User Guide for India's 2047 Energy Calculator

Coal and Gas Power Stations

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1. Introduction

As of 2014, India has low levels of electricity access and per-capita electricity consumption. The share of households using electricity as the primary source of lighting is around 75%, which means about 300 million citizens, do not have access to electricity. Similarly, India's per-capita electricity consumption is very low at only 957 kWh per capita per year, compared to a world average of about 2,700 kWh per year. Therefore, there is a huge pent-up demand for electricity in India which needs to be rapidly met in the coming years.

Thermal power generation capacity based on coal and gas is about 187 GW (164 GW of coal and 23 GW of gas), that is about 69% of India's power generation capacity of about 272 GW (CEA, May 2015)[1]. In terms of actual generation, thermal power's contribution was even greater, at over 79%. In future, the share of thermal generation in India's power basket and its implications on other issues such as land requirements, water requirements and CO_2 emissions depend on the path that would be adopted by India. This document presents the key insights regarding thermal power generation in India up to 2047 arising from the IESS tool.

1.1 Thermal Generation Capacity

Thermal generation capacity in India will increase significantly in the coming decades. Even in the least effort scenario (L1), it is expected that installed thermal generation capacity will go up from 149 GW in 2012 to 290 GW in 2047, with 253 GW being coal-based and 37 GW being gas-based. This will be 25.3% of India's total power generation capacity in 2047 if the other sources of power generation (such as renewables, large hydro and nuclear) follow a determined efforts trajectory up to 2047. Thus, thermal generation will play a non-trivial role even if in a least-effort scenario.

If thermal capacity addition follows a determined effort pathway (L2), total capacity would be 383 GW in 2047, with 333 GW being coal-based and 50 GW being gas-based. This would form 33.3% of India's 2047 capacity if other sources followed a determined trajectory. If thermal capacity addition follows an aggressive pathway, then capacity would go up to 542 GW, and it would contribute 34% of the capacity in 2047. In the heroic effort scenario, where India focuses on addition of thermal based capacity, the thermal capacity in 2047 would be as high 723 GW. If all sources of power generation, including thermal, follow a heroic effort scenario (L4),

[1] Also, there is some, perhaps non-trivial, diesel based generation capacity primarily used as backup generation due to unreliable power supply quality. It is expected that the role of such capacity will become negligible in future as supply quality improves.

thermal based capacity would still have a share of 28% in India's power generation basket in 2047.

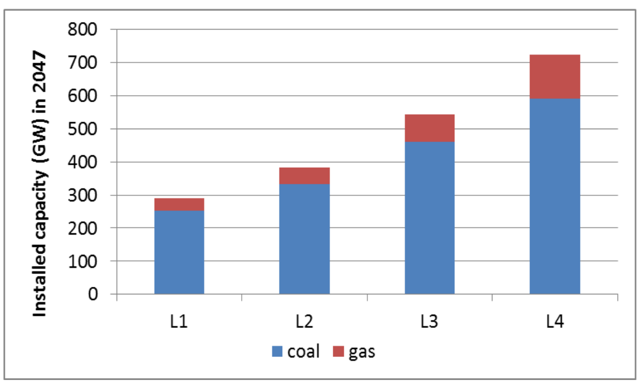
1.2 Thermal Power Generation

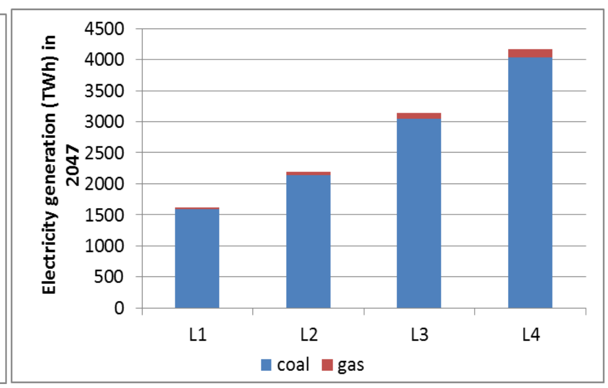
Given that thermal based power generation, particularly coal-based generation, typically has high PLFs and is used to supply base-load power, the share of such capacity in actual electricity supplied is greater than the share of its capacity.

Thus, according to IESS, in 2047, thermal power generation ranges from 1583.2 TWh to 4401 TWh between the least effort and heroic effort scenarios. This translates to a share of between 31% and 68.3% of total electricity generated assuming other sources of power generation follow a determined effort scenario. Note that this amount of generation is equal to about 1.4 to 4 times the total electricity generation in 2012.

Figure 1 shows the installed thermal capacity in 2047 under the various scenarios and the total electricity generated from the same.

Figure 1: Scenarios of installed thermal capacity and thermal power generation in 2047





2. Coal Based Generation

2.1 Coal Power Stations

2.1.1 Overview

At the end of the 11th five year plan i.e. by 2012, coal based power generation contributed over 125 GW i.e. 62% of India's capacity and 66% of electricity generation (CEA, 2012, pp. 19, 20, 50, 54). India's low per-capita electricity consumption of around 957 kWh (1/3rd of world's average) and low levels of electricity access (25% of the population without electricity access) demands significant addition in electricity supply (CEA, 2012, p. 1; PIB, 2012). In the last decade, coal based power generation capacity was doubled and substantial capacity addition is planned (CEA, 2012, p. 8).

2.1.2 Assumptions

- The capacities mentioned include utility and captive power plants fired by coal or lignite, though a lower PLF is assumed for them as they would be used less often.
- Captive power plants do not use efficient technologies as they are mostly small sized while newer technologies (e.g. supercritical technology) need larger capacities.
- The energy generation and coal requirement computed for different capacity addition trajectories shown here also depend on efficiencies of coal-fired thermal power plants. Such efficiency trajectories are given separately in the coal TPP efficiency one-pager.
- The coal based power capacities have also been roughly cross-checked with coal production scenarios to ensure that imports of coal for power production do not become unrealistic.

2.1.3 Trajectories

Level 1

Coal based power generation is discouraged due to increasing fuel prices, import dependence, pressure to reduce carbon emissions, reducing prices of renewable energy etc. Installed capacity grows slowly to a high of 271 GW in 2032, corresponding to the least coal scenario of the Integrated Energy Policy

(Planning Commission, 2006, p. 46), and will reduce thereafter to 253 GW by 2047 whereas the capacity in 2012 was 125 GW. PLF of power plants remains 73% up to 2032 and improves to 74% in 2047. As a result, total electricity generated in 2047 from coal-fired power plants would be 1453 TWh, compared to 710 TWh in 2012.

