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India's Gas Market Post-COP21

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1. Introduction

A number of factors have put India back in the spotlight as a potential future growth market for gas. Among these are: the decline of gas in European energy balances, the US's transformation from energy importer to exporter, a tempering in China's rapid pace of economic expansion and energy consumption, and the expectation of an oversupplied gas market up to the mid-2020s. The view on gas from within India has, on the other hand, been in constant flux over the last decade, with no realistic vision or long-term objectives on its role in the energy mix. No confident assessment of gas demand in India has been possible so far, as the Indian gas market as a whole has been comprised of two segments: one using gas allocated at government-controlled prices, and the other paying market prices for imported LNG.[1] Some degree of overlap between the two segments makes the picture even messier. Consequently, government projections of future demand have tended to be over-optimistic, and international assessments by multilateral institutions cautious yet confused. Yet, a developing country of over one billion people cannot be confidently dismissed as an important future centre of energy demand. In other words, India is a 'wildcard' in the global gas market.

Sen (2015) examined India's prolonged attempts at gas pricing reforms, and concluded that the main focus of reforms would continue to be around the price level, rather than designing a mechanism that improved the overall competitiveness of gas with other fuels in the Indian market, unless two changes occurred. First, there needed to be the implementation of a clear road map for gas pricing reform which reflected the dynamics of the Indian gas market and secondly, a reorientation of policy towards a longer term goal for the role of gas in the energy mix. Following the global oil (and gas) price downturn since mid-2014, there have been several notable developments which indicate that the outlook may be changing. The short-term developments include:

- a significant rise in imports of Liquefied Natural Gas (LNG) over 2015/2016;
- the government's stated intention to increase the share of gas in India's primary energy mix to 15 per cent "within 3-5 years" (compared with 6.5 per cent at present) through "doubling LNG imports", accompanied by statements of intention to "shift India to a gas-based economy"[2];
- higher prices – linked to a basket of coal, fuel oil, naphtha and imported LNG – for gas produced from deep water, ultra-deep water, and high temperature high pressure fields; and,
- the launching of an open acreage licensing (OAL) regime allowing companies to initiate bidding for prospective blocks, and instituting a single license for the exploration of conventional and unconventional resources.

At the same time, there have been a series of parallel connected developments in the wider energy sector that may be construed as longer-term determinants that could influence the role of gas:

- India's ratification of the COP21 agreement in December 2015, with targets on increasing the share of 'non-fossil-fuel' electric installed capacity to 40 per cent, and reducing the emissions intensity of GDP by 33-35 per cent over 2005 levels, by 2030;
- a domestic non-binding target to increase the share of renewable installed electric power capacity to 175 Gigawatts (GW) from roughly 57 GW[3] at present;
- the expectation that no new coal power plants would be needed, beyond those already under construction, until at least 2027; the retirement of plants over 25 years old (comprising around 20 per cent of the fleet) with some fleet replacement; and,

[1] See Sen (2015).
[2] See GoI (2016a).
[3] CEA (2017).

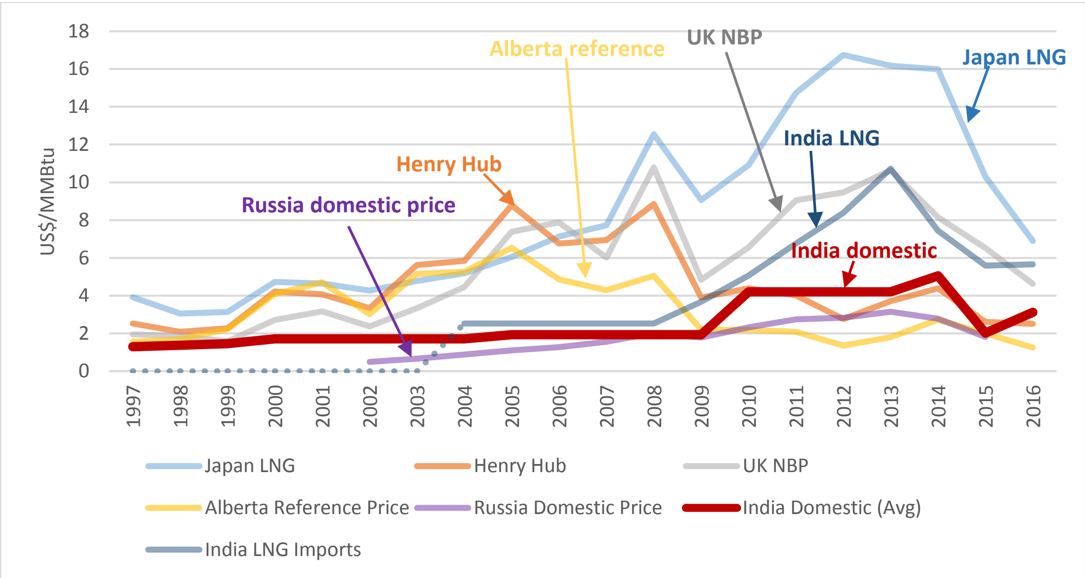
- an intensified awareness of the need to curb air pollution in Indian states and cities, visible in the transport and coal-based power generation sectors.

The immediate impression is that these factors further complicate, rather than clarify, the prospects for the future of gas in India's energy mix as they increase the number of variables that need to be considered to make any sort of informed assessment. This paper aims to disentangle these multiple determinants and present a broad yet informed future outlook for gas.[4] The next section reviews short term developments in the gas market, focusing on the period since 2015 (with references to historical data where appropriate) including the recent surge in LNG imports. Section 3 revisits the dynamics of gas demand in its main consuming sectors (power, fertilisers, city gas and industry). Section 4 sets out the longer-term determinants of gas demand in India, and Section 5 discusses three illustrative 'outlook' cases. Section 6 concludes.

