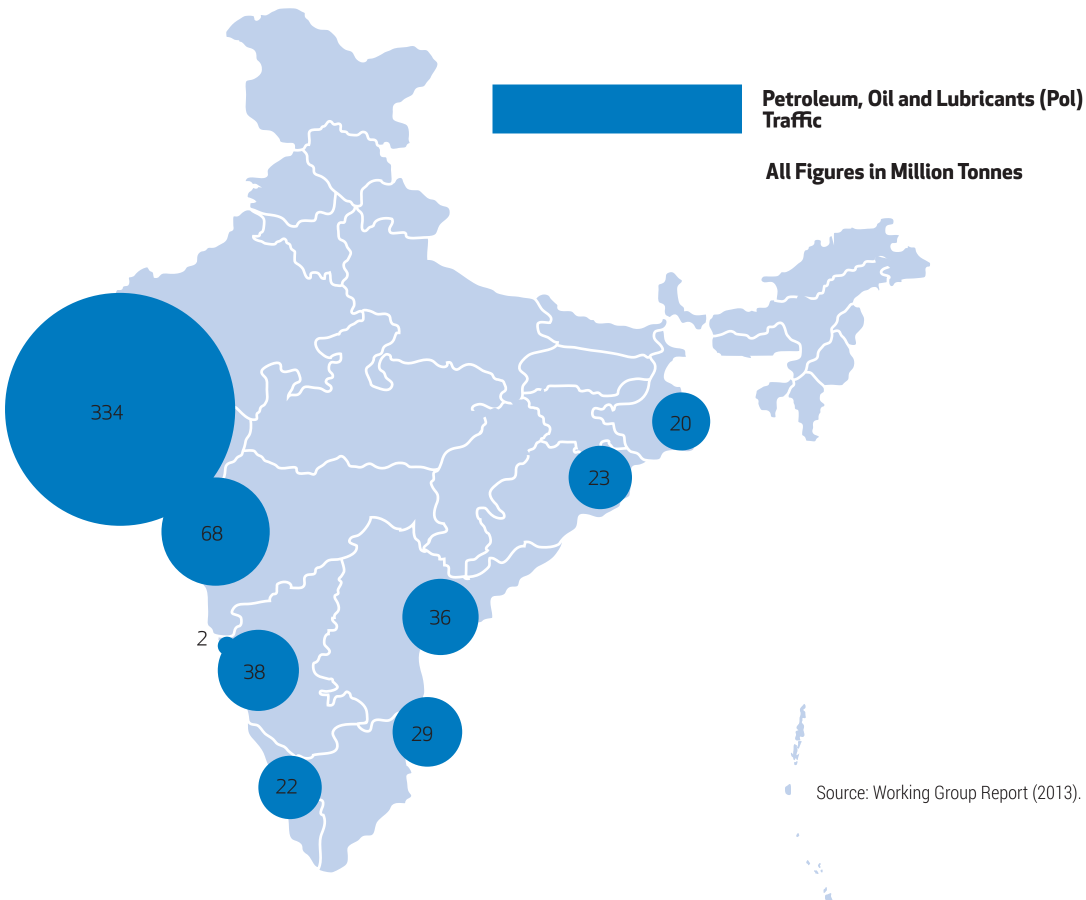
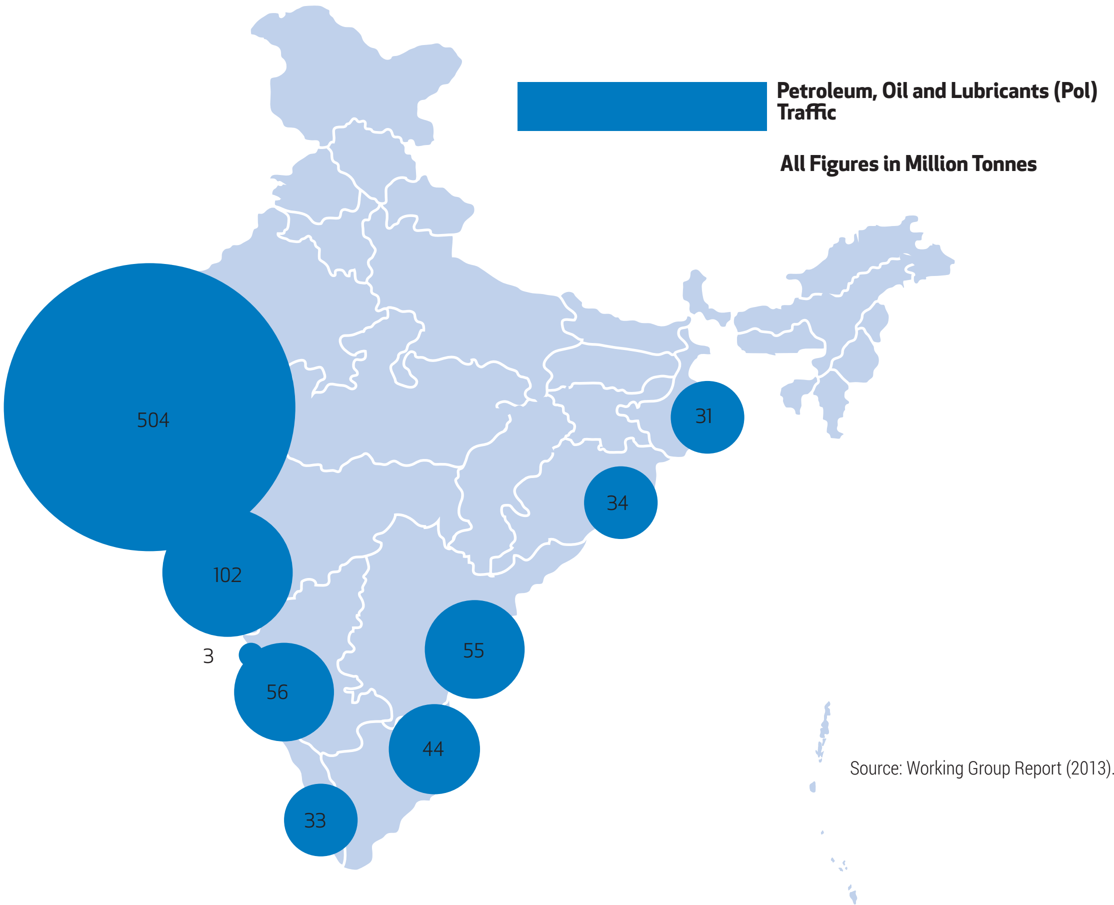
