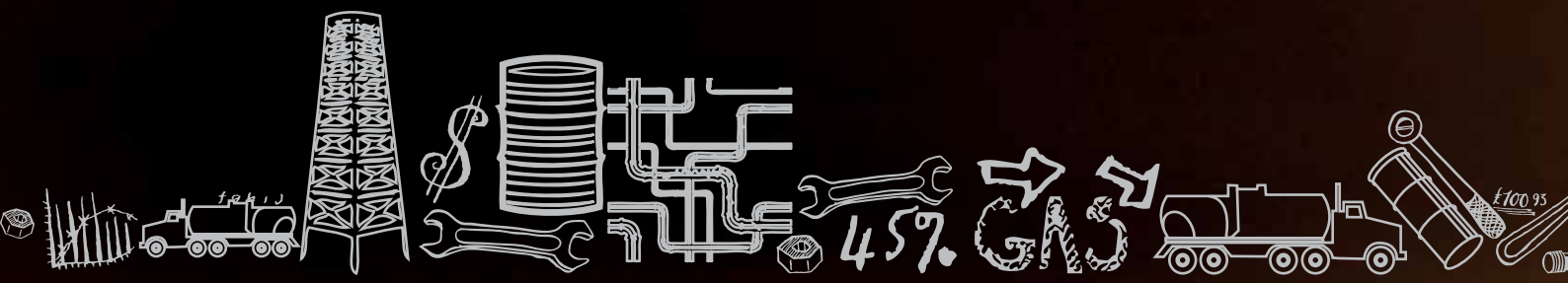
5th IEF-IGU Ministerial Gas Forum

New Delhi, India

India: Clean Development – Role of Natural Gas

Knowledge paper

December 2016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1 Executive summary

India is the 3rd largest consumer of energy in the world. Globally, natural gas contributes approximately 24% to the primary energy mix.[1] However, in India, natural gas has a nominal share of 6.5% market share. As a part of its "Intended Nationally Determined Contributions" (INDC), India has committed to reducing its carbon emissions intensity to GDP by 33%–35% by 2030 from 2005 level.[2] To meet this commitment while at the same time supporting its economic growth trajectory, India needs to add cleaner sources of energy to its fuel mix.

India's power generation capacity is projected to more than double from the current 307 GW to 746 GW by 2030. Coal-based power accounts for 61% of the current power generation capacity as the marginal cost of power generated using natural gas is 50% costlier than coal-based power at current feedstock prices. However, after accounting for the implicit cost of emissions, land disturbances, health impact and climate damage, natural gas-based power is a better option. It is 15% cheaper than coal-based power.

Approximately 90% of India's current coal-based power capacity is based on subcritical technology. With new Environment Protection Rules ratified in December 2015 by the Ministry of Environment & Forests (MOEF), coal-based power plants in India are expected to be upgraded to supercritical technology in the coming years, leading to a reduction in emissions intensity.

India is implementing one of the largest global renewable energy programs, which aims for 175 GW of renewable capacity by 2022. However, most of the supply from renewable energy sources (RES) is variable and uncertain because of daily and seasonal variations. Natural gas, with its low emissions profile and reliable supply, can help balance the grid and enable a greater degree of grid integration for renewable energy sources.

The power and the fertiliser sectors continue to be the major users of gas; however, this mix is set to change as more gas and regasified liquid natural gas (RLNG) is supplied to the Indian market over the medium and longer term. Growth of retail gas markets and industrialisation would be the key demand push drivers going forward.

The industrial segment is currently estimated to consume 15 billion cubic metres (BCM) of gas annually. The costs of coal and furnace oil are typically cheaper than natural gas at market prices, and thus consumers are reluctant to switch to natural gas. However, consumers using other fuels such as naphtha, diesel, and LPG are expected to convert their captive power units to utilise gas. In order to encourage the use of gas, improved connectivity and affordable gas supplies are essential.

The transport sector in India currently consumes more than 50% of petroleum products and accounts for 12%[3] of India's energy-related CO_2 emissions. India is moving towards cleaner emission standards of fuel and is planning major investments in its refineries over the next few years to move from Bharat IV to Bharat VI by 2020, thereby reducing sulphur and nitrous emissions. Compressed natural gas (CNG) and LNG, being a clean and efficient fuel, can provide a viable alternative as a transport fuel.

India's current CNG consumption is estimated to be 3 BCM/year, and promoting the use of CNG further would help the Government meet its objective of better environment standards and sustainability. It would also supplement the Government's efforts in promoting alternatives for the dominant fuels in the transport sector through investments in hybrid and electric cars.

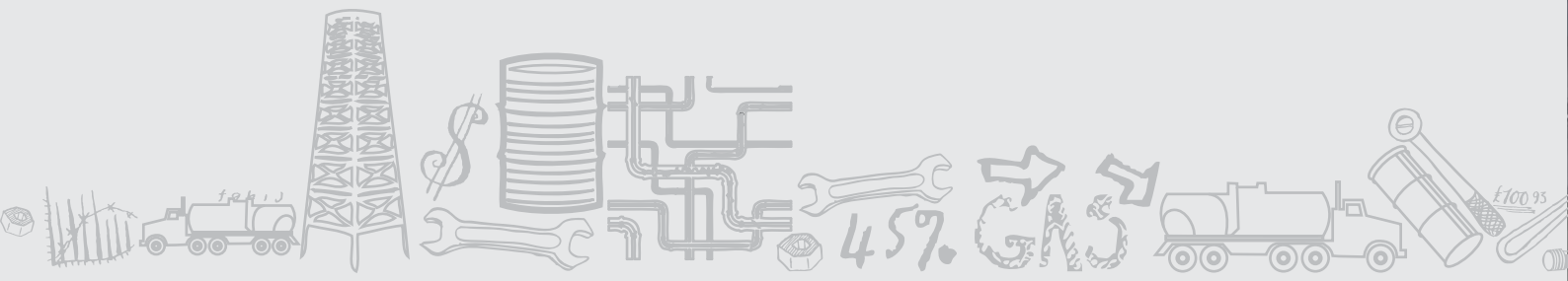
India has entered a major transformational phase in its economic, social and climate-change goals. India will continue to be one of the fastest growing energy markets in the world. The Government of India has been developing new policies on the demand side, supply side and infrastructure growth side to shift to a gas-based economy. Key enablers on which work is underway or intended to be undertaken include:

- India has adopted a comprehensive long-term Integrated Energy Policy in early 2000. Currently, a new long-term energy policy is being prepared by the National Institute for Transforming India (NITI Aayog) in consultation with a number of stakeholders. The new policy, among various other aspects, would take into consideration the goals and targets contained in the INDC and the role gas can play in the country's energy mix in the long-term. New policies are thus

1 BP Statistical Review of World Energy June 2016

2 "INDIA'S INTENDED NATIONALLY DETERMINED CONTRIBUTION: WORKING TOWARDS CLIMATE JUSTICE," UNFCC website, http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf, accessed 16 November 2016

3 India "First Biennial Update Report to the United Nations Framework Convention on Climate Change", Ministry of Environment, Forest and Climate Change (MoEF), Government of India, December 2015, MoEF website, http://www.moef.gov.in/sites/default/files/indbur1.pdf, accessed 16th November



expected to emerge shortly for the medium- and long-term role of gas in the Indian primary energy mix.

- The retail gas sector is receiving strong policy support to address many serious concerns pertaining to urban pollution from vehicular emissions.
- New "Energy Sinks" such as the Industrial Corridors (Delhi Mumbai Industrial Corridors) and Smart Cities are under implementation. These relatively concentrated demand centres provide robust opportunities for gas use in multiple applications.

Consequently, India offers numerous opportunities for expanding gas use and moving towards a larger share of gas, as a cleaner energy source, in its energy mix.