2. Short-term Developments – a review of pricing, supply and demand

Historically, India's gas prices have been determined by the regulatory regime governing any producing field. There have been frequent revisions to the regime, which began with a cost-plus regime dominated by the NOCs until the early 1990s, followed by a regime which permitted private companies to participate with a 30 per cent carried interest for NOCs. This was then replaced with a liberalised profit-sharing upstream fiscal regime in 1998, followed by a revenue-sharing regime in 2016. This has resulted in a multiplicity of gas prices, as different producing fields operate under different regimes. However, following a major reform of gas pricing in October 2014, the price of domestically produced gas has been linked to a 12-month trailing, physical volume-weighted average of four international 'benchmark' prices: US Henry Hub, UK NBP, the Russian domestic gas price, and the Alberta reference price.[5] The formula is adjusted biannually, and previous regimes are expected to eventually converge to the new pricing regime, upon the expiry of existing contractual price clauses.

Figure 1: International Benchmarks and India's Domestic Gas Prices



Source(s): Platts (2016); BP (2016); PPAC (2017a); Alberta Energy (2017)

[4] This paper focuses on developments post-2015. For a historical perspective, please refer to Sen (2015).
[5] For a full exposition of the evolution of gas prices in India refer to Sen (2015).

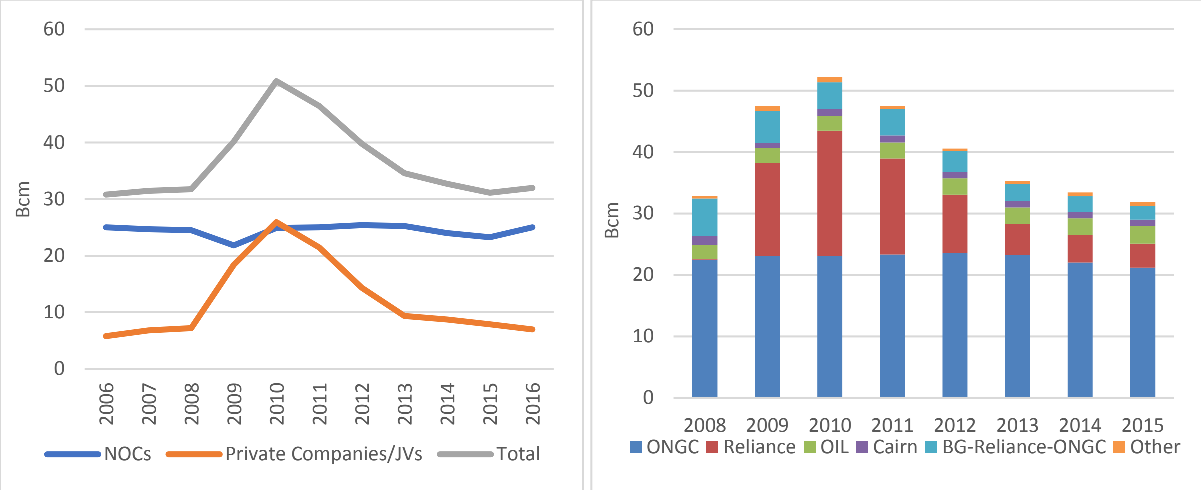
While the benchmarks chosen for the new formula yielded a low price for domestic gas, the implementation of the reform additionally coincided with the global price downturn. Consequently, from late 2014 the domestic gas price trended even lower, and is currently at US$2.48/MMBtu[6], close to the levels at which it was fixed during the era of 'administered' (controlled) pricing from around 1997 to 2009 (see Figure 1 above). Perhaps in recognition that the price was too low to incentivise any type of domestic production, in April 2016 the government announced a new gas price 'ceiling' for production from discoveries located in deep water, ultra-deep water, and high temperature, high pressure fields. This ceiling is linked to an average of: (a) the landed price of fuel oil, (b) weighted average landed import price of substitute fuels including coal, fuel oil and naphtha, and (c) the landed price of imported LNG.[7] The formula is adjusted biannually and is somewhat more representative of the fuels that gas is meant to be replacing in the domestic market. However, the price it yielded for the period October 2016 to March 2017 was US$5.56/MMBtu, as against a minimum price of US$8/MMBtu estimated to be required to incentivise substantial new volumes of domestic production.[8] The price ceiling is one of the centrepieces of India's OAL policy, which promises gas producers 'marketing freedom' and under which a round of bidding is expected to commence in July.[9]

The pricing reform has failed to produce a revival in gas production. Barring a brief spike in 2009/10 driven by the eastern offshore 'KG-D6' field operated by private company Reliance Industries Limited, which subsequently ran into problems and thereafter went into decline[10], production has continued to languish. NOC[11] production has remained flat during the 2000s, averaging just over 20 Billion Cubic metres (Bcm) during 2006-16, with a marginal increase during 2014-16. Although 65 per cent of licensed acreage and 56 per cent of proven reserves (1.4 Tcm[12]) continue to be held by NOCs, at their current average costs of production[13] relative to low domestic gas prices, they have been unable to boost domestic supply. Figure 2 shows the extent of stagnation in the upstream gas sector since the 2010 'peak', driven primarily by a drop of over 70 per cent in production from the private sector.