Level 2

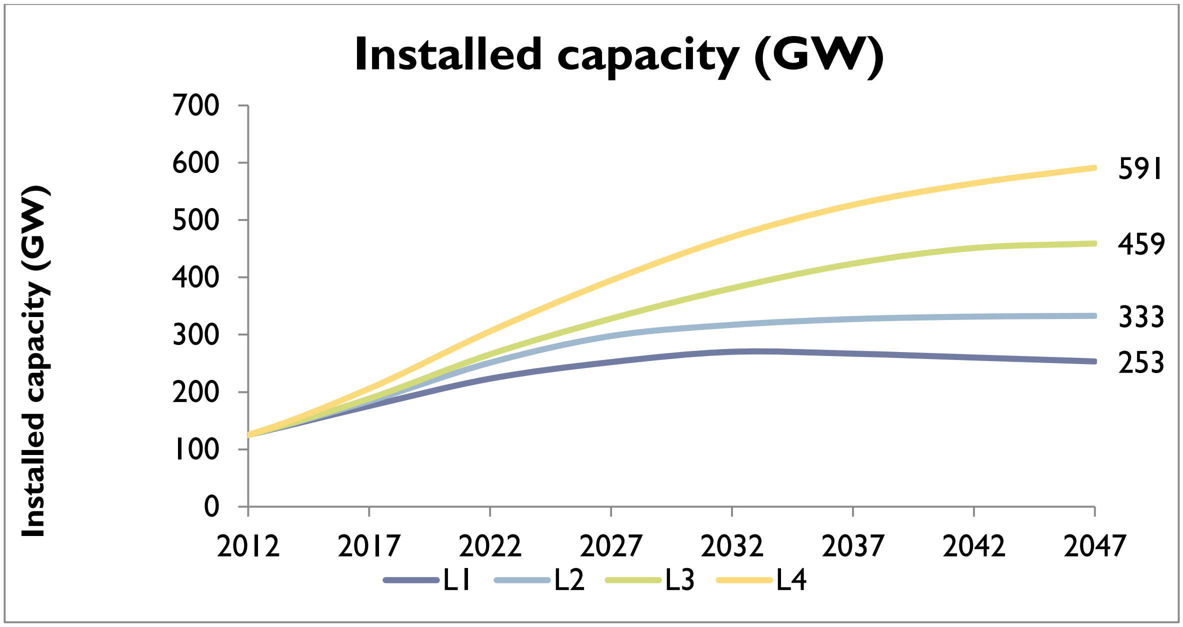
Level 2 projections are in line with Planning Commission's projections for next decade with a reduced growth rate thereafter. Installed capacity will grow rapidly to 297 GW in 2027, and then grow slowly to 333 GW in 2047 due to increasing coal prices, increasing import dependence and increasing pressures to reduce emissions. PLF is assumed to improve to 75% for next two decades and to 76% by 2047. Total electricity generated from coal-fired plants in 2047 would be 1963.4 TWh.

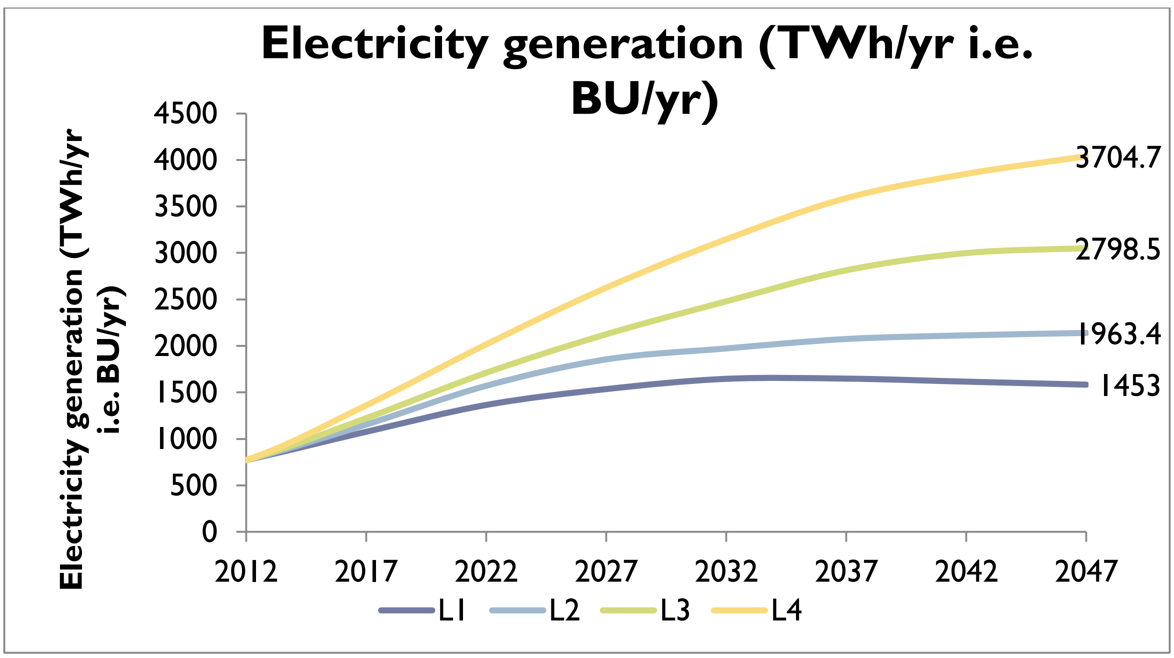
Level 3

Level 3 assumes a coal-fired capacity addition slightly lower than what is assumed for the 8% GDP growth scenario in the interim report of the Expert Group on Low Carbon Strategies for Inclusive Growth (Planning Commission, 2011, pp. 41,42). The growth rate of capacity addition is assumed to reduce subsequently. In this scenario, installed capacity will grow to 381 GW by 2032, and then slow down to reach 459 GW by 2047. Current PLF will improve to 77% for next two decades and to 78% in 2047, resulting in total generation of 2798.5 TWh in 2047.

Level 4

Level 4 assumes a coal-fired capacity addition slightly lower than what is assumed for the 9% GDP growth scenario in the interim report of the Expert Group on Low Carbon Strategies for Inclusive Growth (Planning Commission, 2011, pp. 41,42). The growth rate of capacity addition is assumed to reduce subsequently. Installed capacity will grow to 591 GW in the next 35 years i.e. by 2047 due to improved domestic coal supply, softening of imported coal prices and availability of more carbon space to countries like India. Current PLF will improve to 79% for next two decades and to 80% in 2047, resulting in electricity generation of 3704.7 TWh in 2047.