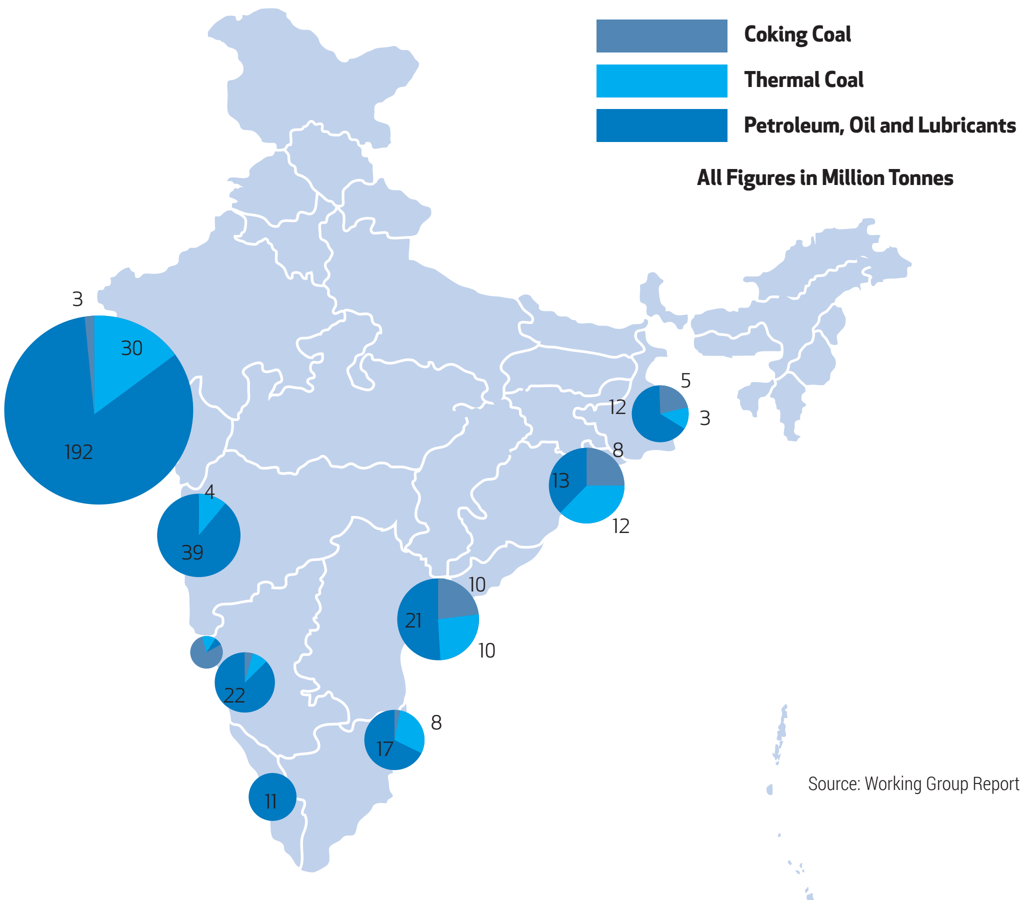