Given the decline in domestic production, the incremental source of gas - Liquefied Natural gas (LNG) imports – has experienced substantial growth, continuing to climb since 2004, when India imported its first cargoes. As seen in Figure 3, LNG imports surged upwards between 2014-16, growing by 70 per cent (from around 13.9 Mtpa to 24.6 Mtpa[14]) – with imports in 2016 more than double their 2010 level.

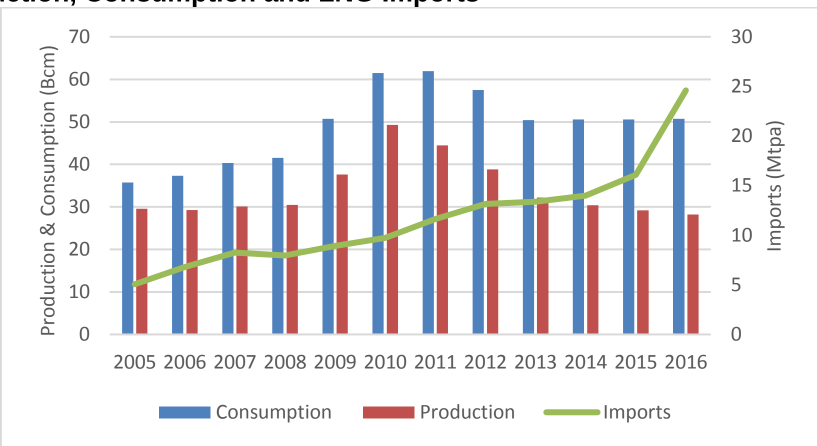
[6] Based on Gross Calorific Value.
[7] For sources of data used in the formula see http://ppac.org.in/content/155_1_GasPrices.aspx .
[8] Estimated in an IHS study carried out for the Indian government. See Sen (2015).
[9] See Sen (2016) for a short review.
[10] See Sen (2015) and Jain (2012) for details.
[11] National Oil Companies.
[12] Trillion cubic metres.
[13] US$3.63/MMBtu for Oil and Natural Gas Corporation (ONGC) and US$3.21 for Oil India Limited (OIL) (Sen, 2015; Sen, 2016). ONGC's reserve replacement ratio fell from 1.08 in 2012 to 0.70 in 2014 (1P). (GoI, 2016b).
[14] Million tonnes per annum.

Figure 2: Sector-wise and Company-wise Gas Production in India



Source: PPAC (2017b); DGH (2015)

Figure 3: Production, Consumption and LNG Imports



Source: BP (2016); PPAC (2017b)

India was importing around 27 per cent of its gas consumption in March 2014; by September 2015 this had risen to a three-year (2014-17) peak of 50 percent, dropping marginally to 47 per cent by February 2017. An important feature of this upsurge was a change in the composition of imports: in 2010, the percentages of spot/short-term contracted to long-term contracted imports were around 18 per cent and 82 per cent respectively, but by 2014 these had changed to 46 and 54 per cent, revealing a strong preference for flexible supply.[15] India also chose not to offtake around a third of its long-term contracted supply from RasGas Qatar, successfully renegotiating its contract in July 2015 which reportedly resulted in a halving of the contracted price from US$13.57/MMBtu in 2014 to US$5.89/MMBtu by the first quarter (Q1) of 2016, plus a waiver of a US$1.5 Bn take or pay penalty.[16] Subsequently, RasGas, whose market share dropped from around 88 per cent in 2013 to 66 per cent in 2015, was able to regain a portion of this by Q1 2016.[17] The renegotiation led the Indian oil and gas

[15] EIA (2016).
[16] MEES (2016).
[17] Qatari gas has a comparative advantage in this regard. It takes three days to transport cargoes from Qatar to India, versus two weeks from Europe (Hellenic Shipping News, 2016).

authorities to direct state-owned/promoted LNG buyers (such as GAIL[18] and Petronet LNG) to seek better terms on other long-term contracts.[19]

Before looking at which sectors absorbed the incremental LNG imports vis-à-vis domestic gas, it is useful to revisit the two-tiered structure of gas demand described in Sen (2015). Gas that is produced domestically is rationed by the government according to a 'Gas Utilisation Policy' in order of priority to two tiers of consumers. The first tier comprises, in order of priority:

- city gas for households (Piped Natural Gas - PNG) and transport (Compressed Natural Gas – CNG);
- fertiliser manufacturing plants using gas as an input;
- LPG plants using gas as an input; and
- gas-based power plants that supply gas to grid-connected power distribution utilities.