Scope of this study

EY has prepared this study to evaluate the role of natural gas in ensuring that India's energy mix remains environmentally sustainable as the country continues on its growth agenda. It will support the energy dialogue taking place at the 5th IEF-IGU Ministerial Gas Forum hosted by the Government of India and supported by Gail (India) Limited & Natural Gas Society on 6 December 2016 at the Hyatt Regency, New Delhi, India.

The study evaluates the following broad themes in the aforementioned context::

- Power generation
  - Cost analysis of coal vis-à-vis natural gas–based power taking into consideration externality costs
  - Role of natural gas as a bridge fuel in supporting the advancement of the renewable sector
  - Importance of the power sector for growth of the natural gas market
- Industrial sector
  - Fuels and their usage, including captive power generation
  - Cost and advantages (including environmental advantages) for industries in switching over to gas
- Transport sector
  - Environmental impact of emissions from transport fuels and comparison with natural gas
  - Investments required for vehicles to switch and the advantages thereof

The study also suggests the policy support required from the Government and the way forward for increasing gas usage in the aforementioned segments.

2 Introduction

India is the 3rd largest consumer of energy in the world, with primary energy consumption of 700 MMTOE in 2015. Natural gas accounts for 6.5% of primary energy consumption, compared to the global average of 24% (Figure 2.1). India's primary energy market is expected to grow from 700 MMTOE to 1,440 MMTOE by 2030 (CAGR of 4.9%). Energy consumption in India has maintained a high CAGR of ~5.9% over the last 10 years, compared with a global growth rate of 1.9%.

Figure 2.1: Primary energy mix

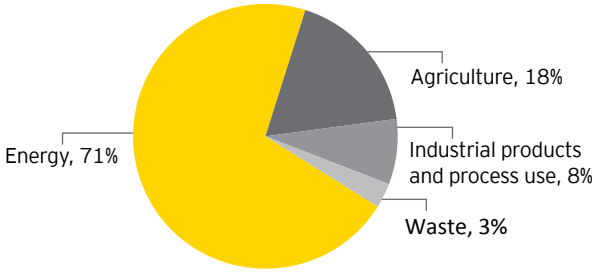
Fuel type	World (2015)	India (2015)	India estimated (2030)
Oil	33%	28%	23%
Coal	29%	58%	48%
Natural gas	24%	7%	7%
Renewables and Hydroelectricity	10%	6%	19%
Nuclear energy	4%	1%	3%

Source: BP Statistical Review of World Energy June 2016, International Energy Agency (IEA) World Energy Outlook 2015, EY analysis

In India, the share of gas in the primary energy basket is expected to increase from 6.5% to 7.2% by 2030, according to IEA's baseline assumptions. This translates into an increase in gas consumption from the current 47 BCM/year to 114 BCM/year in 2030 (CAGR of 6.1% during 2015–2030). Further, the Government of India is understood to be contemplating increasing the gas share in the energy mix to 15% in the next three to four years by implementing new policies and projects.[4] As a result, gas consumption could increase to 237 BCM/year by 2030. Gas accounts for a nominal 8% of the power generation capacity compared to coal, which accounts for over 60%.[5]

Consequently, the current usage of coal makes India a significant contributor to CO_2 emissions – India accounted for 6.6% of global CO_2 emissions in 2015.[6] India's sector-wise greenhouse gas emissions are highlighted below:

Figure 2.2: India Greenhouse Gas Emissions



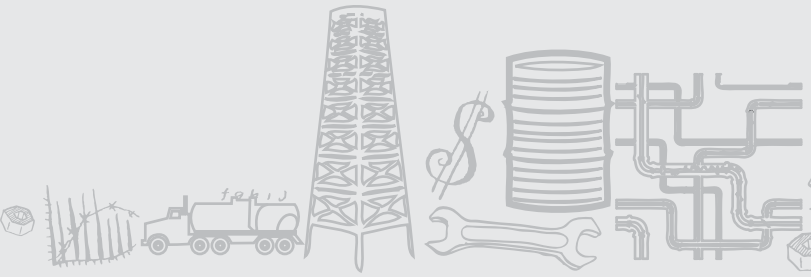
Source: Biennial Update Report Jan 2016 to United Nations Framework Convention on Climate Change, Government of India

Of the total emissions from the energy sector, 54% are attributed to the power sector, 30% to manufacturing industries and 12% to the transport sector, with the balance being accounted for by residential and fugitive emissions.

4 "Share of gas in India 's fuel basket is set to zoom to 15 %," Business Standard, 6 September 2016, via Factiva, © 2016 Business Standard Ltd.

5 EIA World Energy Outlook 2015

6 BP Statistical Review of World Energy June 2016,



India: COP21 commitments

In the COP21, key aspects of India's INDC include[7]:

- Reduce the emissions intensity of its GDP by 33%–35% by 2030 from 2005 levels
- Generate 40% of its total electricity requirements from non-fossil fuel-based energy sources
- Create an additional carbon sink of 2.5-3 billion tons of CO2 equivalent (CO2e) through additional forest cover by 2030
- Increase energy efficiency and save 10% of current energy consumption by 2018
- Reduce pollution through various systems, government bodies for monitoring and regulating industries and emission levels, improvement in waste management etc.

India's INDC commitment is to reduce the estimated emissions intensity of 6.5 Gt of CO2e on a business-as-usual basis by 2 Gt of CO2e by 2030.[8] Natural gas has an important role to play in reducing the emission intensity in the power generation, industrial and transport sectors. The role of gas in supporting India's clean development goals is presented in subsequent sections of this study.

7 "INDIA'S INTENDED NATIONALLY DETERMINED CONTRIBUTION: WORKING TOWARDS CLIMATE JUSTICE," UNFCC website, http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf, accessed 16 November 2016

8 "The Paris Agreement: A Universal Call to Action for Governments and Businesses: What it means for India," EY, 2016


5,8 m
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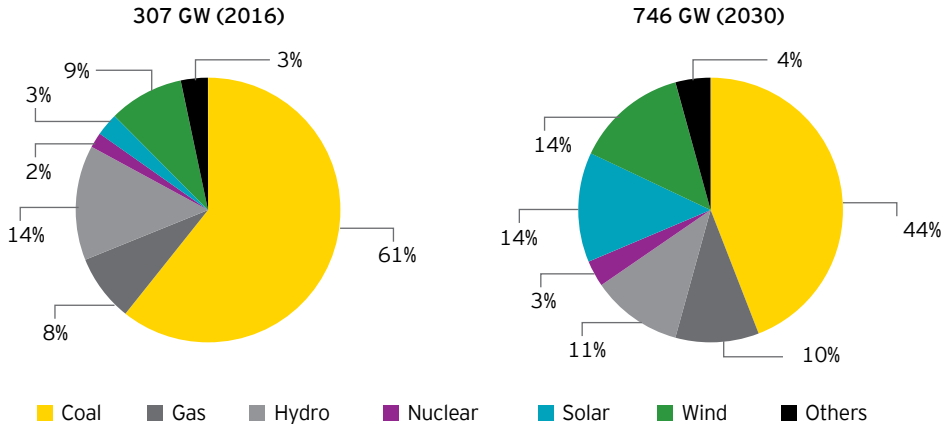
3 Power sector

India is the 3rd largest energy producer and the 4th largest consumer of electricity in the world, with a consumption of 1,174 TWh[9] in FY15. As per IEA estimates, India's 2030 electricity consumption is estimated to reach 2,241 TWh, at a CAGR of 4.1%. India has a total power generation capacity of 307 GW in 2016, which is expected to grow to 746 GW by 2030 (at a CAGR of 6.2%).[10] A breakup of India's current and projected generation capacity is presented in the figures below:

Figure 3.1: India's current and projected generation capacity



Source: IEA World Energy Outlook, 2015

Energy shortfall in India declined from about 10% in 2009 to 2% in 2015. During the same period, the peak-power shortfall declined from 10% to about 3%. The overall plant load factor (PLF) for thermal power plants in the country has also shown a declining trend: 64.5 % in FY15 compared to a peak of 78.6 % in FY08.[11] Various steps are being taken to improve the PLF of installed capacity, including improved supplies of domestic and imported fuels, strengthening of transmission grids and retirement of inefficient generation units. This low PLF indicates that there is considerable headroom in the existing generation capacity to cater to future requirements.