Figure 8. 58
Port Traffic for POL 2031-32



Source: Working Group Report (2013).

Figure 8. 59
Composite Port Traffic 2011-12



Source: Working Group Report (2013).

Figure 8. 60
Composite Port Traffic 2021-22

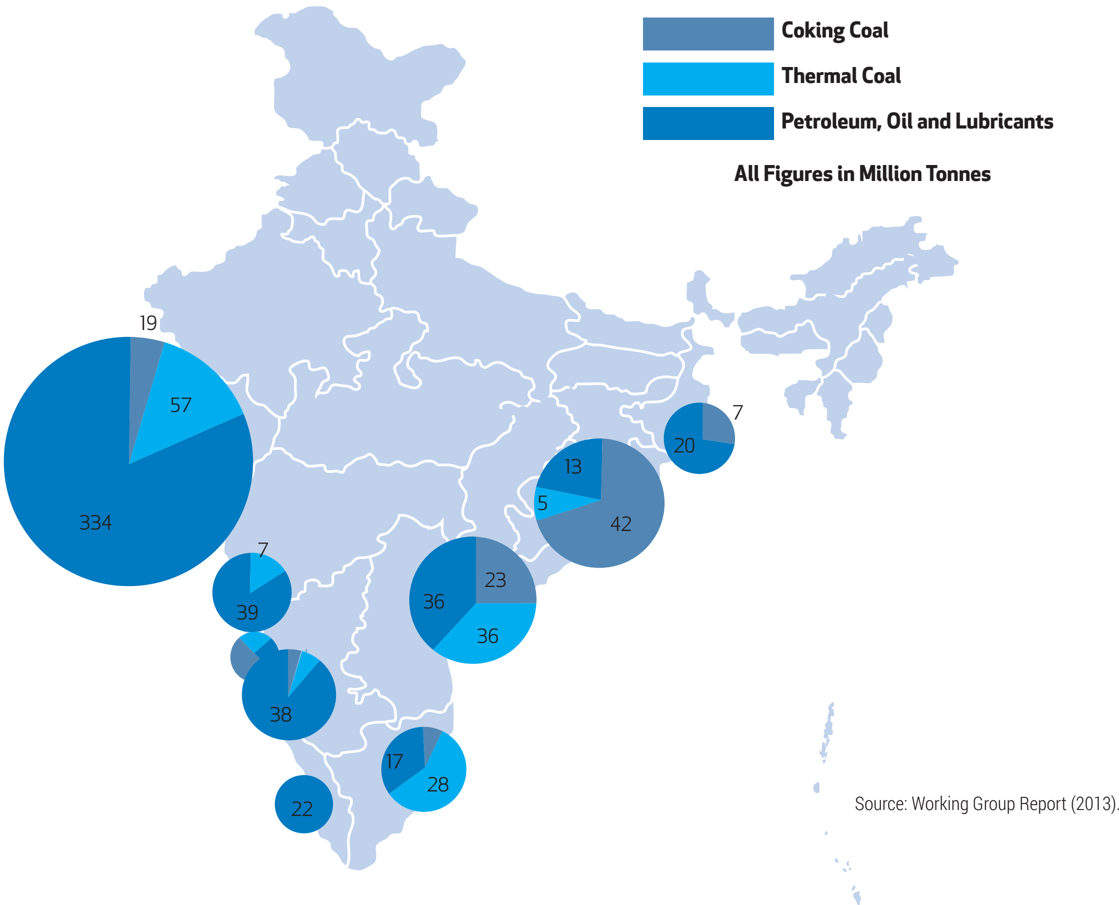


Figure 8. 61
Composite Port Traffic 2031-32

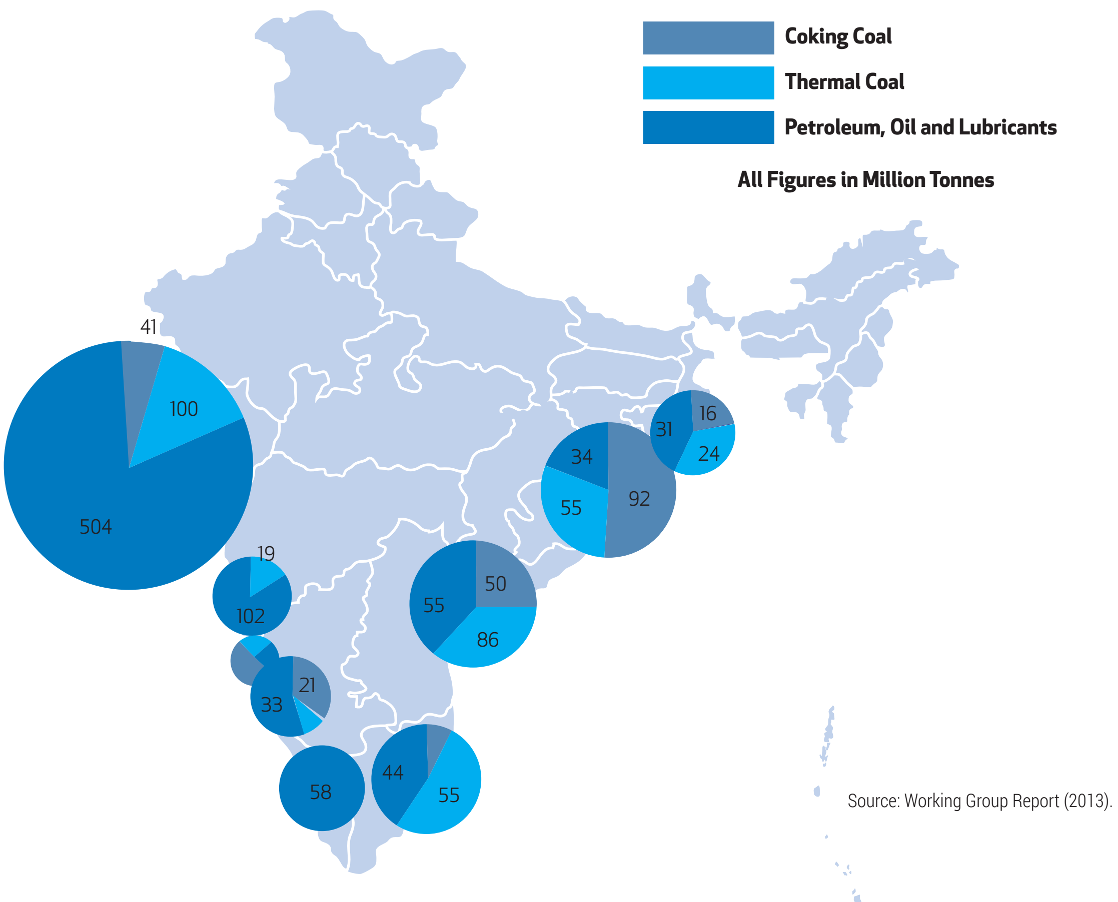


Table 8. 32
Ports with Dedicated Facilities for Dry Bulk Commodities

COUNTRY	PORT	COMMODITY
Canada	Port Cartier	Iron Ore
	Seven Islands	Iron Ore and other minerals
	CSL Transshipment	Iron Ore, Coal
Brazil	Tubarao Terminal	Iron Ore
South Africa	Richards Bay	Coal
	Saldanha	Iron Ore and Steel
Australia	Port of Hay Point	Coal
	Dalrymple Bay Coal Terminal	Coal
	Port of Abbot Point	Coal

Source: Ecorys (2012).

long-term effects on the sediment transport near the shore and need to be constructed only after intensive and comprehensive geo-technical studies on ocean currents in order to avoid damage to the coastline[47].

DEDICATED BULK-HANDLING FACILITIES

Except for Paradip, no major port in India has dedicated berths for unloading coal. Traditionally, this was how it was in other countries too, with bulk cargo being handled along with general cargo in multipurpose ports. However, now there is a worldwide trend towards development of facilities dedicated to handling bulk cargo. Some of the reasons for this development are[48]:

- The scale of shipments and size of ships for bulk commodities have increased. Bulk cargo technologies have advanced. Larger ships require more storage space and deeper water.
- Rail connectivity up to the terminal and unit train operations have become prerequisites for bulk transport.
- In an attempt to gain control over the entire supply-chain including dedicated port facilities, shippers are looking for vertical integration.
- Urban society is becoming more conscious of environmental issues and does not want 'dirty' coal and coal-dust in its neighbourhoods. Furthermore, there are safety and security issues associated with commodities such as coal and POL.