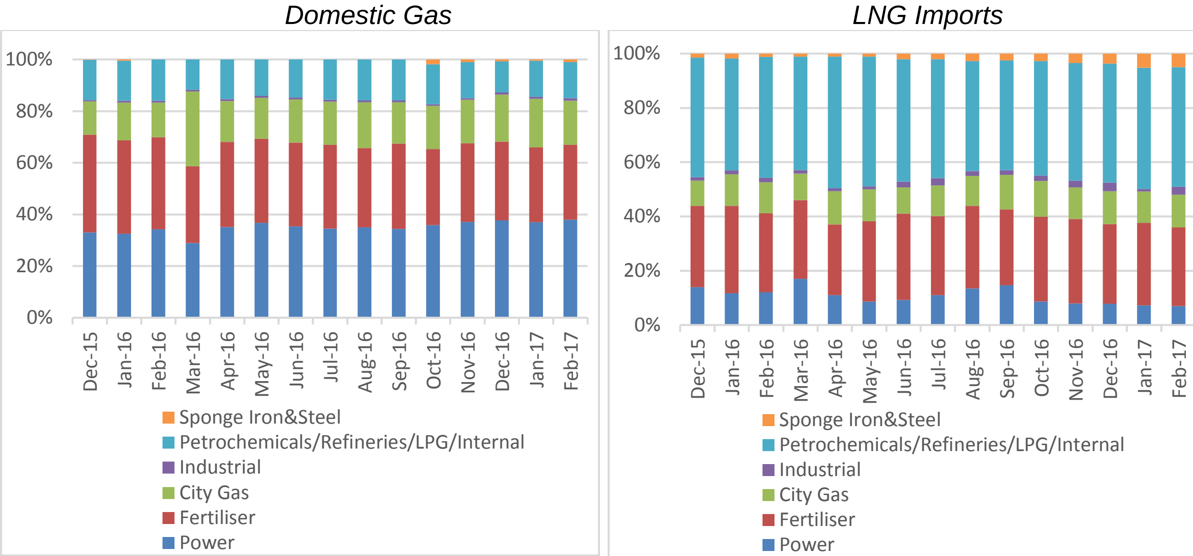
The priority order for tier-1 consumers has remained largely unchanged over the last decade, apart from one major adjustment in July 2015, when city gas was moved to the top of the tier from the bottom, displacing fertilisers. All domestic gas left over is then released into a more general second tier of consumers, which includes:

- steel, refineries and petrochemical plants;
- city gas for industrial and commercial consumers;
- captive and merchant power plants; and
- other consumers, feedstock and fuel.

In 2014, tier-1 consumers accounted for close to 90 per cent of domestic gas consumed, and just over 50 per cent of LNG imports consumed, whereas tier-2 consumers accounted for around 10 per cent of domestic gas and just over 40 per cent of LNG imports consumed.[20] The LNG import 'upsurge' in recent months has in contrast been driven predominantly by the main tier-2 consumers. As seen in Figure 4, the industrial sectors (petrochemicals, refineries, LPG shrinkage, iron and steel, and other industry) accounted for 45 per cent of LNG consumed between December 2015 and February 2017.[21] This was followed by the fertiliser sector, which consumed roughly 30 per cent of imported LNG. The city gas sector consumed a relatively low amount – 12 per cent of imported LNG – over this period, but had the fastest growth in imported LNG consumption, which increased by 30 per cent.[22]

[18] Gas Authority of India Limited.
[19] Chakraborty and Sundria (2016). No outcomes had been reported at the time of writing.
[20] Sen (2015).
[21] These are the months for which reasonably reliable data is available.
[22] In comparison, industrial consumption of imported LNG grew by 15 per cent and fertilisers by 7 per cent.

Figure 4: Sector-wise Consumption of Gas, December 2015 – February 2017



Source: PPAC Monthly Gas Reports (2015-17)

Consumption of LNG imports by the power sector fluctuated over the same period, rising from roughly 14 per cent of imports in December 2015 to 17 per cent by March 2016, but declining to 7 per cent by March 2017. This fluctuation was in large part due to the introduction of a temporary subsidy to gas-based power generators in January 2015 to make gas competitive with alternate fuels (primarily coal) in the electricity sector. The subsidy – which was financed through a combination of federal funding, state government exemptions on local taxes on imported LNG, and reduced transportation tariffs and margins for GAIL – was provided on a power tariff of up to Rupees (₹) 4.70/ Kilowatt-hours (kWh), and was aimed at reviving around 18 Gigawatts (GW) (out of 24 GW) of idle gas-fired power capacity in an attempt to reduce India's chronic electricity supply shortages at the time.[23] This lifted short-term power demand, but the government did not renew the subsidy in its February 2017 Federal Budget. This may have been partly due to the reported reluctance of some entities to continue offering tax exemptions. This may have contributed to the downturn in power sector consumption of LNG imports.[24]

Despite the difficulties with assessing both demand and supply, national and multilateral agencies have attempted some broad projections on the anticipated outlook for gas in the Indian market. Figures 5 and 6 below assemble three prominent projections: the World Economic Outlook New Policies Scenario (IEA, 2016) published by the International Energy Agency (IEA), International Energy Outlook (EIA, 2016) published by the US Energy Information Administration, and a forecast published by India's downstream gas regulator, the Petroleum and Natural Gas Regulatory Board–(PNGRB) which adjusts projections from India's (erstwhile) 12th Five Year Plan downwards to reflect a 'realistic' long-term scenario for gas demand and supply.[25]

[23] See GoI (2015a).
[24] Hellenic Shipping News (2017).
[25] India Vision 2030 'Realistic'- this scenario originally extended only to 2030 but projections to 2040 were extrapolated using a Compound Average Growth Rate. Readers are directed to original sources for detailed assumptions. The five year plans have been retired, but have yet to be replaced with an alternative outlook.