2.2 Coal Efficiency

2.2.1 Overview

India's existing coal based thermal power plants (TPPs) are currently based on inefficient subcritical technology, though efforts are now being made to adopt new efficient technologies like super-critical, ultra super-critical technology etc. Super critical technology is proposed to be adopted at a significant scale (38%) during the

12th five year plan (Ministry of Power, 2012). From the 13th five year plan, it is proposed that no subcritical TPPs would be allowed. However the development and deployment of these efficient technologies is sluggish due to the Indian coal with high ash content and low calorific value.

2.2.2 Assumptions

1. Average life of a power plant is 40 years
2. Gross calorific value of Indian coal for power generation = 3541 Kcal/kg (CEA, 2012, p. 116)
3. Gross calorific value of imported coal = 5500 Kcal/kg
4. The coal consumption figures shown in this one-pager correspond to level 2 of capacity addition as described in the coal thermal power plant addition one-pager.
5. Specific coal consumption for different technologies for high ash Indian coal is as follows:

Technology	Specific coal consumption (kg/gross kWh)[2]
Subcritical (current India)	0.74
Super critical	0.61
Ultra supercritical	0.53
Integrated Gasification Combined Cycle (IGCC)	0.50

2.2.3 Trajectories

Level A

New technology development/deployment will be slow. Subcritical capacity addition will stop only after 2022, ultra supercritical technology will be introduced only in 2027 and IGCC is introduced in 2037. The share of IGCC in the coal-fired capacity addition during 2042-47 would be only 30%, and its share of the total capacity in 2047 would be only 18.6 GW at level 2 capacity addition, amounting to just about 6%, while 64% of the capacity would be super-critical. Total demand for Indian grade coal in 2047 in this scenario is 1390 million tons.

Level B

New technology development/deployment will be slightly faster than scenario A. Subcritical plant addition will stop after 2017 as per current Government plans

[2] Source: (CEA, 2012, p. 112; IEA, 2012; Mitsubishi; Planning Commission, 2013, p. 138)

(Ministry of Power, 2012). Ultra supercritical technology will be commercialized after 2017 and IGCC after 2027. IGCC will contribute 50% of the capacity addition in the 18th five year plan (2042–47). The share of IGCC in the coal-fired capacity in 2047 would be 10%, and super-critical technology would have a share of 55%. Total demand for Indian grade coal in 2047 in this scenario is 1194 million tons.

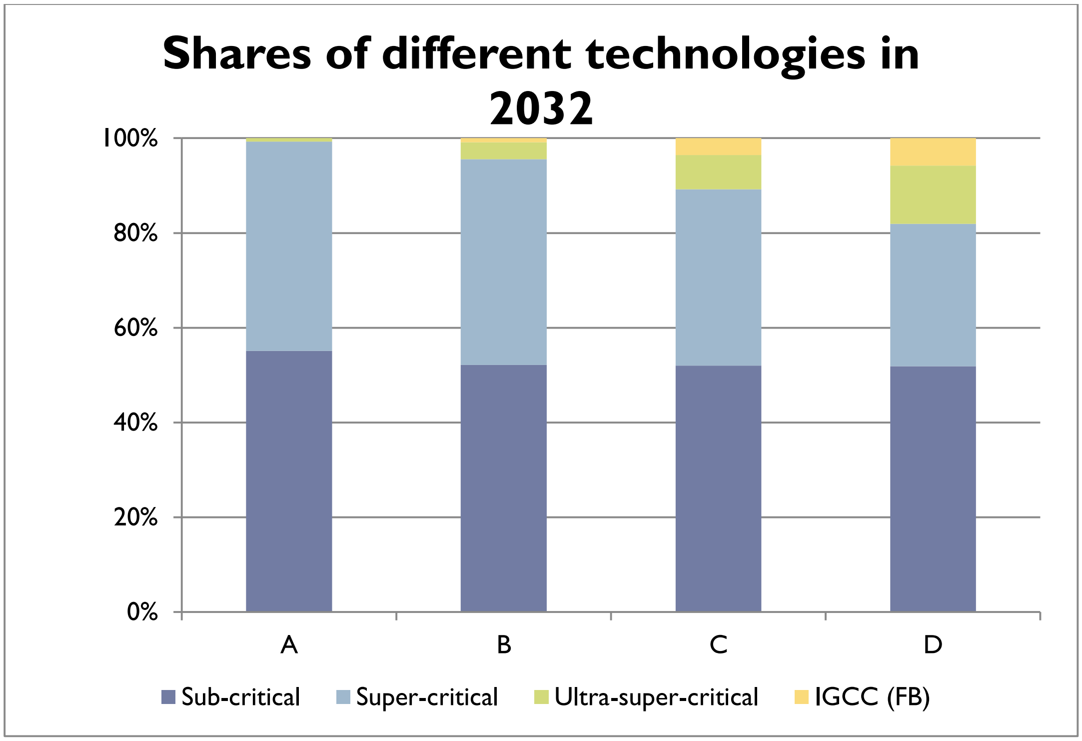
Level C

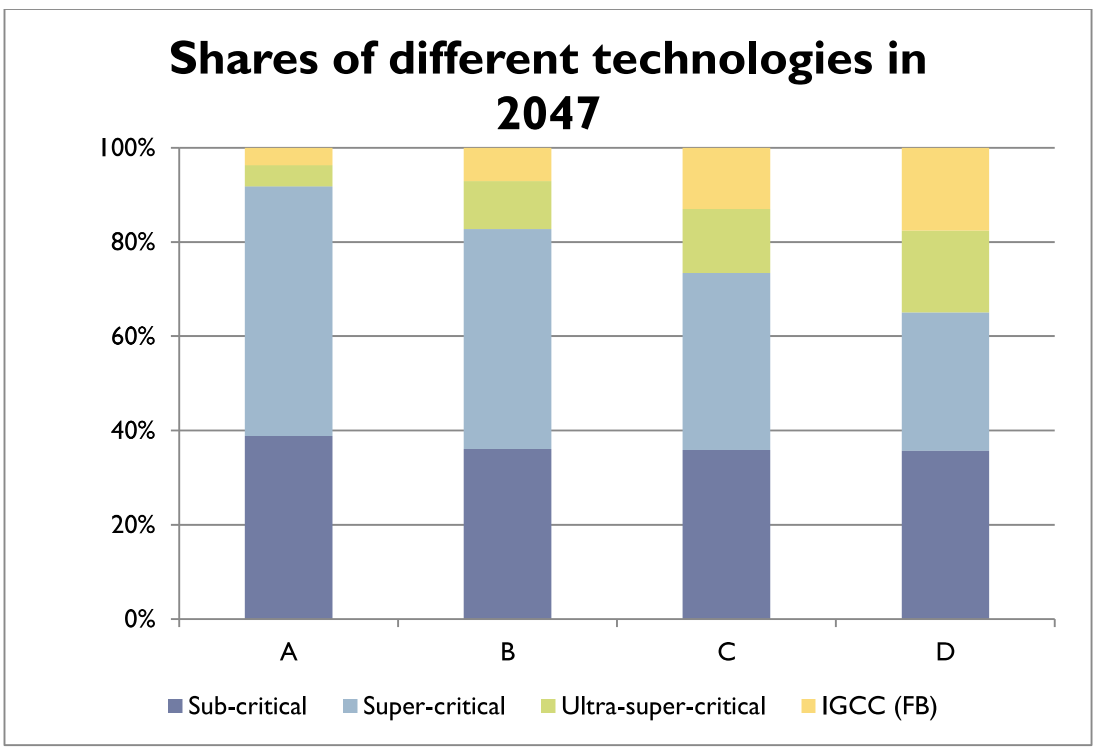
New technology development/deployment will be encouraged and hence its adoption would be faster. Sub-critical capacity addition will stop after 2017, ultra-supercritical technology will be commercialized in 2022 and IGCC in 2027. IGCC's share of the capacity addition in the 18th five year plan (2042–47) would be 65%. In 2047, the share of IGCC in the coal-fired capacity would have increased to 20% and super-critical technology would have reduced to 43%. Total demand for Indian grade coal in 2047 in this scenario is 1165 million tons.