The tendency towards vertical integration will need to be monitored for monopolistic practices. If a private player sets up a terminal in a port for its exclusive use and restricts entry of others or charges monopoly rents for its use, then it may distort the market for the commodity. Appropriate regulatory measures will be required to monitor and prevent such practices.

Table 8.32 gives some examples of dedicated facilities[49].

DEDICATED PORTS/TERMINALS FOR COASTAL SHIPPING

Ships used for coastal shipping are smaller and require appropriate berths. Major ports do not have separate berthing facilities for coastal ships. At the same time, minor ports lack adequate infrastructure and much of the equipment does not work. Consequently, turnaround times for coastal ships are high. About 70 per cent of a coastal ship's time is spent in ports and only about 30 per cent on voyages, inflicting huge losses on the coastal shipping companies[50]. It is suggested that several minor ports be developed along the coast every 100-200 km with the following capacity[51]:

- Ability to handle vessels with a requirement of draft up to 5 metres.
- Material handling and other infrastructure to turn around a vessel in 12-18 hours.
- Sufficient first and last mile connectivity to road/rail network.

47. imaritime (2003).
48. Ecorys (2012).
49. See Ecorys (2012) for details.
50. E&Y (2011).
51. Ibid.

Connectivity to the non-major ports is very poor. Of the 200 non-major ports, only 60-65 ports are active, handling import and export of cargo. Of these, only six have complete rail connectivity.

This will reduce congestion at major ports and enhance the efficiency of coastal shipping.

CONNECTIVITY TO PORTS

Ports should be seen as nodes in the transport network and not a goal in themselves. Port connectivity is essential for the import of both thermal and coking coal. In 2005, a Committee of Secretaries was set up to establish policies to improve port connectivity. The Committee recommended that each major port should be connected by minimum a four-lane road and a double-line rail. As imported coal is most likely to be transported by rail, we focus only on rail connectivity here.