Figure 5: Supply Projections

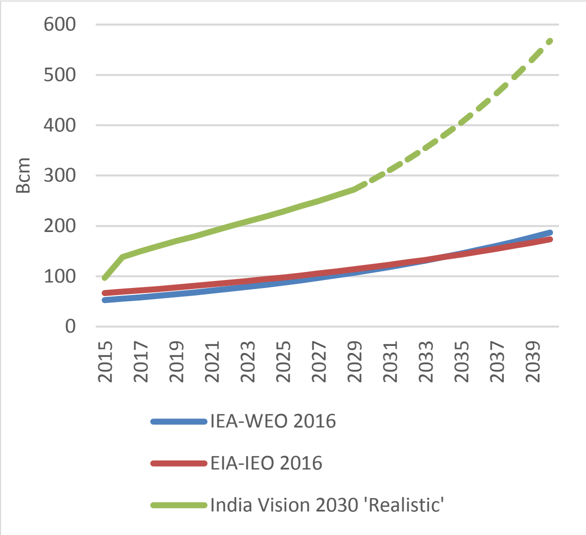
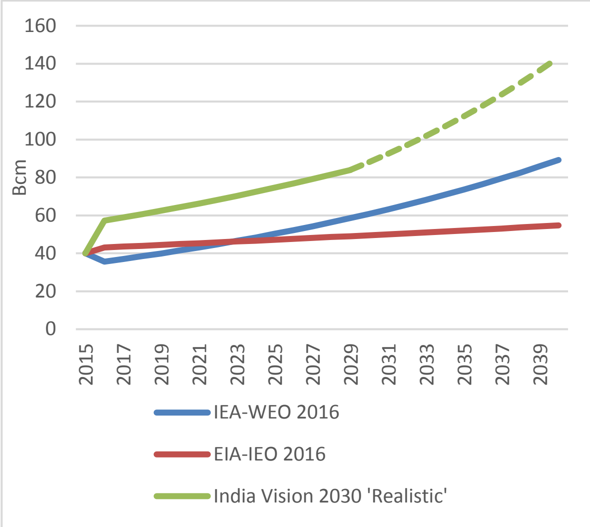


Figure 6: Demand Projections



Source: IEA (2016); EIA (2016); PNGRB (2013)

Two observations can be made from the above: first, the PNRGB projection is far more optimistic than those by the multilateral agencies – this holds true for previous government forecasts.[26] Second, the divergence between multilateral agency forecasts is much less for supply projections (174-180 Bcm by 2040) than demand projections (55-90 Bcm by 2040) – the latter being largely due to the complexities of assessing the two overlapping markets, as described in the introduction. Nevertheless, recent history suggests that conservative forecasts tend to be more accurate than over-optimistic forecasts. In late 2016, the Indian Ministry of Petroleum and Natural Gas released a statement on “shifting India to a gas-based economy”[27], and although no official target has been set, a goal of doubling the share of gas in the energy mix, from 6.5 to 15 per cent has been referred to by senior oil ministry officials. The timeframe for this is, however, unclear. It appears that even a medium term timeframe would be challenging – for instance, a study by Crisil Research[28] estimates that a target year of 2020 would require gas consumption to double to over 100 Bcm. As domestic production is unlikely to rise to meet this, it would have to be met through LNG imports (which would need to rise to 65 Bcm), which in turn would require regasification capacity to triple to 60 Mtpa from 25 Mtpa at present. Furthermore, the IEA (2016) predicts that the share of gas in primary energy demand will remain below 10 per cent well into the 2030s. Ultimately, in order to make any assessment of the future of gas in India’s energy mix, it is useful to understand the underpinning dynamics of gas demand in the main consuming sectors.

3. Revisiting the dynamics of sector demand

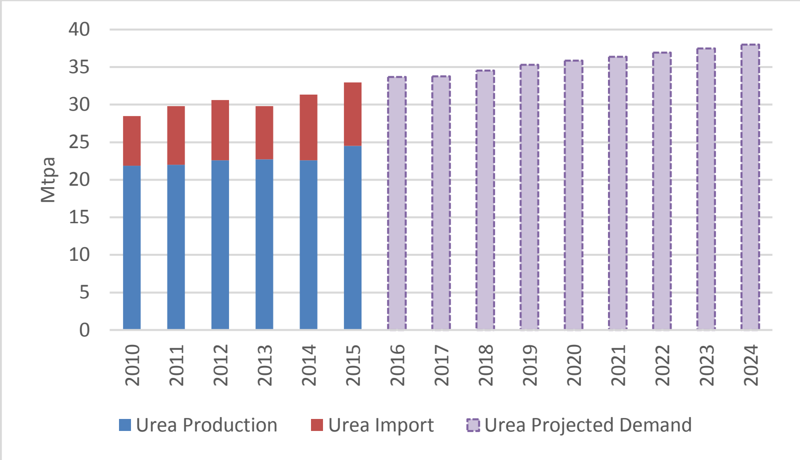
Gas consumption in India is broadly driven by four sectors: fertilisers (in which manufacturing and retail prices are regulated), power (in which end-user prices are regulated), city gas (in which prices are deregulated) and other industry, which comprises refineries, petrochemicals, iron and steel, and merchant/commercial consumers of gas (in which prices are deregulated). The economics of gas demand is driven by a combination of government policy and competitiveness with the price of gas substitutes.

[26] This is because government forecasts are typically carried out with a ‘planner’s perspective’. See Jain (2012).
[27] GoI (2016b).
[28] Business Standard (2016).

3.1 The Fertilisers Sector

Consumption of gas in fertilisers is driven by the consumption of urea (used in agriculture), which accounts for the largest proportion (around 64 per cent) of fertiliser products produced in the country. Around 90 per cent of urea manufacturing capacity is gas-based, with the remaining 10 per cent based on naphtha. There has been a push to convert all urea manufacturing capacity to gas, partly to reduce India's dependence on oil and oil product (naphtha) imports.[29] India consumes roughly 33 Mtpa of urea (2015 estimate), of which 25 Mtpa is domestically produced (using gas or naphtha) and 8 Mtpa is imported.[30]