Level D

New technology development/deployment will be aggressively promoted and hence adopted very fast. Subcritical capacity addition will stop after 2017. 20% of new capacity addition in the 14th five year plan from 2022 would be ultra-supercritical technology and 20% of new capacity addition in the 15th five year plan from 2027 would be IGCC. Of the capacity addition in the 18th five year plan ending in 2047, 80% would be IGCC, resulting in its share in the total installed capacity in 2047 being 26%. Total demand for Indian grade coal in 2047 in this scenario is 1142 million tons.

The share of different technologies in total coal based installed capacity for these four scenarios in 2032 and 2047 year will be as shown in the following figure. The sub-critical technology based capacity that exists in 2047 is primarily because of existing capacity, which does not retire fully until 2047.

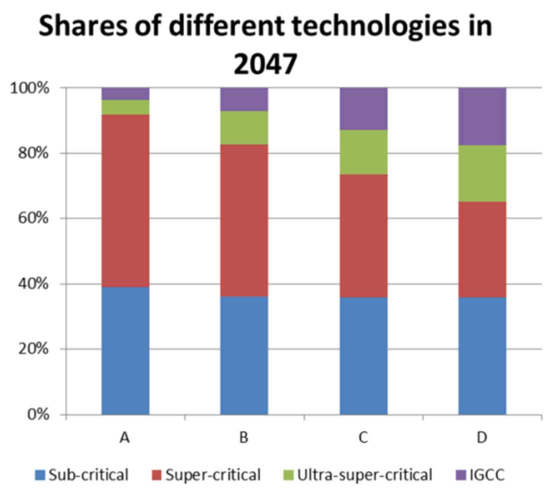

Shares of different technologies in 2032
100%
80%
60%
40%
20%
0%
A
B
C
D
Sub-critical
Super-critical
Ultra-super-critical
IGCC (FB)


Shares of different technologies in 2047
100%
80%
60%
40%
20%
0%
A
B
C
D
Sub-critical
Super-critical
Ultra-super-critical
IGCC (FB)

3. The role of efficiency in power

IESS also allows the user to choose adoption rates for different technologies for coal-based power generation which forms the bulk of thermal generation. Note that the technology adoption rates only affect new capacity addition and do not have any impact on existing capacity. If thermal capacity addition follows a determined effort scenario, the shares of different technologies in India's coal-based capacity in 2047 are as shown Figure 2.

Figure 2: Shares of different technologies in determined effort capacity addition scenario



In the least effort scenario (A) of technology adoption, very little new technology adoption takes place. Even in 2047, about 40% of coal-based capacity uses sub-critical technology, about 50% uses super-critical technology, while efficient ultra-super-critical and IGCC technologies contribute only about 5% each. In all other scenarios (B-D), sub-critical capacity in 2047 reduces to 36% while the shares of other technologies vary. This is because power plants have a life of 30 years and sub-critical plants continue to get installed until 2017 – which means they do not get decommissioned by 2047. However, one would expect the shares of other efficient technologies in installed capacity to increase rapidly after 2047 as new sub-critical capacity addition stops in 2017 in all scenarios except the least-effort scenario. The shares of ultra-super-critical plants in the technology mix in 2047 are 14% and 17% respectively in the aggressive and heroic effort scenarios. Similarly, the shares of IGCC are 13% and 18% respectively in these scenarios.

As a result of this 'sticky nature' of power plants, the difference in total coal requirement by power plants does not vary much up to 2047 across the four efficiency scenarios though the specific coal requirement for IGCC is nearly 33% lower than for sub-critical technology (see Table 1). For the determined effort scenario of coal-based capacity addition, the difference in coal required in 2047 between the most efficient and least efficient technology adoption pathways is about 84 million tonnes (MT) out of a total demand in the region of 1,300 MT. Once again, it should be noted that the coal demanded by the different technology adoption pathways is expected to rapidly diverge after 2047.

Table 1: Specific coal consumption for different technologies

Technology	Specific coal consumption (kg/gross kWh)[3]
Subcritical (current India)	0.74
Super critical	0.61
Ultra supercritical	0.53
Integrated Gasification Combined Cycle (IGCC)	0.50

[3] Reference: (CEA, 2012, p. 115; Planning Commission, 2013, p. 138; IEA, 2012; Mitsubishi).

4. Gas Based Generation

4.1 Overview

Gas based generation in India got impetus in the eighties when HVJ (Hajira-Vijaypur-Jagdishpur) gas pipeline was commissioned by Gas Authority of India Limited (GAIL), after discovery of gas in the west coast of India. This led to a number of Gas based CCGTs commissioned along the HVJ pipeline in the Western and Northern parts of India. Apart from the major HVJ gas pipeline, certain isolated gas fields in North –East India, Kaveri basin, Ravva basin etc. helped in development of some off grid gas based capacities in those areas. After the KG- D6 discovery of gas and commissioning of East -West pipeline by RGTIL (to transport the gas from Bay of Bengal fields to the west coast), KG -D6 gas got infused into the system in early 2009.