While Kolkata, Haldia, Vizag, Ennore, Chennai, Tuticorin, have the required double-line connectivity, for the following ports the provision of double-line connectivity is in progress:

- Paradip port is connected by a double-line section with Cuttack to the Howrah-Chennai trunk line. The Daitari-Banspani and Haridaspur-Paradip lines are under construction.
- Cochin port has single-line connectivity and is in the process of getting double-line connectivity
- New Mangalore port has limited rail connectivity and additional connectivity needs to be provided.
- Mumbai Port has double-line connectivity but the trains have to pass through a busy suburban section. Work on a third line is in progress.
- Kandla port has connectivity to Mumbai and Delhi via Ahmedabad. Doubling of the Gandhidham-Kandla is in progress.

Connectivity to the non-major ports is very poor. Of the 200 non-major ports, only 60-65 ports are active, handling import and export of cargo. Of these, only six have complete rail connectivity. Another 8-10 have a railway station nearby but still need last-mile connectivity. Provision of rail connectivity to the non-major ports needs to be improved urgently.

INVESTMENT FOR UPGRADING PORTS

The estimates of investment required in ports for bulk commodities are based on the volume of import/export traffic for coal and POL. We have considered coal and POL only so that we can estimate how much investment can be attributed to these bulk commodities. However, we recognise that actual planning and investment would consider all commodities and would take into account synergies between the various commodities. Further, these estimates are only indicative and are not based on detailed planning. Such detailed planning can only follow a detailed strategy for ports that takes into account some of the considerations outlined earlier.

The calculation of the investment required is shown in Table 8.33. It starts with estimates of traffic for import of thermal coal; import of coking coal; and POL import of crude oil and import and export of petroleum products. In order to minimise delays, international practice requires that cargo-handling capacity at ports be 30 per cent more than the anticipated traffic[52]. In order to calculate the cost of creating capacity, estimates of Rs 550 million/Mt of additional capacity for coal and Rs 520 million/Mt for POL have been used. These estimates have been suggested in the WG report and are based on calculations by TAMP of the cost of adding capacity. Lastly, 100 per cent has been added to these costs for additional facilities and activities such as deepening and maintenance of channels and other infrastructure. These calculations indicate that about Rs 1,485 billion would be required over the next two decades to support the required import/export of coal and POL.

CONCLUSIONS AND RECOMMENDATIONS

Economic growth is critically dependent on adequate amounts of electric power and steel. Almost all economic activity requires electricity and steel is an important input for many industries. In order to sustain a GDP growth rate of 8 to 9 per cent over the next two decades, it is estimated the production of electrical energy will need to increase by 3.5 times from 1,105 BU now to 3,860 BU by 2031-32. As coal is expected to remain the dominant fuel for the power sector, the requirement for coal is expected to grow correspondingly. Domestic coal is expected to grow by about 2.5 times; from about 440 Mt in 2011-12 to 1,110 Mt in 2031-32. Its use in the power industry will be limited by the amount produced and imports will bridge the deficit and grow much faster; by almost five times; from 73 Mt in 2011-12 to 355 Mt by 2031-32.

The intensity of steel use in the economy is expected to increase. So requirements for steel will grow faster than the growth of the economy from 73 Mt in 2011-12 to 495 Mt in 2031-32; almost an eightfold increase. Keeping in mind that a tonne of finished steel requires three to four tonne of raw material, the transport requirements for the steel industry will be huge; growing from 600 Mt in 2011-12 to about 2230 Mt in 2031-32.

52. Ministry of Shipping (2012).

Table 8. 33
Investment Required in Ports for Coal and POL

	2011-12	2016-17	2021-22	2026-27	2031-32
Traffic (Mt)					
Thermal Coal	97	142	224	340	423
Coking Coal	32	65	108	173	238
POL	329	475	572	702	864
Capacity (Mt)					
Thermal Coal	126	185	291	442	550
Coking Coal	42	85	140	225	309
POL	428	618	744	913	1,123
Incremental Capacity Reqd (Mt)					
Thermal Coal		59	107	151	108
Coking Coal		43	56	85	85
POL		190	126	169	211
Cost of Creating Capacity (Rs Million)					
Thermal Coal		32,175	58,630	82,940	59,345
Coking Coal		23,595	30,745	46,475	46,475
POL		98,696	65,572	87,880	109,512
Total		154,466	154,947	217,295	215,332
Cost of Other Facilities		154,466	154,947	217,295	215,332
TOTAL INVESTMENT REQUIRED		**308,932**	**309,894**	**434,590**	**430,664**
TOTAL CUMULATIVE INVESTMENT 2012-2032 (Rs Million)					**1,484,080**

Source: Ministry of Shipping and Working Group Report (2012).

The transport requirements for the power and steel industry are expected to grow from about 900 Mt now to 3,700 Mt in 2031-32. While POL and natural gas will also grow, most of the transport for these commodities will be carried out through pipelines. Some POL will be transported by rail but the volumes will be very small and are not expected to impact the rail network much. However, it will have a huge impact on cargo traffic at ports. It already has the largest share (38 per cent) of port traffic, that will increase by over 2.5 times from about 330 Mt in 2011-12 to 865 Mt in 2031-32.