Figure 7: Production, Imports & Projected Demand for Fertiliser



Source: Indian Fertiliser Scenario (2015); PIB (2015); Author's estimates

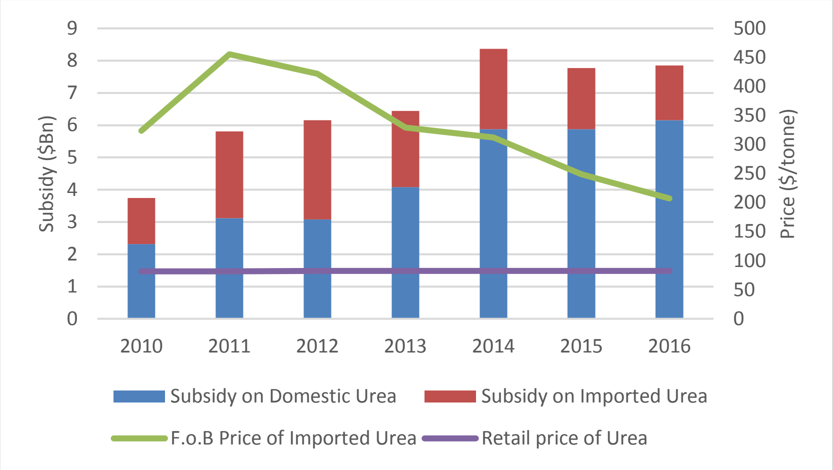
As seen from Figure 7, roughly a quarter of urea consumption has been met through urea imports since 2010. Urea consumption is expected to reach 38 Mtpa by 2024.[31] The retail price of urea (along with other fertiliser products) has long been subsidised (at nearly 50 per cent) to the farmer – an important electoral base for all Indian governments[32] – making this sector relatively price inelastic. The fertiliser subsidy bill (which at roughly US$8 Bn is India's second largest subsidy bill after food) is mainly driven by the differential between the prices of domestic gas, imported LNG, and imported urea, with government policy usually favouring the cheapest option which is generally domestic gas.[33]

In January 2015, in order to boost urea production and reduce dependence on urea imports, a 'gas price pooling' scheme was created, whereby urea manufacturing plants communicate their gas requirements to a pool operator, which sources any imported LNG that is needed to meet incremental demand for gas in the sector.[34] The imported LNG is pooled with domestic gas and sold to manufacturing plants at an average uniform price. As seen in Figure 8 below, this scheme was successful in reducing the urea subsidy bill – which had been climbing since 2010[35] – by 7 per cent between 2015 and 2014, and stabilising it in 2016. It also increased urea production in 2015 (as seen earlier, in Figure 7). The scheme has been partly responsible for the high share of LNG imports

[29] India's current administration aims to reduce oil and gas imports by 10 per cent by 2022. See PIB (2016b).
[30] Roughly 2 Mtpa of imports are based on cheaper long-term contracts from Oman, which run until 2020.
[31] PIB (2015). Demand projections for 2019-2024 are based on simple linear extrapolation by the author.
[32] Over 50 per cent of the population are engaged in agriculture, which comprises 17.5 per cent of India's GDP.
[33] Jain (2012). Up to January 2015, incremental demand was primarily supplied through urea imports.
[34] PIB (2015).
[35] The drop in domestic gas production from its 2010 peak contributed to the higher subsidy bill.

consumed in the fertiliser sector over the past 18 months. Figure 8 also shows the difference between the prices of imported urea and the retail price of urea to farmers, indicating the amount of subsidy.

Figure 8: Subsidy to Fertiliser (LHS) & Retail Price of Fertiliser (RHS)



Source: Indian Fertiliser Scenario (2015); Sahu (2016)

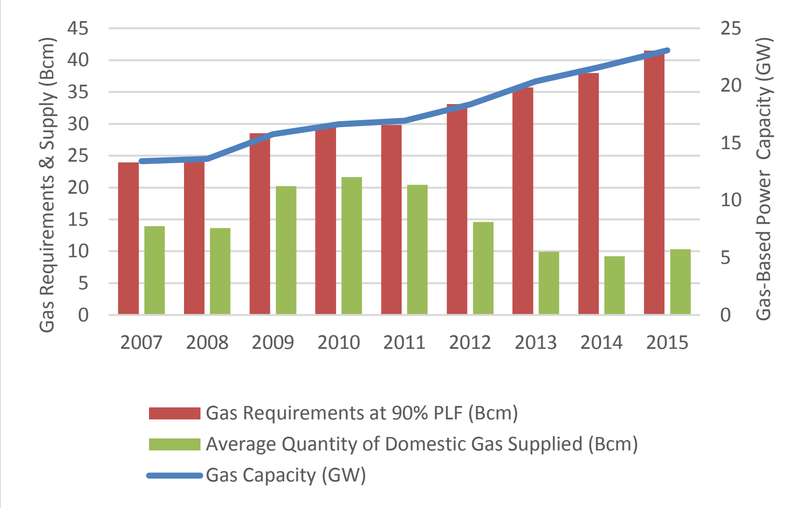
Despite a decline in international urea prices, in May 2015 the government announced its intention to reduce urea imports (and later, to end them by 2022)[36] through improving the efficiency of existing plants and reviving old units (equivalent to additional urea manufacturing capacity of 2.6 Mtpa).[37] Rather than removing the subsidy altogether – which would be politically difficult if not impossible – the government's chosen policy has been rather to streamline the manufacturing and procurement of feedstock, and also to plug leakages in the subsidy mechanism using direct cash transfers to bank accounts of eligible recipients, including fertiliser marketing companies, and eventually, farmers.[38] Based on a broad extrapolation of official demand projections, India may need an additional 5 Mtpa of urea by 2024 (Figure 7). These dynamics, and the fact that there is no long-term substitute to gas in this sector, imply that that the use of gas will continue to increase in India's fertiliser sector, and that, at least in the short-term, there will continue to be a significant role for imported LNG. We return to this in Section 4.