India's current generation capacity is predominantly dependent on coal-based power. Approximately 85% of coal-based power plants in India are based on sub-critical boiler technology, and usually operating at a lower efficiency levels of below 35%.[12]

This dependence on coal-based power has resulted in low carbon efficiency of India's power sector: 791 g of CO2 per kWh of power generated compared to a global average of 522 g.

The underlying reason for such dependence on coal is the low generation cost. In India, the typical levelised cost of power generated from a coal-based power plant is in the range of INR2.5-3 per kWh, whereas the corresponding cost of power generation from LNG amounts to INR4.5-5 per kWh[13]. Coal-based power production in India is levied a "Carbon Tax" of INR400 per tonne of coal used, which translates into INR0.14 per kWh additional cost.[14] This nominal tax does not account for hidden costs of coal pertaining to fatalities and health issues in mining communities and emissions from and the climate impact of power plants.

9 "Power Sector Report," India Brand Equity Foundation (IBEF), November 2016, IBEF website http://www.ibef.org , accessed 16 November 2016

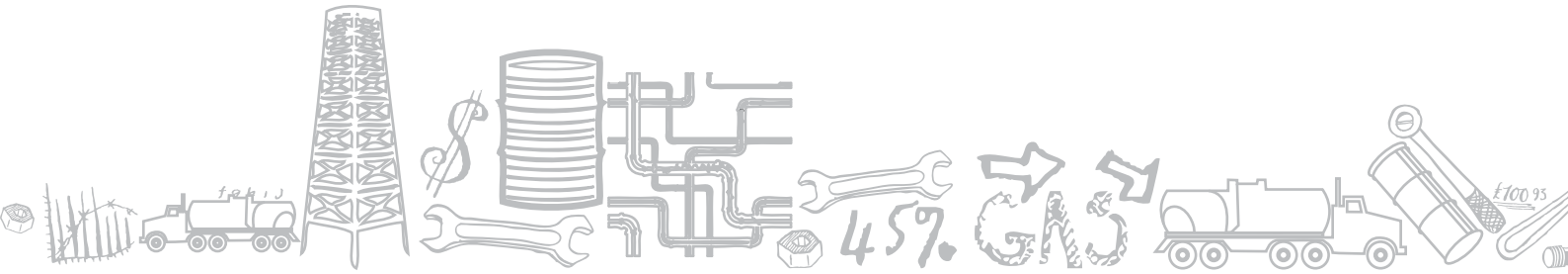
10 IEA World Energy Outlook 2015

11 Central Electricity Authority Annual Report 2014-15

12 IEA World Energy Outlook 2015

13 Considers delivered Natural gas price of USD 8 – 9 / MMBTU at power plant

14 "REPEAT: Summary of stories on Union Budget for FY17," Cogencis Moneywire, 1 March 2016, via Factiva, © Cogencis Information Services Ltd



Hidden costs of coal-based power generation (externalities costs)

The aforementioned indicative generation costs for coal- and gas-based power plants include the capital costs (i.e., depreciation and financing costs), fuel costs and operating costs related to the power plants. However, various hidden costs such as land disturbance, methane emissions (leaks) from mines, public health burden in mining communities, fatalities owing to coal operations, health impact from mercury emissions and climate damage from air pollutants from combustion of coal are not considered. Some of these externalities are attributable to the gas sector too.

As per environmental studies, India's coal-fired plant on an average emits above 1,100 g equivalent of CO_2/kWh. Whereas, GHG emission from a gas-fired plant in India, is approximately 600 g equivalent of CO_2/kWh. This shows that power plants fired by coal produce nearly 2 times more GHG emissions as compared to natural gas–based power plants.

As per international scientific studies, the externalities costs pertaining to coal-based power is estimated to be above. 6 cents per kWh.[15] This costs, includes fatalities, health and emissions from coal mining and climate damage from CO_2 and other emissions. Comparative costs for gas based power plants is less than 30% of the total externalities cost associated with coal based power generation. In India, the external cost amounts to circa. 8 cents per kWh[16] or INR5.4 per kWh. This cost corresponds to the non-carbon external cost of electricity generation.

If such costs are added to the aforementioned coal-based power plant generation costs, then the total costs of coal-based power would amount to circa. INR 8–8.5/kWh, which for gas on a comparable basis is circa. INR5.5 – 6/kWh, making gas-based power a more viable alternative compared to coal.

Given the future demand and projection for coal-based capacity in India is expected to almost double by 2030, India needs to simultaneously address its power needs and adopt low-carbon-generation strategies while driving its growth agenda. Natural gas, with one of the lowest CO_2 and particulate matter emissions, provides an ideal option to fulfil the additional energy demand while maintaining low emission intensity. India's gas-based power plants are operating at a low PLF of 23.6% (April – October 2016)[17]. If these power plants were operating at 85% PLF and replacing coal-based power, then a saving of 65-70 million tonnes of CO_2e emissions would be achieved annually.

India is also upgrading its existing coal-based generation capacity from mainly sub-critical plants to super-critical technology in keeping with its emission reduction commitments.

Super Critical and Ultra Super Critical Coal Technologies

According to IEA estimates, India's generation capacity is expected to more than double by 2030 – along with an increase in coal-based power generation from the current 185 GW to 329 GW by 2030.[18]

The Ministry of Environment and Forest, through a notification on 7 December 2015, has issued new stringent emission norms for the power sector. These new norms cover water use, particle matter, sulphur dioxide, oxides of nitrogen and mercury and are comparable to those that apply in OECD countries. The new rules have a bearing on existing and future thermal power plants. All old plants and those likely to be completed by December 2016 are required to meet the new emission standards within two years' time. Compliance with the new rules will require new capital investments by the existing power plants and higher capex by the new power plants. The power industry is of the view that the new provisions would significantly increase the coal-based generation costs. It is understood that a Working Group is currently studying the overall impact of the new rules, including the cost of generation.

15 National Research Council of the National Academies (NRC), Hidden Costs of Energy, US in 2010

16 "Power System Planning in India – Incorporating Environmental Externality Costs and benefits," World Bank, 11 April 2007, World Bank website, http://www.worldbank.org//, accessed 13 November 2016

17 "India records overall power deficit of 0.7% in April-October period," Accord Fintech, 25 November 2016, via Factiva, © Accord Fintech

18 IEA World Energy Outlook 2015

In order to meet the INDC commitments as well as providing affordable power to consumers, the Government of India is undertaking further steps to reduce carbon emissions and increase the overall efficiency of coal usage. A comparison of CO_2 emissions by sub-critical, super critical and ultra-super critical power plants is presented in the table below.

Table 3.1: Comparison of coal-based power by criticality

Power Plant Category	CO2 emissions (g / kWh)	Coal Usage (g / kWh)
Sub-critical	880+	380+
Super-critical	800-880	340-380
Ultra-supercritical	740-800	320-340

Source: 2012, "Technology Roadmap – High Efficiency, Low Emissions Coal Fired Power Generation," IEA, 4 December 2012

It is important to note the CO_2 emissions under the most advanced ultra-supercritical technology are 25% higher than under gas-based power generation.