These very large increases in the transport requirements for bulk commodities will be a great challenge because our transport systems are barely able to cope with the traffic today. The trunk railway network is heavily congested. Generally, a rail route is considered congested when the capacity utilisation increases beyond 80 per cent. Almost all the major rail routes[53] over which coal and iron ore will be transported are operating above 100 per cent capacity. Build-up of coal stocks at pitheads is an early warning of the lack of capacity.

Similarly, the capacity utilisation for ports averages 85 per cent with at least four operating at 100 per cent or more. International norms recommend a capacity utilisation below 70 per cent to avoid delays.

Unless well-planned steps to rapidly improve the bulk transport system are successfully implemented,

53. Overall in the country, about 40 per cent of the sections are operating at 100 per cent or higher of capacity. Another 20 per cent are operating between 80 and 100 per cent capacity. The sections making up the high-density routes fall predominantly in the first category. Therefore, high-density routes on which coal and iron ore are transported are almost all congested.

Odisha, Jharkhand and Chhattisgarh are expected to produce about two-thirds of all domestic coal by 2031-32. Together, they will also have more than half the country's steel capacity. Clearly this tri-state region will be critical for meeting the demand for domestic coal and steel for the next two decades. Ensuring adequate transportation infrastructure in this region, which also services adjoining states, is critical for the country's growth.

the transport system will become a stranglehold on the economy, starving it of energy materials and other key commodities essential for economic growth.

RAIL NETWORK

Coal and iron ore are brought mostly by road from mines to the rail sidings. Feeder routes then carry the coal or iron ore from the rail sidings to the trunk routes. The trunk routes carry the minerals long distances, usually between distant states. Close to the destination, feeder routes move the materials from the trunk route to the rail siding at the power or steel plant.

Not all shipments of coal or iron ore traverse all these segments. For example, thermal coal destined for a power plant within the coal-producing state is likely to be moved over a single feeder route between the mine and the power plant. The transport requirements can be quite different depending on the types of rail segments traversed. Coal transported to plants within the coal-producing region will rely mostly on MGR, conveyor belts/ropes and short rail routes. Such routes may use only a short part of a DFC. On the other hand, transport to distant states is likely to make extensive use of routes covered by DFCs.

As the economy grows, domestic coal will be used 'closer to home' and therefore, the importance of shorter rail routes will increase. The rate of growth of the economy will affect the relative importance of short rail routes versus DFCs, highlighting the importance of adaptability of plans for bulk transport.

CRITICAL FEEDER ROUTES AT MINES

Most of the increase in coal production is expected to come from three regions: (1) Talcher and Ib Valley coalfields in Odisha with a potential increase of 110 Mtpa by 2031-32; (2) North Karanpura coalfields in Jharkhand with an increase of 75 Mtpa; and (3) Mand-Raigad coalfields in Chhattisgarh with an increase of 90 Mtpa. Feeder routes that will carry coal from the mine to the trunk routes are critical to bring the coal to power and steel plants. But eight critical feeder routes in these regions are awaiting completion. Shortages of coal, which are already slowing down the economy, will become even more acute in the future if these feeder routes are not completed. Similarly, critical feeder routes for moving iron ore must be completed to ensure steel production keeps up with the economy's requirements.

The total cost of these routes will be about Rs 35 billion for coal and Rs 117 billion for steel; just 2.4 per cent of the Railways budget for the 12th Five Year Plan, but with large benefits for the economy. These critical routes must be completed on the highest priority within the 12th Five Year Plan.

IMPORTANCE OF SHORT DISTANCE TRANSPORT OF COAL

As the economy grows, domestic coal will be used closer to home. Consumption of coal within coal-producing states is expected to increase from 44 per cent currently to 60 per cent by 2031-32. If we include transport of coal to neighbouring states, we find that about 70 per cent of domestic coal in 2031-32 will be used within coal-producing regions. As a result, a very large portion of domestic coal will make limited use of DFCs over short sections. Similarly, more than 80 per cent of the imported coal will be used by importing coastal states. *The share of short-rail routes, road, MGR and conveyor belts or ropes will thus grow and these modes should get attention to ensure that the power sector does not suffer from an insufficient supply of coal.*

FEEDER ROUTES TO POWER PLANTS WITHIN COAL PRODUCING STATES

As in-state consumption of coal for power is likely to increase, much of this new capacity will come up in clusters of about 3,000-4,000 MW each. Such power plants need to be located near coal mines and also near sources of water. It is difficult to predict where these clusters will be located but feeder routes from the mines will be needed.

We estimate that such links will be about 70-100 km long and will be required to carry about 20 Mtpa each. Therefore, roughly one such feeder route to a cluster of power plants will be required every other year in the tri-state region of Odisha, Jharkhand and Chhattisgarh. These links should be designed for heavy-haul technology where a rake per day carries 4 Mtpa. It is likely that some of these feeder routes may overlap to some extent, with each other or the feeder routes that bring coal from the mine to the trunk route. As each such feeder route will take a minimum of six years to complete, planning for these routes must be coordinated with investments being planned in the power sector. Decisions for the corresponding transport investment should be taken simultaneously.