3.2 The Power Sector

Gas forms roughly 8 per cent of India's total installed power capacity (25 GW out of 329 GW). Out of the 23 GW officially monitored by the power ministry[39], around 20 GW is connected to the gas grid/main gas pipelines and 3 GW is connected with isolated gas fields. Of the grid-connected capacity, 34 per cent is meant to be supplied with gas allocated from the 'KG-D6' block (discussed in Section 2) and 40 per cent with gas allocated from the NOCs' legacy fields (both as part of tier-1 consumption). Thus, 5.27 GW of capacity stands without any specific domestic gas allocation. An additional 3.89 GW can reportedly be commissioned in the short-term, if the supply of gas is made available.[40]

[36] See Livemint (2017).
[37] PIB (2016c).
[38] This is based on a major social security reform called 'Aadhaar' which requires all citizens to have a Unique Identification Number' based on their biometric data. It has been estimated that this could result in savings of US$0.77-1.08 Bn on subsidies. See TOI (2017).
[39] No details were available on the remaining 2 GW (NEP, 2016).
[40] NEP (2016).

Figure 9: Gas Based Power Capacity & Gas Supply to Power Sector



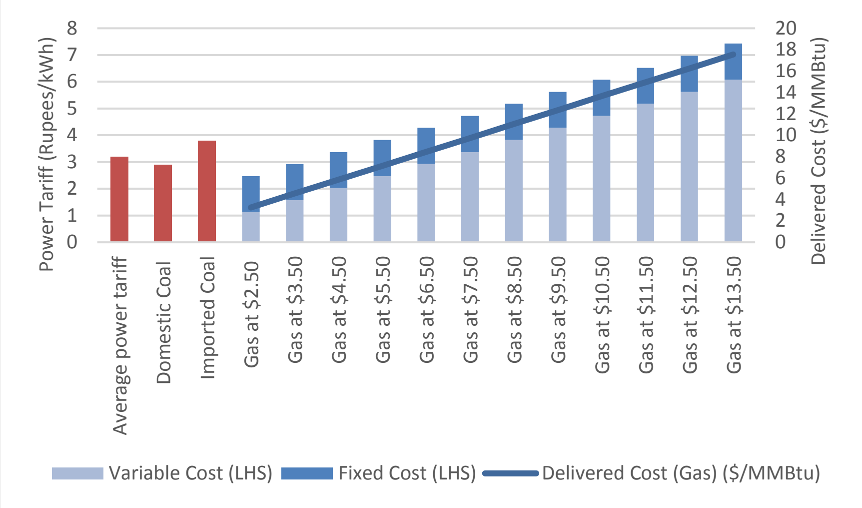
Source: NEP (2016)

As Figure 9 above shows, despite the increase in gas-fired power capacity over the last 10 years, the amount of domestic gas supplied to power has fallen sharply since 2010, leading to a considerable amount of stranded capacity (estimated at around 14 GW in 2017).[41] This has been accompanied by a drop in the average Plant Load Factors (PLF) of gas-based power plants, down from 55 per cent in 2007, to 23 per cent in 2015. Power generators have been unable to resort to imported LNG to make up the deficit for two reasons: firstly, gas cannot compete with low-priced domestic coal in power generation, given the system of merit-order dispatch whereby the cheapest electricity is dispatched first. This is particularly the case given the absence of an explicit disincentive to coal use, such as a carbon tax set to high enough levels.[42] Secondly, electricity tariffs to end-users are regulated by state governments who have autonomy over electricity policy. Consequently, end-user tariffs have been on average 20 per cent below the cost of supply in many states, making any pass-through of higher priced LNG imports difficult.[43] In the past, any power shortages have been bridged by consumers themselves mainly through the use of cheap decentralised diesel-fired generator sets, rather than imported gas. India has however managed to reduce its overall electricity deficit (albeit not its peak deficit) dramatically from double digits in 2009 to around 1 per cent by April 2017, through a concerted effort to streamline coal supply chains and boost domestic coal production in the past two years.[44]

The heterogeneity of electricity sector structure and regulation precludes a straightforward assessment of the potential for gas in power. However, Figure 10 below updates a broad comparison that was originally provided in Sen (2015).[45] Figure 10 – which is meant to be illustrative rather than definitive – reflects the poor competitiveness of gas with coal at delivered prices above US$4.55/MMBtu. Although this cannot be applied generally across the entire Indian power sector for reasons mentioned above, it is in line with the Indian Power Minister's recent estimate of US$5/MMBtu as a 'viable proposition' for gas in the power sector.[46]

[41] See HT (2017).
[42] As discussed later in Section 4, the current tax on coal production is insufficient to incentivise switching.
[43] CEA (2017).
[44] See Singh (2017).
[45] The average selling price of power has been estimated at around ₹3.2/kWh, and the fixed cost at ₹1.35/kWh. This corresponds to a capital cost of ₹35-45 Million/MW for a gas-based power station (ICRA, 2014; CRISIL, 2010). Jain (2011, p.44) estimates that this fixed cost is for a medium sized power plant. Every US$1/MMBtu increase in gas prices leads to an increase of US$1.3/MMBtu in the delivered price of gas to power, and an increase of roughly ₹0.45/kWh in the variable cost (GoI, 2013a).
[46] See Singh (2016).