The Government of India has taken a number of recent initiatives to improve the efficiency of coal-based power plants and to reduce the carbon footprint of the power sector:[19]

- A total of 87,000 MW thermal capacity is being constructed, of which, approximately 48,000 MW uses the supercritical technology, which in turn, uses less coal.
- The government has made it mandatory for all Ultra Mega Power Projects (UMPPs), which have a capacity over 4,000 MW, to use Supercritical technology.
- 3,000 MW of old legacy coal-based power plants has already been retired.
- Further, 5,860 MW of existing coal capacity (from 13 existing lignite plants which are over 25 years old) is being replaced with 10,180 MW of supercritical technology. This change is expected to cost US$10 billion in the next three to five years.
- An Advanced Ultra Super Critical Technology R&D Project has been approved by the Government at a cost of INR 1,500 crore (US$224 million).

The Government of India is also focusing on increasing the share of renewable energy in the overall power generation mix in the country.

Renewables: power generation

As of 31 October 2016, India had a total installed capacity of 45.9 GW from RES (wind, biomass, solar and small hydro plants).[20] The share of RES in India's total installed generation capacity is about 14.9%.

India has rolled out the world's largest renewable energy program with an installed capacity target of 175 GW from RES by 2022. This ramp up in RES power capacity is expected to assist India in reaching its target of 40% of generation capacity from renewable sources. The table below highlights the current installed capacity vs. the 2022 targets.

Table 3.2: Installed vs. Target Capacity (in GW)

Source	March 2016 (Current)	2022 (Target)
Solar	6.8	100
Wind	26.9	60
Small Hydro	4.3	5
Biomass	4.9	10
Total	**42.9**	**175**

Source: Source: CEA, NITI Aayog[21]

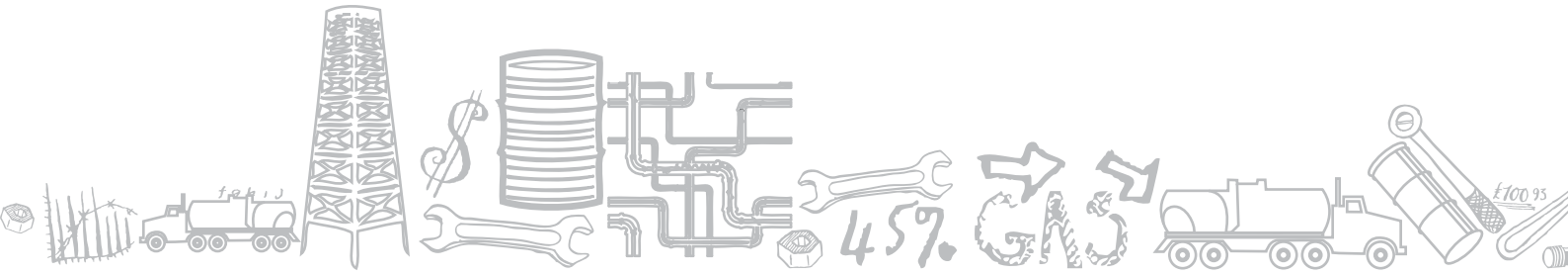
While the generation capacity addition from renewable sources provides opportunities, it also brings a lot of challenges. The overall utilisation of RES is measured in terms of capacity utilisation factor (CUF). In FY15, the CUF for solar power plants typically averaged between 18% and 22% during the year, while that of wind energy averaged between 20% and 27%. The relatively low CUF compared to PLF of coal-based power plants (currently 59%) is because of variability and uncertainty of power generated from RES.[22]

19 "Initiatives to Improve the Efficiency of Coal Based Power Plants," Press Information Bureau (PIB), Government of India, 12 March 2015, PIB website, pib.nic.in, accessed 15 November 2016

20 "Power Sector" Central Electricity Authority (CEA), Oct 2016, CEA website, www.cea.nic.in, accessed 16 November 2016

21 "Report of the Expert Group on 175 GW RE by 2022", NITI Aayog, 31 December 2015, NITI Aayog website, niti.gov.in, accessed 16 November 2016

22 "Muted demand continue to impact generation growth," Emkay, 25 November 2016, via Factiva, © Emkay



Use of natural gas as bridging fuel

Given the variability and uncertainty pertaining to electricity generated from RES, gas-based power plants can play an important role to address peak demand situations and grid integration. Gas-based power plants in India are currently operating at a PLF of 23.6%, consuming around 13 BCM/year of natural gas,[23] which leaves a large spare capacity available that can be utilised to balance the grid. The current low utilisation of gas-based capacity is due to a drop in domestic gas supplies, as well as affordability issues with the use of RLNG; therefore, market penetration is slow.

In India, most of the gas-based power capacity is combined cycle based. These plants can potentially ramp up to 85% PLF in 30 minutes and ramp down in a similar period. As per industry sources, peak power demand in evening hours and shortfall from RES at the same time can be potentially addressed by running existing gas-based power plants at high PLF for a period of six hours in the evening. During other hours, gas-based power plants can operate at a moderate PLF and thus would be well placed to cater to peak demand requirements as well as providing grid integration and grid stability.

Coal-based power is the other alternative for grid balancing during peak hours given that the current PLF of coal-based power plants is 59%. However, the use of gas-based power is preferable over coal-based power because of its inability to ramp up as quickly as gas and given the environmental impact discussed earlier.

Underutilisation of natural gas infrastructure

Power and fertiliser have traditionally formed anchor loads for the development of gas pipeline infrastructure as well as LNG terminals in India. Fertiliser sector gas demand is currently 17 BCM/year which is being supplied by existing gas sources. Based on the announced capacities and revival plants, incremental gas demand from the fertiliser sector is expected to grow by 6.5 BCM/year to reach 23 BCM/year by 2025. In the power sector, India has an installed gas based capacity of 25,075 MW with an estimated gas demand of 42 BCM/year (at 85% PLF). However, only 13 BCM/year is being currently supplied to gas-based power plants owing to domestic gas supply-side constraints and power generated from LNG being expensive compared to coal.

Further, over 35% of gas-based power capacities are located in the eastern state of Andhra Pradesh. These capacities are currently stranded because of a decline in production from gas-producing offshore fields in the Krishna Godavari (KG) Basin.[24] The delivered cost of LNG to these power plants falls within the range of US$8–8.5/MMBTU. This is due to high gas transportation costs from LNG regasification terminals located on the West Coast of India, making gas-based power expensive (INR4.7–5.2/kWh) compared to other sources of power such as coal (INR3–3.5/kWh).[25]

This situation of low utilisation of gas-based power plants has also led to a decline in the utilisation of pipeline capacity in the country. The capacity utilisation of India's major transmission pipelines is illustrated in the table below. It illustrates a high degree of underutilisation of pipeline capacity in the country, which impacts return on capital on pipeline infrastructure.