Natural gas based power generation capacity of India was about 24.2 GW by the end of 11th plan i.e. by 2012, out of which, about 18.3 GW was utility and 5.9 GW was captive power plants (CEA, 2013, pp. 8,50). This capacity constitutes about 10% of total installed capacity whereas its electricity generation constituted about 11% of total electricity generation (CEA, 2013, pp. 8,20,50,54). Due to high cost of electricity generation and flexibility of the natural gas based power generation, it is mainly used for electricity supply for peaking/balancing power rather than base-load (Planning Commission, 2013, p. 148; EIA, 2013). Considering the recent uncertainties in availability of domestic natural gas, PLFs of about 54.5% in 2012 of gas-based plants will further come down. However, it is expected that the situation is likely to improve in the coming years / decades.

4.2 Assumptions

1. GCV of natural gas= 9000 kcal/kg (MoPNG, 2013, p. 174)
2. Installed capacity addition of gas based power plants includes both utility and captive power plants.
3. Only combined cycle gas turbine power plants will be added[4].
4. Life time of gas power plants is assumed as 40 years. So the total new capacity addition will be replacement for retired capacity plus new capacity addition required to meet the installed capacity target.

[4] We do not consider potential addition of some captive Combined Heat and Power (CHP) plants in this tool for simplicity reasons.

4.3 Trajectories

Level 1

Level 1 assumes that only the 12th plan's under construction capacity of about 12 GW will be added, though only by 2027 (MoP, 2012, p. 1.14). There will be no gas-based capacity addition later on due to domestic fuel shortage, expensive imports, lack of infrastructure etc. Considering the addition, the total capacity will increase from 24.2 GW in 2012 to 36.5 GW in 2032 and will remain same till 2047. The PLF of gas-based power plants will remain at 40.7% (same as in 2013) throughout the period due to lower gas availability and conversion efficiency will be about 58% by 2047, which is same as that in 2012. So, the corresponding electricity generation will rise from 115.4 TWh in 2012 to 130 TWh in 2047 and the requirement for gas would be about 23.7 BCM.

Level 2

Level 2 assumes that the expected capacity at the end of the 13th five year plan under high gas scenario will be added by 2047[5] (MoP, 2012, p. 1.14). The average CAGR will be about 2.1% and PLF will increase slowly from 42.5% in 2017 to 45% due to slightly improved gas availability and conversion efficiency will be about 62% by 2047. As a result, the corresponding cumulative capacity will reach 50.2 GW, electricity generation will be 198 TWh and gas required would be 36 BCM in 2047.

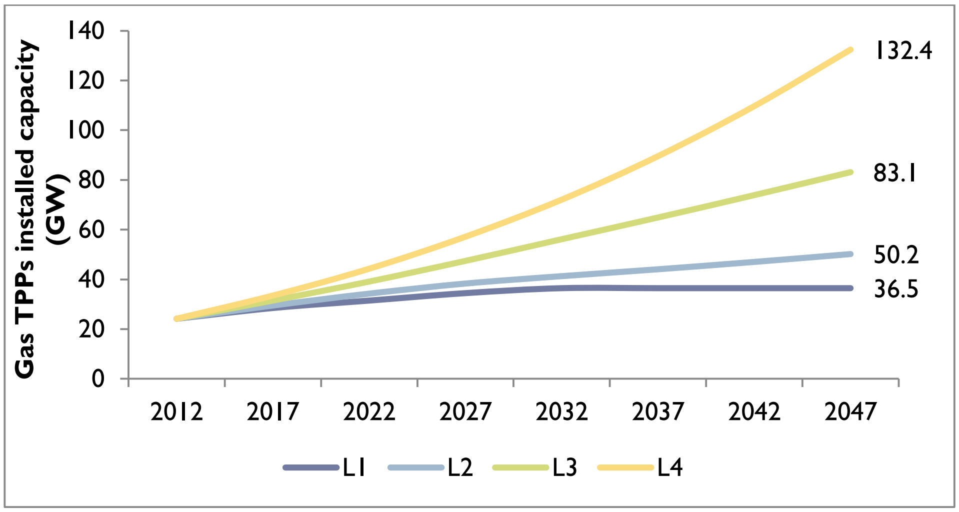
Level 3

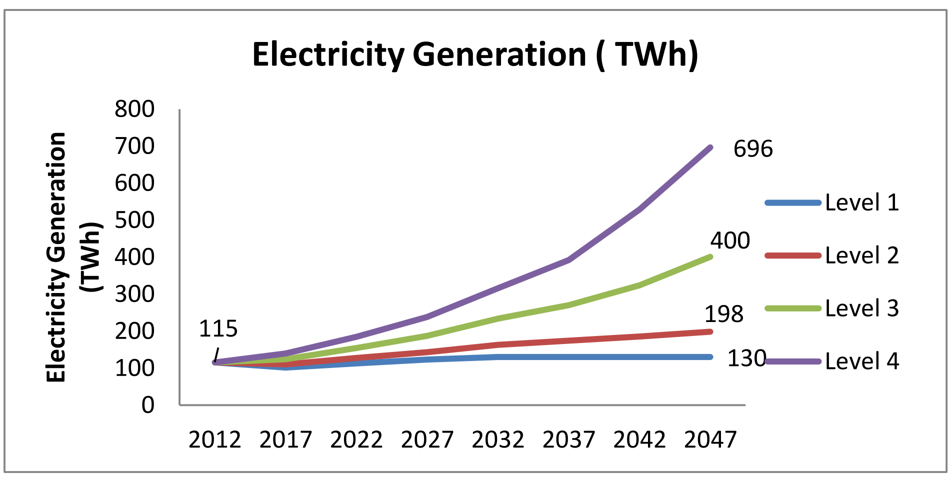
Level 3 assumes that the expected capacity in Natural Gas Pipeline Vision-2030 Document by Petroleum and Natural Gas Regulatory Board (PNGRB) will be added by 2047 (PNGRB, 2013, pp. 21,22). Total capacity will be about 83 GW by 2047. PLF will increase from 45% in 2017 to 55% in 2047 due to improved gas availability. Conversion efficiency will improve to about 64% by 2047 due to technological advancements. As a result, the corresponding electricity generation will be 400 TWh in 2047 and gas used for power generation would be 72.9 BCM.

[5] The 12th plan working group report for power doesn't give the separate gas based power capacity addition projections for the 13th plan and only gives total thermal power capacity addition of about 63.4 GW. Gas power capacity addition in 13th plan is estimated by assuming that the share of gas-based capacity in total thermal capacity is the same as the 12th plan (MoP, 2012, p. 1.14).