PRIVATE PARTICIPATION IN RAIL CONNECTIVITY PROJECTS

The urgent need for such feeder routes highlights the growing need for rail connectivity to previously unconnected areas. Indian Railways (IR) faces resource constraints to fulfill these demands. Therefore, it has launched a new policy to attract private participation in rail connectivity and capacity augmentation. The five models in the policy cover most of the circumstances under which private investment could accelerate the development of rail infrastructure. IR will remain a key player even with private participation and will be responsible for many functions: certification of lines; supervision of the maintenance of lines; operation of the rail network with IR rolling stock; and collection of freight charges. Therefore, success of the new PPP policy will depend on how well IR is able to execute these functions. Large integrated producers of steel or large mining companies are likely to enter into these PPP arrangements but smaller parties may find it difficult to do so. Institutional mechanisms will need to be developed to facilitate coordination among SMEs and large firms in the same area to pool their resources to create common infrastructure.

NEED TO FOCUS ON THE TRI-STATE REGION OF ODISHA, JHARKHAND AND CHHATTISGARH

Most of the critical feeder routes for coal and iron ore lie in Odisha, Jharkhand and Chhattisgarh. This is no coincidence because steel plants and mineral resources, particularly coal and iron ore, are concentrated in these states. These states produce more than half of the total domestic coal and are expected to produce about two-thirds by 2031-32. Together, they will also have more than half the country's steel capacity. Clearly this tri-state region will be critical for meeting the demand for domestic coal and steel for the next two decades. Ensuring adequate transportation infrastructure in this region, which also services adjoining states, is critical for the country's growth.

CONSTRUCTION OF DFCS

Even though domestic coal will be used closer to home, transport to distant states will also increase. Some DFCs may be more important than others for this long-distance transport. The Eastern DFC is likely to carry an overwhelming share of the long-distance coal traffic, with its share increasing from about half currently to about two-thirds by 2031-32. Excluding the Southern DFC which is not expected to carry much coal, the other DFCs have a much smaller and about equal share of the long-distance coal traffic. Therefore, the eastern DFC must be given the highest priority among the DFCs, and should be completed within the 12th Five Year Plan. The Western, East-West, North-South and East Coast DFCs should be completed by the end of the 13th Plan, and the Southern DFC can be completed by the end of the 15th Plan. For the DFCs that have one termination point in the eastern resource-rich part of the country, construction must start from there because bulk traffic is the highest in those areas. This will also facilitate transport within coal-producing states using short sections of DFCs.

A strategic bulk transport planning group, that monitors developments and potential developments in coal and other fuel markets, renewable energy technologies and domestic fuel supply, should be established. The group should include all major stakeholders and representatives from power, railways, and natural gas sectors.

ADAPTIVE PLANNING AND COORDINATION BETWEEN MINISTRIES

A counter-intuitive result from the model of the power sector is that under the low-growth scenario, the movement of domestic coal is larger, putting even more pressure on the rail freight system. This is because as growth slows, domestic coal will not be required to the same extent closer to the producing area and will be available to be sent to areas further away, thus reducing imports of coal. This will increase the burden on the rail transport system, unfortunately, right when public resources are likely to be more constrained. The results from the modeling exercise also show that there can be great variation in both the amount of coal to be transported and the pattern of the movement, triggered by changes in the rate at which the economy is growing, greater use of renewables, increased availability of gas or higher energy efficiency.

Given this uncertainty, it is important that planning for bulk transport of energy commodities be adaptive. A strategic bulk transport planning group, that monitors developments and potential developments in coal and other fuel markets, renewable energy technologies and domestic fuel supply, should be established. In response to changing conditions, it should periodically (say every five years) direct changes in the plans for transport of fuels so that adequate fuel supplies are available to power plants without delay and at low cost. The group should include all major stakeholders and representatives from power, railways and natural gas sectors.

Chapter 5, Volume II on Institutions for Transport System Governance proposes an Office of Transport Strategy (OTS) that would integrate transport planning across modes and coordinate between the ministries and other levels of government. The strategic bulk transport planning group could be established under the OTS. The OTS could extend coordination to non-transport ministries such as power, petroleum and natural gas, and steel on issues related to transport of bulk commodities.

MODERNISATION OF EQUIPMENT

Freight transport in India is far less efficient than rail in other countries. There is a great need for upgrading and modernising equipment, rolling stock and rail lines. As the Railways recognises, trains must be heavier, longer and faster in order to maximise the use of existing infrastructure. Heavy-haul technology should be used wherever possible and new lines should be designed for it. This increases the capacity of trains about fourfold so that a train per day would result in transport of four Mtpa from about one Mtpa using current technology.

IMPROVEMENTS IN FIRST-MILE CONNECTIVITY BETWEEN MINE AND RAIL SIDING

Coal and iron ore are generally transported from coal mines to the nearest rail siding by road. Often, the evacuation of material is hampered by inadequate road capacity from the mine head to the railway siding. Creation of road infrastructure takes time. Therefore, advance planning is essential to develop the required roads but such planning is rarely done.