Table 3.3: Major pipeline capacity and utilization (FY16)

Pipeline network[38]	Length (km)	Capacity (BCM/year)	FY16 utilisation
HVJ including spurlines	4,658	19	63.5%
DVPL–GREP	1,119	20	49.0%
DUPL–DPPL including spurlines	875	7	62.5%
EWPL	1,469	29	25.0%
GSPL Gujarat Network	2,540	9	56.9%
Dabhol–Bangalore	1097	6	7.5%

Source: PPAC[26]

Financial implications

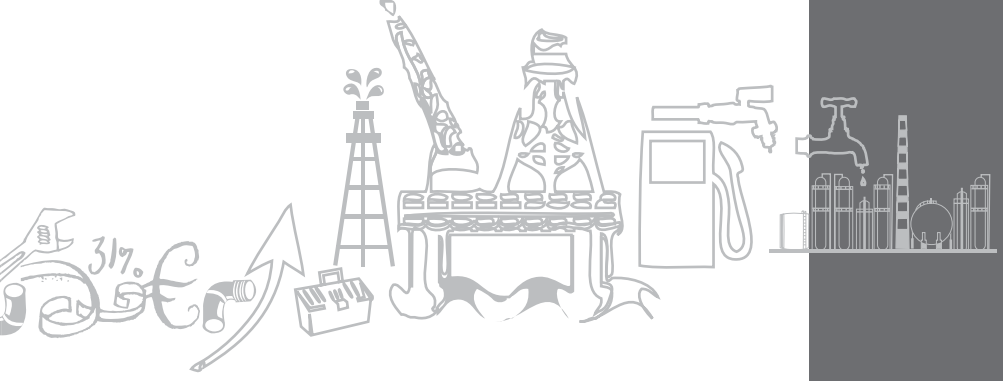
Gas-based power plants have been the anchor loads for transmission pipelines connecting North India (HVJ, DVPL) and Eastern India (EWPL) to the West Coast. However, gas flows to such power plants have been at low utilisation levels, which have severely impacted financial returns for cross-country pipeline projects. Lack of returns is now delaying future pipeline projects and is an impediment to the development of a national gas grid linking RLNG and pipeline imports to inland demand centres in India.

23 "Monthly Report on Natural gas production, availability and consumption," Petroleum Planning & Analysis Cell (PPAC), September, 2016

24 EY estimates, assumes US$5.5/MMBTU DES LNG Price, US$2/MMBTU for transportation to the East Coast

25 EY estimates, assumes INR2,000–2,500 per tonne delivered cost of coal to power plant

26 "Gas pipeline network as on 30 Sept 2016," PPAC



India has made an estimated investment of US$15 billion (INR1 lakh crore) in the gas-based power sector in the last decade. However, this capital is producing sub-optimal returns and has led to a concerning non-performing asset (NPA) situation for the lenders, who are unable to finance other investments because of this situation. Additionally, there is a cascading effect when underutilisation of other physical infrastructure facilities is factored in. For a partly developed gas market such as India, price sensitivity of end users exposes LNG importers to additional financial risks.

Similarly, based on interactions with the natural gas industry players, the post-tax return on capital employed for transmission pipeline projects commissioned in the past three years is currently at 4% compared to a 12% hurdle rate on these projects.

If the existing gas-based power plants were to run at 85% PLF compared to 31% currently, it would generate additional US$15 billion of transmission revenues, leading to more investment in pipelines, and would also address the NPA issues pertaining to underutilised gas based-power plants.

Recent government initiatives

The Government of India has embarked upon the following initiatives to increase gas utilisation in the power sector:

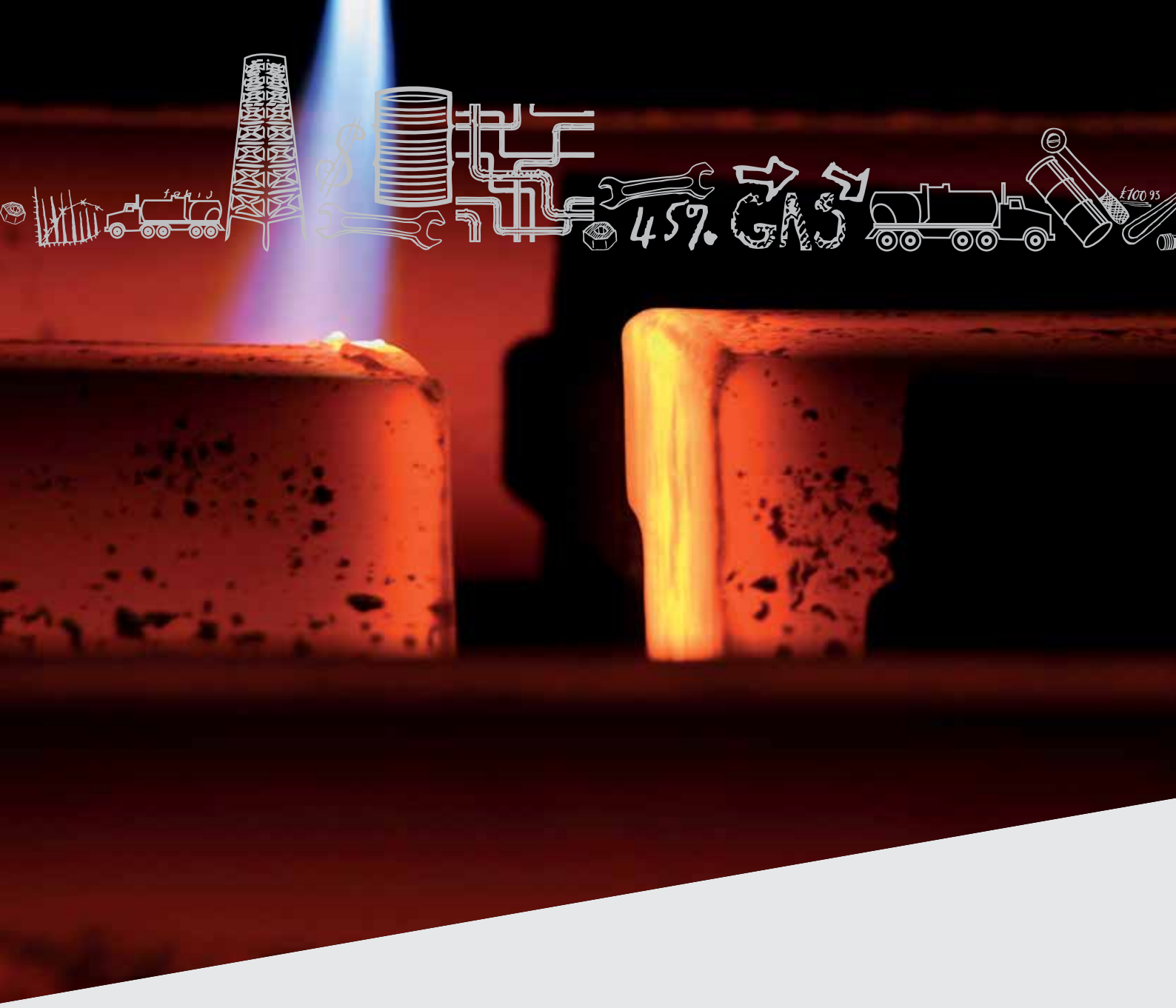
- E-Bid RLNG Scheme for Stranded Power Projects: stranded power plants bid for financial support required (per kWh) to reach a pre-defined PLF.
  - Financial support of INR2,100 crore (US$315 million) from the Power System Development Fund (PSDF) every 6 months until March 2017
  - Reduction in pipeline and regasification charges and waiver of taxes and duties to lower the generated cost of power
- Gas pricing reform to incentivise domestic gas production
  - Well head gas price from deepwater, HP/HT and difficult environments linked to alternate fuel prices to incentivise domestic production
  - Marketing and pricing freedom for gas produced from fields auctioned under the Discovered Small Fields bid round and the recently notified Hydrocarbon Exploration and Licensing Policy (HELP).
- Financial support for National Gas Grid development
  - Viability gap funding (VGF) support from the Government to the Jagdishpur Haldia pipeline to promote gas usage and the establishment of a national gas grid in the Eastern region of India
  - Similar VGF support expected for other trunk pipeline projects

Outlook

In order to meet its INDC commitments, India is required to create its future coal-based generation capacity by adopting supercritical generation technologies. The recently introduced stringent norms for emissions and environment management for power generation are a very significant policy step and, along with larger adoption of super critical technology, will reduce the emission intensity of Indian coal-based power generation capacity. However, the impact of all the new norms would need to be clearly understood in terms of cost of generation.