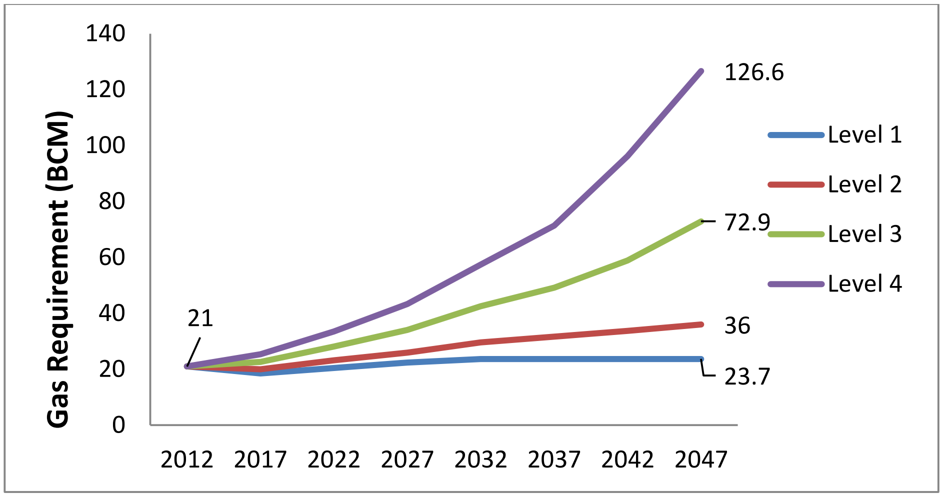
Level 4

Level 4 assumes that the expected capacity by 2032 as per forced gas scenario of Integrated Energy Policy (IEP) by Planning Commission will be achieved by 2047 (Planning Commission, 2006, pp. 20,41)[6]. Total capacity will be about 132 GW by 2047. The average CAGR under this scenario will be about 5%. PLF increases from 48% in 2017 to 60% due to improved gas availability from both domestic and imported sources and conversion efficiency will be about 66% by 2047 due to improved technologies. As a result, the corresponding electricity generation will be 696 TWh in 2047, with a gas requirement of 126.6 BCM.





[6] The IEP report doesn't give the installed capacity of gas-based power plants. The capacity is therefore estimated from the % share of gas in total electricity generation assuming a PLF of 50%.



Gas Requirement (BCM)
140
120
100
80
60
40
20
0
2012
2017
2022
2027
2032
2037
2042
2047
21
126.6
72.9
36
23.7
Level 1
Level 2
Level 3
Level 4

5. Cost estimates

5.1 Coal based power generation:

Thermal power generation and coal mining are highly capital intensive industries. Currently the capital cost of coal power plants varies between 4,500 and 5,500 Rs cr/GW depending upon the technology used (sub-critical or super critical). These costs are expected to increase with time due to various factors such as increase in material cost and labour cost. As of now, the cleaner technologies like ultra-super critical and IGCC are not available in India and even in other countries, these technologies are evolving. So, their costs are relatively higher as of now (~5,600-11,000 Rs cr/GW). Future costs for these technologies are estimated by deriving a rate of growth of costs from (Shakti Foundation, 2013, p. 41). Annual operation and maintenance (O&M) costs are about 15 Rs/MW for current power plants (mainly subcritical), which translates into about 3% of capital cost (CERC, 2014, p. 72) – we use the same percentage for all technologies for simplicity.

Table 2: Current and projected capital costs of thermal generation technologies (2012 Rs crores/GW)

Fuel	Technology	2012		2047	
		Low estimate	High estimate	Low estimate	High estimate
Coal	SubC	4750	4750	6191	6879.2
	SC	5250	5250	6879	7567.1
	USC	6063	6063	7739	8942.9
	IGCC	9121	9121	9983	15113.6
Gas[7]		3586.5	3586.5	4022	5847

Data sources: (MoEF, 2014; Toshiba Corporation, 2012; EIA, 2013; Emerson Process Experts, 2013)

The total cost of fuel for coal based thermal power generation is calculated based on estimation of domestic and imported coal and gas prices. The pithead price of domestic steam coal is about 1080 Rs/tonne for electricity generation and it is about 5120 Rs/tonne for imported non-coking coal in 2012[8] (CCO, 2012, pp. 6.1, 7.1). Coal prices until 2047 are projected based on available literature[9] according to which domestic coal prices are estimated to be between Rs.450/ ton and Rs.2,290 / ton in 2047, while imported coal prices range between Rs. 4578 / ton and Rs. 7748

[7] Gas TPP's rate of increase in capex is assumed to be same as that of supercritical coal based power plants.
[8] Non-coking or steam coal is mainly used for power generation.
[9] Long term projections for Indian coal are not available. So, the low estimates and high estimates of 2047's projections are done based on other countries' projections (IEA, 2012; DECC, 2014, p. 12).

/ ton. The cumulative cost to the economy from coal-based power generation (excluding other costs such as fuel transport, debt financing etc.) up to 2047 works out to about 1.14% of the cumulative GDP for a heroic-effort pathway keeping determined effort pathway as the base/reference case.

5.2 Gas based power generation:

The gas-based power plants have current capital cost somewhat lower than coal power plants and are in between 2900 and 4300 Rs Cr/GW. This capex is projected for 2047 based on the literature available for coal power plants. It is in between Rs. 4020 and 5847 Cr/GW. Their annual O&M cost is about 4% of capital cost (CERC, 2014, p. 74).

The cumulative cost to the economy from gas-based power generation (excluding other costs such as fuel transport, debt financing etc.) up to 2047 works out to about 0.22% of the cumulative GDP for a heroic-effort pathway keeping determined effort pathway as base/reference case. Also, when the gas power stations are moved to level 4 i.e. Heroic pathway, it is assumed that our domestic gas production would also ramp up to level 4.