Conversion of existing fair-weather roads in high-growth coal fields, particularly where captive coal blocks are expected to become operative, into all-weather express coal corridors should be seriously considered. Coal mining companies should also consider developing a hub-based system for transporting coal from existing mines, wherever feasible.

Coal from the mines in the traditional coal fields has to be moved through heavily-populated villages and is vulnerable to blockage and other disturbances due to socio-political events. Hence, wherever possible, long-distance conveyor belt systems should be used for movement. This will also reduce the environmental impact of road transport.

BULK TRANSPORT-RELATED INVESTMENT REQUIRED IN THE RAIL NETWORK

Suggested Plan-wise investments have been prioritised on level of impact of the investment; and urgency of the route development. A total investment of about Rs 8,700 billion over the 20-year period will be required. The investment is relatively higher in the 12th and 13th Plan when most of the major investments will be made.

PORTS AND SHIPPING

As discussed earlier, by 2031-32, Indian ports will have to handle five times more thermal coal than today, 7.5 times more coking coal, and about 3.5 times more POL. Indian ports are barely able to handle current levels of imports so these large increases in the future will be a big challenge.

NEED FOR A VISION FOR THE PORTS SECTOR

Efforts are being made to improve the performance of ports; however, they are focused on improving the performance of individual ports while improvements are neededon a systemwide basis. A vision needs to be developed for the ports sector and a national strategy based on it. One issue is the establishment of mega ports. Most of the world's major economies have a few. India has none. Mega ports can accomodate larger ships resulting in a reduction of up to 40 per cent of transport costs. In addition, mega ports provide very signficant economies of scale for advanced handling equipment which can dramatically reduce turnaround times for vessels. A vision for the ports sector should consider issues such as: How many mega ports should there be in the country and where should they be located? What will be the roles of mega ports, major ports and non-major ports in such a framework? What role should coastal shipping play in the framework?

SELECTION OF SITES FOR MEGA PORTS

An analysis of the expected port traffic from POL and coal over the next two decades reveals that Gujarat is by far the state that has the most port traffic for all three commodities, and would clearly be a prime location for a mega port. On the East coast, Odisha, Andhra and Tamil Nadu have a large amount of traffic and are potential candidates for mega ports. On the west coast, in addition to Gujarat, one or two more mega ports will be required. Maharashtra has the largest amount of port traffic on the west coast after Gujarat, and it may be appropriate to have a port on the southern end of the Maharashtra coast that could also be used to serve Goa and Karnataka. Some of the existing ports that have a deep draft and could be developed to become mega ports are: Mundra (Gujarat); Gangavaram (AP); Dhamra (Odisha); and Ennore (TN).

However, selection of sites for locating mega ports will require extensive modeling and analysis. First, all types of port traffic including containers and other commodities needs to be included in the analysis. Second, detailed data are required on the cost of development of candidate ports, and then detailed modeling is required to examine the costs and benefits of the potential sites.

PROMOTION OF COASTAL SHIPPING

Coastal shipping is an important mode of transport for bulk commodities that uses only about one-sixth the fuel per tonne-km as that used by road transport and about half of that used by rail. Hence, it is less expensive and has a lower environmental impact. However, coastal shipping carries about only about 7 per cent of the freight traffic, well below its potential given India's long coastline. The cost advantage of coastal shipping is not realised because of high handling charges and poor first and last mile connectivity. Handling charges can be reduced by creating dedicated ports or terminals for coastal shipping. Terminals dedicated to service coastal ships should be set up at the major ports. In addition, five or six non-major ports on the east and west coasts should be selected to be ports for coastal shipping and developed and equipped for that purpose. Adequate road and rail connectivity to these coastal shipping terminals and ports should be provided.

INVESTMENTS IN THE PORT SECTOR

Investment of about Rs 1,485 billion will be required over the 20-year period.

ANNEX I. OVERVIEW OF INTEGRATED PLANNING MODEL® (IPM®)

The modelling of the power sector was done using the India-Integrated Planning Model® (I-IPM®) developed by ICF International. It uses linear programming to select investment options and to dispatch generating units to meet overall electric demand over the chosen planning horizon.

I-IPM® is backed by an extensive database capturing all the parameters of the Indian power sector. The key data include:

- Data on all power plants, their costs, operation parameters and fuel capability. All new power plants currently under construction, along with the characteristics of new, unplanned units
- Demand represented at the state level along with the demand profiles for each state.
- Fuel supply, extensively treated with distinct supply regions and transport infrastructure and costs.
- Transmission capability between states, including proposed new builds.

As a forward-looking model, I-IPM® determines the most efficient, capacity addition path. As the model solves for all years simultaneously, it selects the most appropriate solution to meet the demand for electricity by considering options such as building new base load or peaking units; retrofitting or repowering existing units; selecting units that should be retired or mothballed. It also identifies the timing of such events.

Outputs from the model include optimal generation capacity expansions including mothballing, retrofits, retirements and new builds, optimal transmission expansion builds, optimal fuel transportation and optimal compliance plans for individual generation units.

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