India's thrust on increasing RES generation capacity to 175 GW by 2022 will go a long way to meet its emission commitments. However, the interruptible and seasonal nature of RES poses a challenge towards maintaining electricity grid integrity and discipline. To address this power shortfall in peak hours, gas-based capacities will be required for steady power supply and effective grid integration of RES. Given the underutilisation of gas-based power plants, India may consider coming out with medium-to-long-term policy proposals for utilising existing and planned gas based capacity to meeting its objectives of balancing renewables. In our view, there is a case for creating an integrated renewable and gas-based generation model for India.

Subsidies provided by the Government have encouraged investments and cost reduction in RES. The Government may consider further support to promote gas use and support its renewables program. Resources for this purpose could be raised through a further increase in the carbon tax levied on coal.



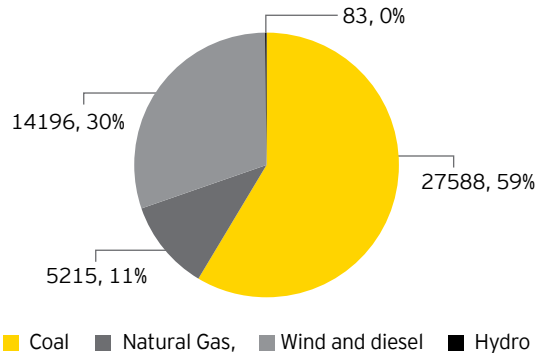
4 Industry segment

The industrial segment accounted for 16.5% of India's GDP in FY16.[27] The Government of India has embarked on initiatives to increase the share of the manufacturing sector in India's GDP to 25% by 2025 through the National Manufacturing Policy, "Make in India" programs, development of industrial corridors etc.[28] However, this increase in manufacturing GDP will require an increase in fuel consumption for power and for various other industrial process purposes.

As per India's Biennial Update Report dated January 2016, the manufacturing sector in India also accounts for 28% of GHG emissions, including emissions from energy used in manufacturing and emissions from industrial process and product use (IPPU).

Industries in India rely on captive power plants as well as grid power. The generation capacity of captive power plants in India is 47,082 MW[29], as illustrated below:

Figure 4.1: Captive capacity (MW) in FY15



Source: CEA

Coal forms the majority of the captive power projects, followed by diesel. Captive power plants present an opportunity for increasing the share of gas through the replacement of coal- and diesel-based generation capacity.

The major fuels in the industrial sector (for both power and non-power applications) are as follows:

Table 4.1: Major fuels

Fuel	Usage

Coal	▸ Coking coal: mainly used in steel production
	▸ Non-coking coal
	  ▸ Primarily used in the power sector (grid and captive)
	  ▸ Used in cement, cast iron, brick kilns etc.

Furnace oil	▸ Secondary fuel for thermal power plants, and fuel/feedstock for fertiliser plants and industrial units
Naphtha	▸ Feedstock/fuel for fertiliser units, feedstock for the petro-chemical sector and fuel for captive power plants
Commercial LPG	▸ Used for metal cutting, chemical engineering, food processing, and ceramic and pottery ware
Gas	▸ Substitute for all of the above applications

Use of natural gas in industries

Besides power and fertiliser, gas consumption in India is divided into two major categories: the city gas distribution (CGD) segment and the industrial segment. The CGD segment caters to cities, wherein entities supply CNG for vehicles (discussed in detail in the Transport section), and piped gas to homes and commercial establishments such as hotels, restaurants and colleges for cooking as well as to small industries within city limits (consuming less than 50,000 scmd).

The Indian industrial sector uses gas as feedstock (fertiliser, steel and refineries) and heating fuel. Traditionally, due to limited domestic gas availability, industrial gas use was assigned lower priority in the gas utilisation policy and this practice broadly continues at present. Domestic gas is directed to retail gas use (homes and transport fuel), power generation and fertiliser production. This practice for optimal utilisation of gas is expected to continue in the foreseeable future as well. The imports of LNG, from 2004 onwards, have led to RLNG being used to provide gas to the industrial sector where it is economic.

27 "Economic Survey 2015-16," IBEF, February 2016, IBEF website http://www.ibef.org/economy/economic-survey-2015-16, accessed 14 November 2016

28 "Why 'Make In India' is so imperative to India's Growth",Indiainfoline New Service, via Factiva © Indiainfoline ltd.

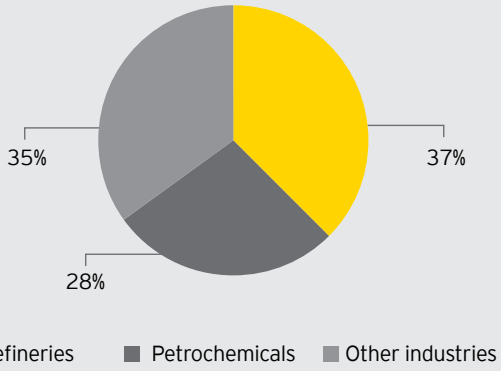
29 " Growth of Electricity Sector in India From 1947-2015" CEA, April 2015, India Environment Portal website, www.indiaenvironmentportal.org.in, accessed 16 November 2015

The industrial segment comprises the following:

- Refineries, and petrochemical projects and LPG plants
- Sponge iron and steel
- Other industrial units (such as textiles, ceramics, glass, chemicals and pharmaceuticals)

Monthly gas consumption by the industrial segment in India has been approximately. 1.3 BCM. (September 2016)[30]

Figure 4.2: Segment-wise industrial sector gas consumption 2016



Source: EY analysis

Besides natural gas, other major liquid fuels consumed by industries in India are commercial LPG, furnace oil (FO), naphtha and diesel. The following chart presents a comparison between alternate fuel prices and delivered gas prices.

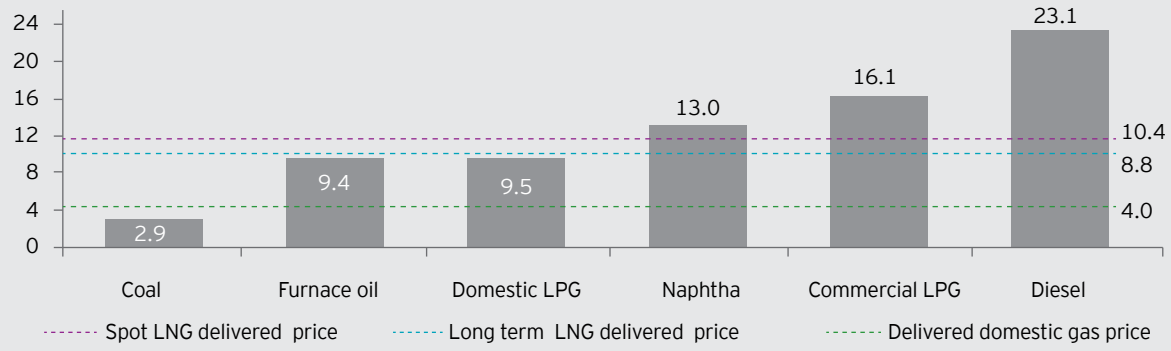
The long-term delivered LNG price is currently higher than the price of FO and coal, making it difficult for industrial consumers to switch to gas. However, the price of naphtha, commercial LPG and diesel (used for power generation by industrial users) makes it attractive for consuming industries to switch to natural gas.

For small consumers (c. 1,000–5000 scmd), the switching cost typically ranges between US$10,000 and US$15,000. The typical payback period for a naphtha consumer switching to LNG is 6-12 months. Typically, Indian industrial consumers prefer to have short-term gas contracts with no take or pay provisions.

Industrial sector: gas use benefits

India is aiming for a transformational shift from being a services-led economy to increasing the share of manufacturing in its GDP. This will have a profound impact on its energy consumption. India will have to do a balancing act between meeting its higher energy demand and keeping its emission intensity low for meeting its INDC commitments. The following table illustrates emissions from the use of various industrial fuels and gas.