6. Energy Security Implications

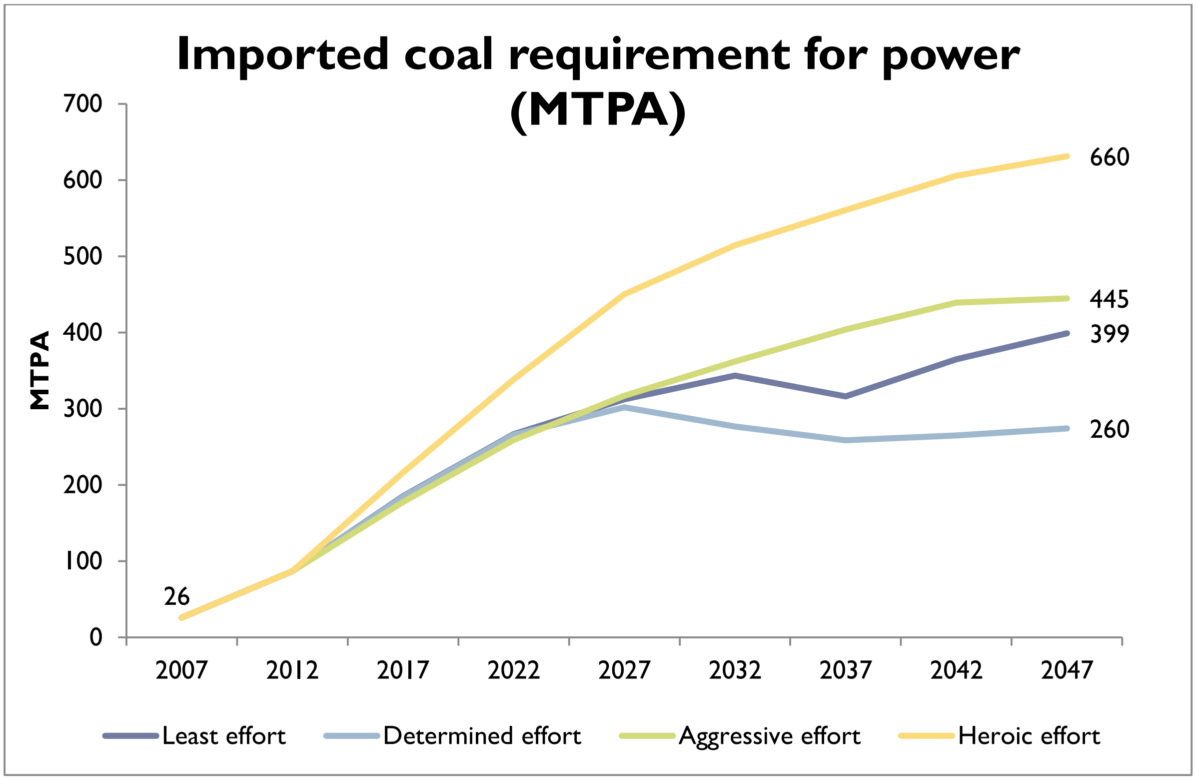
India imported around 22% of its coal requirement and 32% of its gas requirements in 2014. Significant thermal capacity addition could also have an impact on imports of coal and gas, depending on how domestic coal and gas production changes over this period. The likely imports will naturally be a function of domestic production and demand for gas for all uses. The IESS webtool will generate this numbers on the basis of user's choices for the above factors. However, a tentative assessment of coal/gas imports as per the domestic production/demand for power generation scenarios has been discussed below.

6.1 Coal imports:

The IESS scenarios predict that India's domestic coal[10] production in 2047 would vary from a low of a mere 540 MT in the least-effort scenario to a high of 1,608 MT in the heroic scenario. Total import requirements for coal would also depend on how demand from other sectors such as iron and steel and cement changes over time. However, for simplicity assuming that about 75% of domestically produced coal continues to be used for power generation as currently done, coal import requirements from the power sector in 2047 range between 260 MTPA (if coal production and coal-based capacity addition follow a determined path) and 660 MTPA (if coal production and coal-based capacity addition follow a heroic path) even if a heroic effort scenario of technology adoption requiring least coal plays out. This increase of import requirement for the power sector shows that coal production increase does not keep up with coal demand increase from the power sector in the four levels. Figure 3 shows the coal import trajectory for the power sector for each of the levels.

[10] These figures include lignite also.

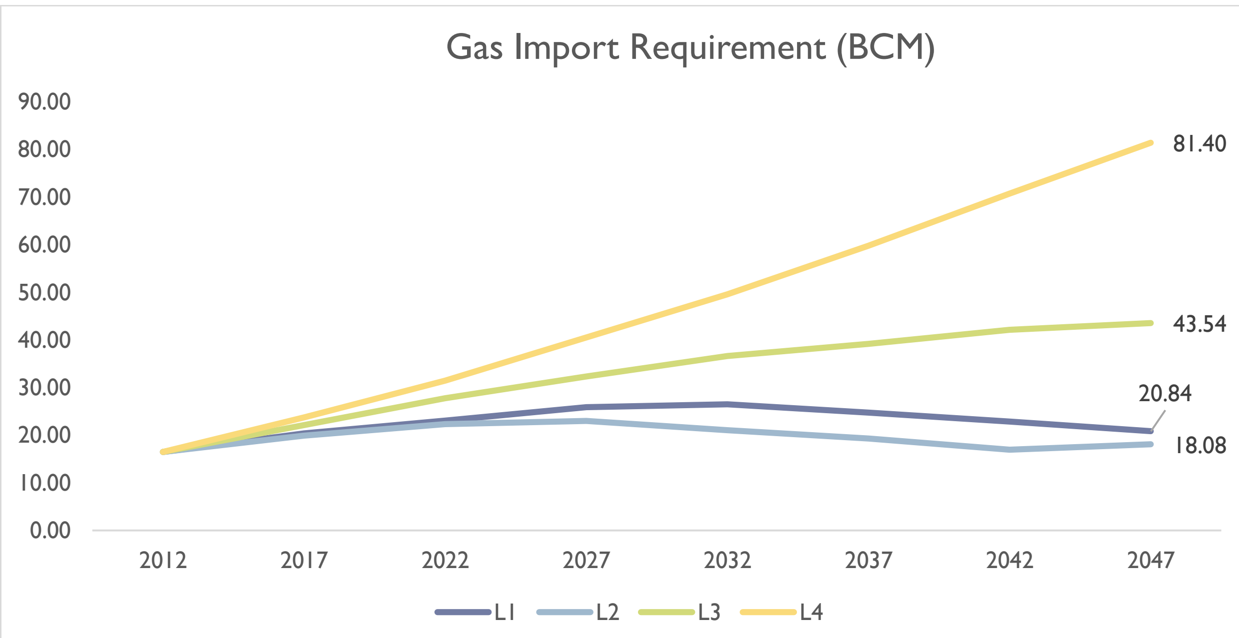
Figure 3: Imported coal requirement for power generation (MTPA) for various scenarios



6.2 Gas imports:

IESS Version 2 estimates that gas-based electricity generation in 2047 would vary from 130 TWh to 696 TWh across the 4 levels. This translates to a gas requirement ranging between 23.7 and 126.6 BCM in 2047 across the 4 levels.[11]. Given the domestic gas production scenarios and likely consumption of this gas by the power sector, the potential gas import scenarios are as shown in Figure 4.