Figure 4.3: Delivered Fuel Price Comparison (All prices in USD/ MMBTU, Delivered in Delhi)



Source: EY analysis, FO, Commercial LPG, Diesel and Naphtha prices as of November 4, 2016, Long term LNG price based on Qatar gas Contract considering average 3 months Brent price of USD 50/bbl, prevailing spot LNG prices considered

30 "Monthly Report on Natural gas production, availability and consumption - September, 2016" PPAC

Table: 4.2: Emissions from various fuels

Fuel	Coal	LPG	Diesel	Furnace Oil	Natural gas
CO_2 (Kg/ MMBTU)	94.3	61.71	70.22	73.3	53.07
$N2_0$ (g/ MMBTU)	1.6	0.60	0.60	0.60	0.10
Methane (g/ MMBTU)	11	3	3	3	1

Source: USEPA[31], for our analysis diesel and naphtha are considered to have same CO_2 emissions

Gas is a cleaner alternative to coal and other liquid fuels used in industries. Given the overall affordability of natural gas vs. alternate fuels, naphtha, commercial LPG and diesel can be replaced by natural gas.

For this study, we have estimated the possible reduction in CO_2 emissions by replacing naphtha, commercial LPG and diesel used in industries with natural gas. The underlying assumptions are as follows:

- Overall naphtha, commercial LPG and diesel (industrial) demand at a country level is considered based on Ministry of Petroleum and Natural Gas' (MoPNG's) statistics
- Long-term fuel consumption growth rates from the 13th Plan projections have been considered
- Two scenarios have been considered: 25% and 50% of the aforementioned liquid fuels consumption volumes will be replaced by natural gas
- CO_2 emissions will reduce based on the difference between CO_2 emissions of liquid fuels and natural gas

For the 25% replacement scenario, the gas consumption of the industrial sector is expected to rise to 23 BCM/year by 2030, amounting to a reduction in emissions of 5.7 million tonnes of CO_2e per annum, while for the 50% replacement scenario, the 32 BCM/year gas consumption by the industrial sector in 2030 amounts to a reduction in emissions of 11.4 million tonnes of CO_2e per annum by 2030.

Outlook

Policy and regulatory reforms are underway to facilitate the growth of the industrial base of the country. Besides attaining and sustaining higher rates of GDP, the growth of the manufacturing sector is also now a national imperative for employment creation, as the service sector cannot match the job creation requirements.

As regards the specific manufacturing sectors in India, relatively higher focus would be on automobile and auto ancillary, agro and food processing, metals and metallurgical products, chemicals and pharmaceuticals, heavy engineering and IT hardware. Many of these industrial manufacturing sectors are energy-intensive. While new technologies with higher energy efficiencies will moderate the energy demand, the overall energy requirement from industries is expected to be on a rapid growth trajectory.

Gas can offer multiple energy solutions covering power, heat and cold energy supplies for the industrial sector. Expansion of domestic gas production, pipeline infrastructure and additional LNG import capacities would facilitate access to gas by industrial consumers and industrial regions under development. This would help unlock many potential gas markets that are currently not being serviced.

Geographical build-up of gas demand by the industrial sector is likely to emerge in north western regions due to the implementation of the Delhi Mumbai Industrial Corridor project, and it will subsequently spread to other parts of the country as similar projects get implemented

31 "Emission Factors for Greenhouse Gas Inventories," United States Environment Protection Agency (USEPA), 4 April 2014, USEPA website, www.epa.gov, accessed 13 November 2016

5 Transport segment

The transport segment is a key consumer of petroleum products in India. It accounted for around 50% of products consumption (circa.90 MMT from HSD, MS and ATF), with diesel being the most consumed fuel.

Going forward, India's automobile usage is set to increase considerably, driven by the following factors:

- Rapid urbanisation
- Increase in disposable income
- Growth of the manufacturing sector
- Development of transport infrastructure providing better connectivity across the country

The auto sector is one of the most important contributors to GDP. India's Automotive Mission Plan 2016–26 envisions that the vehicle sales in the country would grow at a CAGR of 10% until FY26. Over the years, India has emerged as one of the largest automotive markets in the world, with annual sales of about 20 million vehicles. Historically, passenger vehicles have registered a CAGR of 9.1%. Two wheelers have grown at a CAGR of 14.0% and commercial vehicles at a CAGR of 8.5 % over the past seven years.[32] India's passenger vehicle population of around 29 million in 2015 is expected to grow to more than 48 million vehicles by 2020.

India's vehicle emissions

As per India's Biennial Update Report dated January 2016, the transport sector in India accounts for 12% of GHG emissions from fuel combustion. In highly populated urban centres, vehicle pollution is one of the major causes of concern related to health hazards. The emission norms for petrol, diesel and CNG under BS-IV emission standards are presented in the following table:

Table 5.1: Petrol, diesel and CNG emissions (Gross vehicle weight < 2,500 Kg or up to a 6-seater): (g/km)[33]

Fuel	Petrol	Diesel	CNG
CO_2	172.95	148.8	131.2

The CO2 emissions in the table above are estimated emissions, as there are no limits/norms for CO2 emissions from vehicles.

With the increasing importance of climate change and public health, fuel efficiency of vehicles is gaining importance along with focus on reducing dependence on oil at a global level. The United Nations Environment Programme (UNEP) has launched an initiative in this regard, referred to as the Low Carbon Transport (LCT) project. The LCT project aims at:

- Creating an enabling policy environment at the national level to build a sustainable transport system
- Enhancing the capacity of cities to improve mobility with lower CO2 emissions

CNG economics and benefits

CNG cars have a mileage of 17-19 k/kg compared to 11-13 km/litre for a petrol car and 13-15 km/litre for a diesel car.[34] A typical CNG OEM car costs an additional INR50,000–60,000 (US$800–900), which can be recovered in two years. A diesel variant of the same car would cost an additional INR120,000 (US$1,800). The life of CNG and petrol engines is 10-12 years compared to 5-10 years for a diesel engine, depending on the running conditions.

Government initiatives for cleaner transport fuels

The Government has been promoting the use of CNG as a transport fuel for combating high levels of urban pollution. At present, 25 entities are operating CGD networks in 67 geographical areas (GAs) in India.[35] The current overall CNG consumption in India is c. 3 BCM/year[36] spread across various cities across the country. For doubling the existing CNG consumption in the next five years within cities with the existing CNG infrastructure, an additional investment of US$500 million[37] is required to create infrastructure for dispensing CNG to vehicles within city limits.

32 "Automotive Mission Plan 2016-26," Society of Indian Automobile Manufacturers, December 2006, siamindia.com

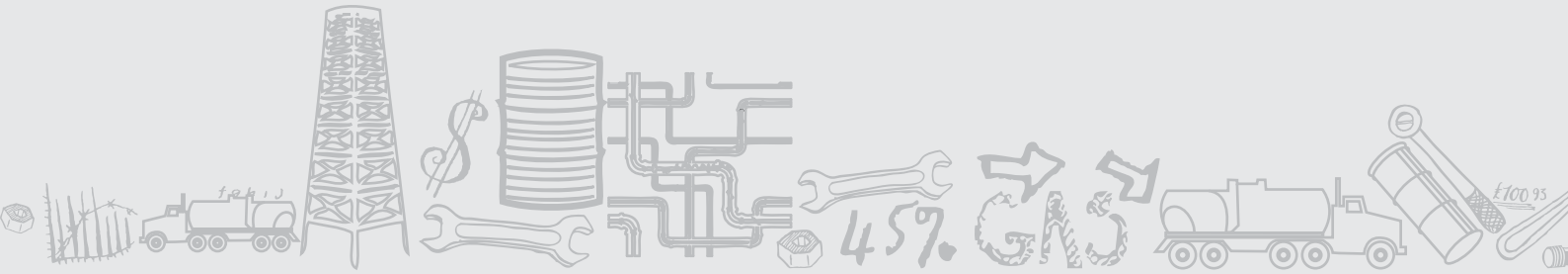
33 " Air Quality Monitoring Project-Indian Clean Air Programme," Central Pollution Control Board (CPCB), March 2008, CPCB website, www.cpcb.nic.in

34 "Fall in Price of natural Gas makes CNG Vehicles more Attractive," Infraline, 12 October 2015

35 "Impact of City Gas Distribution on Gas Market Developments in India," Hans India, via Factiva, © The Hans India

36 "Indian Petroleum & Natural Gas Statistics 2015-16"

37 EY estimates based on investments for CNG retailing in other cities



Under its Smart Cities Mission, India is planning to roll out CGD networks in 20 cities. These networks are likely to be operational by 2018-19. Additionally, another 80 cities are expected to have CGD network implementation under the Smart Cities Mission. The Government has also supported the use of PNG and CNG by allocating domestically produced gas on a priority basis.

The Government has also commissioned studies and pilot projects through various agencies pertaining to the use of LNG as transport fuel in road, railways and waterways transport.

The Government of India is aiming to leapfrog from Euro IV to Euro VI fuels standards by 2020. This will entail refinery upgrade investments of US$6-8 billion and result in a reduction of sulphur emissions from 50mg/km to 10 mg/km.

Electric vehicles market in India

The current electric vehicles (EV) market in India is very small. However, in 2012, India launched the National Electric Mobility Mission Plan (NEMMP), aimed to incentivise EV production and sales with a total proposed investment of US$3.5 billion.[38] The Indian Government has set an ambitious target of 6-7 million units of new vehicle sales of the full range of EVs, along with resultant liquid fuel savings of 2.2-2.5 million tonnes by 2020. India sold 22,000 units of electric vehicles in FY16[39] (up 37% from the previous year) of which, 2,000 units of four-wheelers were sold and the rest included e-rickshaws and two-wheelers.

Gas as transport fuel in Other Countries

Globally, one of the most significant growth drivers for gas is its increasing use as a transport fuel. Major advancements have been happening globally in substituting liquid transport fuel with gas and LNG. The MARPOL 73/78 convention of 02 October 1983 aims at reducing marine pollution from the use of bunker oils by the industry, which has significant adverse effects on port cities and marine life. Keeping MARPOL in mind, the International Marine Organisation has introduced restrictions on emissions from ships, with several regions such as Europe and North America being compulsorily compliant with the regulations by 2015 and the rest of the world being compliant by 2020. To reduce inland pollution by vessels, several countries have promoted the use of LNG as a fuel source for the ships and barges operating in the "Inland Waterways". New vessels under fabrication will be using LNG as fuel in larger number. Similarly, the use of LNG is growing in the road transport segment. The population of NGVs has been increasing in many countries across the world. LNG as a transport fuel for medium and heavy commercial vehicles for cross-country movements of goods has grown rapidly in the US and China, with a similar shift in a few European countries as well.

38 "National Electric Mobility Mission Plan 2020," (NEMMP), Department of Heavy Industry: Ministry of Heavy Industries & Public Enterprises: Government of India, 2012

39 "India's electric vehicle sales grow 37.5% to 22,000 units, " IBEF, April 2016, IBEF website, http://www.ibef.org/news/indias-electric-vehicle-sales-grow-375-to-22000-units, accessed 16 November 2016

Outlook

Safe, Smart and Sustainable Green Transportation Networks is one of the mitigation strategies in India's INDC. It covers the railways, waterways and the urban transport. It also identifies specific programs for each sector to control/ reduce the sector emissions. The Indian transport sector is in a major transformational phase where gas/LNG would have a very significant and growing role to play. Expansion of gas infrastructure, both inter-state and intra-state, will be essential to driving increase of gas usage in transport sector. Large capital investments will be needed in setting up safe dispensing facilities in urban and semi urban settings, national and state highways. Likewise large investments will be required in manufacture of NGV's as well as the auto parts needed. Countrywide facilities will also be needed, over a period of time, for servicing of NGV's along major transport corridors. Currently various policy and regulatory requirements for introduction of LNG as transport fuel are being addressed by the Government of India. Discussions are also underway with automobile manufacturers of commercial vehicles for domestic production of LNG fuelled vehicles. It would hence be reasonable to expect that over the next 5- 10 years, CNG and LNG would have a higher share of transport fuels in India.

6 Conclusion

India has entered a major transformational phase in its economic, social and climate-change goals. India will continue to be one of the fastest growing energy markets in the world. India has ratified the COP21 Climate Change Agreements and adopted stringent targets and quantum of emissions reduction in its INDCs. Concurrently, India has been taking strong policy reforms and announcing new policies to enable a progressive shift to a gas-based economy. In the context of the analysis carried out in the previous sections of this paper and coupled with policy and regulatory reforms, it is evident that gas demand in India is poised to grow at a robust rate. India's impressive plans of 40% of cumulative power generation installed capacity from non-fossil fuel energy sources (predominantly renewable, solar and wind) by 2030 would need gas-based power generation support for effective and efficient grid integration and steady power supply. Gas provides the additional merit of swing electricity producer and peak demand sharing.

Sustained economic growth is leading to rapid urbanisation and improved purchasing power in the hands of people, resulting in distinct shifts in lifestyles. While the automobile sector has been consistently recording strong growth rates, the growth rates are set to climb up further in the medium term.

In order for the country to achieve its long-term growth objective and INDC commitments, the following steps are important:

- India's new energy policy, under development, is being aligned to the INDC and socio-economic goals.
- The new Energy Policy is expected to address the medium–long term role of gas in the Indian primary energy basket. Clear gas usage policies and regulations would then drive the following:
  - Higher capacity utilisation of the national natural gas pipeline infrastructure
  - Significant investments in the implementation of authorised pipeline projects and new projects
  - Renewed global interest in the Indian upstream sector in future bidding rounds under HELP/OALP
  - Setting up of major, as well as medium, small and micro enterprises (MSMEs)
  - Faster growth of the retail gas sector and acceptability of gas/LNG as a transport fuel (road, railways and inland waterways)
- Global gas/LNG scenarios and outlooks provide an attractive opportunity for India to take a long-term position on gas/LNG imports and develop a competitive and diversified supply portfolio.
- Urban pollution is seriously impacting most/all major cities, with 10 out of the 20 most polluted cities in the world being in India . While urban pollution in India results from a number of factors (such as construction, higher baseline dust levels, transport and burning of agricultural waste), expanded gas usage as CNG/LNG in vehicles can partly address the problem. The growth of retail gas under the present priority of the Government would go a long way in addressing the challenges of urban pollution.
- India has a large number of two wheeler vehicles (motor cycles, mopeds, scooters etc.), and technology development work has started on the use of gas as a fuel in such vehicles. This is a step in the right direction.
- New "Energy Sinks" around the industrial corridors (such as the Delhi Mumbai Industrial Corridor) are under implementation to build a strong manufacturing base. These relatively concentrated demand centres will provide robust opportunities for gas use in multiple applications. Gas use in these emerging demand centres would facilitate a shift to a gas-based economy. In the context of Smart Cities, gas use as fuel (homes, commercial, small industrial and transport) and integrated power heating and cooling can offer attractive environment-friendly energy solutions.

India is progressing with policy reforms for major gas end-use sectors. This process should continue and the reforms across such sectors and the gas/energy sector should move in tandem to avoid mismatches. Such synergies would act as catalysts for large amount of fresh investments required in energy and gas value chains.

40 "WHO, Ambient Air Pollution Database", World Health Organization (WHO), May 2016, WHO website, www.who.int/en/, accessed 14 November 2016

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