Figure 4: Imported gas requirements for power generation under various scenarios



[11] Assuming a calorific value of 9000 kcal / cu m

7. Land Requirements

Mining for coal, and thermal power generation are both fairly land-intensive. For example, domestic coal-based power generation requires nearly 247 hectares per GW, while rough estimates based on environmental clearance letters suggest that anywhere between 6 and 122 hectares of land are required for every MT of coal to be extracted depending upon the coal seams characteristics and geology.

India would cumulatively produce between 25,750 and 44,350 MT of coal between 2013 and 2047 across the four levels in IESS. This translates to a land requirement for coal mining between 1,545 and 54,100 square km (across L1-L4 and low-high estimate of land requirement). Note that, some of this land can be made productive again after the mining activity is completed, but this would require the coal miner to restore the land to a usable and/or cultivable state at the end of the useful life of the mine.

For coal-based power generation, India is likely to require land area of 309 to 1460 square km depending upon the scenario in 2047[12]. Given that India's total land area is about 3.3 million square km, the total land requirement for coal production and coal-based power generation amounts to about 0.056 % to 1.7% of India's land area, or 1.4 to 37.4 times the area of Delhi[13].

Table 3: Land requirement for coal power plants and coal mining

	Land requirement (sq km)	
	Minimum	**Maximum**
Coal TPPs	309	1461
Coal mining	1545	54,100
Total coal (TPP+ mining)	2171	55,561
% as India's area	0.056%	1.69%

Whereas the gas-based power generation's land requirement will be in between 10 and 55 square km.

[12] For simplicity, this is estimated assuming all coal-based power plants use domestic coal. Such plants require significantly more land given the higher ash contents of Indian coal and may be considered a worst case estimate.
[13] This assumes that no land is restored or returned. The figure would be somewhat smaller if land were to be restored.

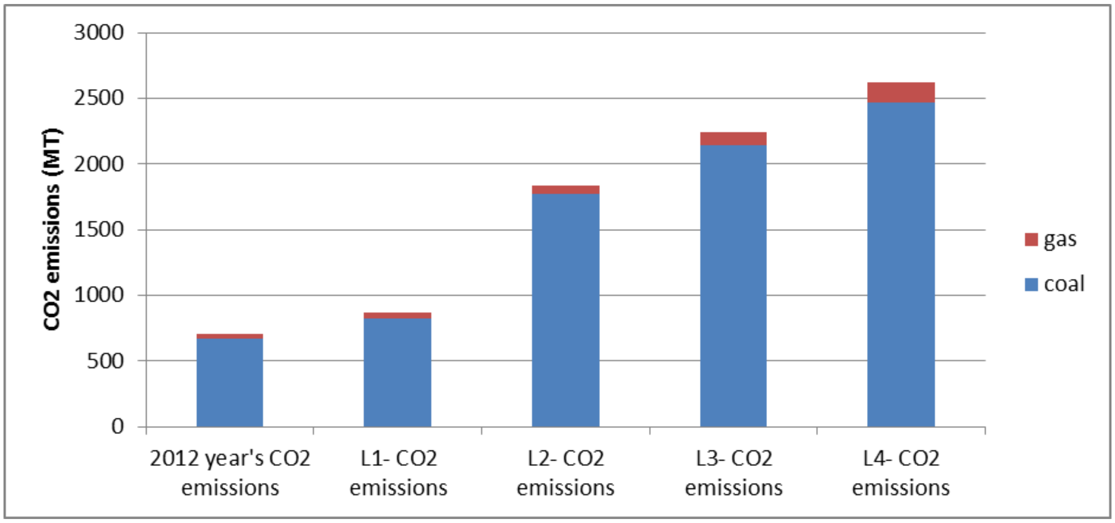
8. Carbon emissions

Thermal power generation is one of the major causes for CO_2 emissions in India and around the world. In 2012, it is estimated that thermal power generation contributed to 811 MT CO_2e emissions out of 2074 MT of energy related CO_2e emissions. That is about 39% of the energy-related CO_2 emissions in 2012 were from thermal power generation.

The share of thermal power generation in India's GHG emissions changes depending on the energy trajectory chosen, which will be a combination of demand and supply. The biggest difference comes from Demand side. If India were to adopt higher levels of efficency in demand sectors, then energy demand comes down which straight away reduces emissions. On the Supply side, it is the technologies (adoption of Level D) which raise the efficency of coal/gas fired power plants, and the sources of generation (gas over coal or RE) which impinge on emissions. Therefore, the webtool is a handy calculator where the user can make his choices on Demand/Supply to derive emission scenarios. However, it should be kept in mind that, since IESS is not a model, it is possible that energy supply is greater than demand and thus a purely supply-sided emissions view may overestimate actual emissions. However, for a simplistic assessment for coal/gas sector emmision, the explanation below is useful for the reader to understand the emission related application of the Tool.

If India follows a determined effort pathway for all energy supply sectors, then the total energy related GHG emissions in 2047 are likely to be around 10848 MT CO_2e, of which thermal power generation would contribute about 3002 MT CO_2e or 27.6%. If, on the other hand, India chooses a heroic effort pathway for thermal power generation (for capacity and efficiency) and determined effort pathway for renewable generation, the share of thermal power generation in total energy emissions becomes 30.8% with total energy related GHG emissions being 11342 MT CO_2e and thermal power generation CO_2 emissions being 3495 MT CO_2e. In the reverse case, where a determined effort path is followed for thermal power generation and a heroic pathway is followed for renewable energy, the share of thermal power generation in total energy GHG emissions would be 20.6% and total energy related GHG emissions are 9882 MT CO_2e.

Figure 5: Graph of CO2 emissions from thermal power generation under different trajectories in 2047 (MT CO2/year)



9. Key messages

The IESS V2 trajectories for thermal power generation, as well as for domestic coal and gas production, bring out a few important messages, which are summarised here.

1. Thermal power generation will have a significant role to play in the Indian power sector for the near to medium term, particularly given the electricity access deficit and poor quality of power supply in the country.
2. Investments in thermal power plants are ‘sticky’ with long lifetimes. Therefore, thermal power capacity addition needs to be carefully planned considering fuel requirements and other impacts of such power generation for the lifetime of the investment.
3. Integrated planning of the energy sector is critical to optimise capacity addition of electricity as well as production of domestic fossil fuels, as well as improve energy security.
4. Given the difference in specific coal consumption (and hence impacts on imports, local and global environment etc.), advanced coal-based power generation technologies should be encouraged in India – though these are unlikely to show great benefits by 2047.
5. Thermal power generation and coal mining are land intensive activities. For a densely populated country such as India, this suggests that careful planning about the siting of thermal power plants and the mechanisms for extracting fossil fuels will be important.
6. Similar remarks also hold good for water consumed in thermal power generation as India is also a water-stressed nation.

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