Figure 10: Competitiveness of Gas with Coal in Power Generation



Source: Author's estimates

The 60 per cent increase in the cost of imported coal during 2016 is, however, likely to push up the cost of power for plants which rely on imported coal supplies. This in turn puts pressure on those producers who have entered into long-term contracts with power distribution companies for coal-fired power supplies which do not allow for a pass-through of escalated fuel costs.[47] The temporary pooling of domestic gas with LNG imports marginally improved the PLF of gas-based power plants, which rose from 18 per cent in January 2015 to 23 per cent in October 2016, as it allowed gas to be supplied at competitive prices to the power sector. However, both the ending of the scheme and an uptick in global LNG prices have made gas unviable in the power sector yet again. The above dynamics suggest that gas has a limited role in the power sector unless its comparative advantage as an environmentally 'cleaner' fuel relative to coal is explicitly taken into account, either through the provision of a subsidy to gas-fired power, or through the imposition of an equivalent tax on coal-fired power.

3.3 The City Gas Sector

As discussed in Section 2, city gas demand is split between tier-1 (households and transport) and tier-2 (commercial and industrial) demand. Tier-1 consumers utilise primarily domestic gas but also some LNG imports, whereas tier-2 consumers utilise domestic gas left over from tier-1 demand, plus LNG imports. City gas is a relatively new and expanding sector, primarily limited to urban areas. It established its market share primarily through the enforcement of environmental legislation in the early 2000s to curb air pollution in city-wide transportation systems, following which it is being gradually adopted as a 'cleaner' alternative to conventional household cooking fuels. CNG is now prevalent in around 11 (out of 29) Indian states, with many cities mandating its use in public transport (taxis, auto-rickshaws and buses). Sales of CNG in 2015 grew by 5.8 per cent over 2014.[48] The competitiveness of CNG and PNG in the Indian transport and household cooking sectors are illustrated in Figures 11 and 12, respectively.

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[47] See Sengupta (2016).

[48] The growth rate of CNG sales has generally been quite high, partly due to a low base. For instance the sales of the three largest city gas companies (Indraprastha Gas Limited (IGL), Mahanagar Gas Limited (MGL) and Gujarat Gas Company Limited (GGCL) grew at 9 per cent/year during 2008-11 (Sen, 2015).

Figure 11: Competitiveness of CNG

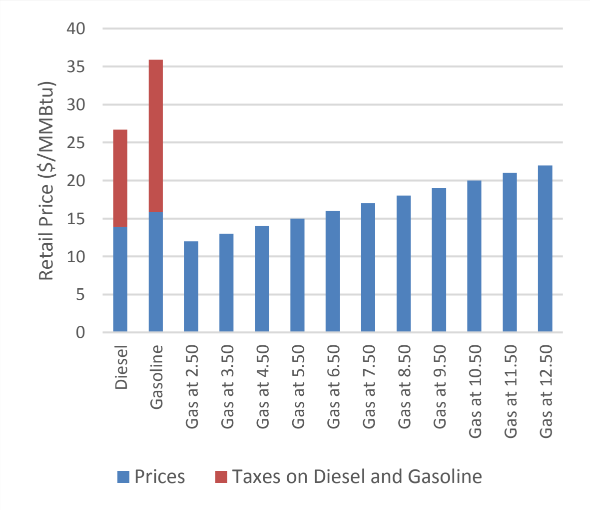
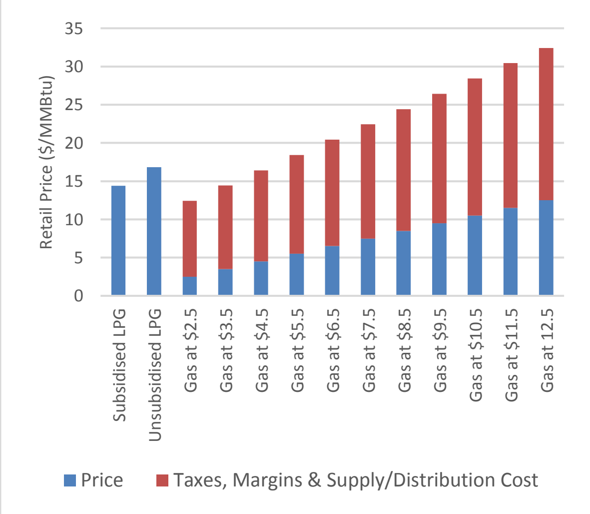


Figure 12: Competitiveness of PNG



Source: Sen (2015); MGL (2016); PPAC (2017); Author's estimates

Note: Break-up of CNG prices into costs, margins and taxes unavailable.

In the transport sector, CNG competes with diesel and gasoline (petrol), the prices of which have been deregulated and are adjusted fortnightly in track with international oil prices. As seen from Figure 11, taxes make up a large component of diesel and petrol prices, making CNG competitive with both even at higher gas prices.[49] Conversely, it means that substantial downward adjustments to taxes and further global oil price declines could worsen the competitiveness of CNG. In the household sector, PNG competes mainly with subsidised liquefied petroleum gas (LPG) which is sold in 14.2 kg cylinders to households and used for cooking. The LPG subsidy is limited to 12 cylinders per household each year, after which consumers pay commercial rates. Unsubsidised LPG (for commercial users) is also sold, at market prices. The estimates in Figure 12 are based on prices and taxes in Maharashtra[50], but they differ across states. Both figures suggest that city gas can bear higher prices and remain competitive with the main substitutes. The absence of price controls on city gas distribution entities suggests that higher prices could if necessary be passed through.

There are around 18 CNG distribution entities operating across various states. Growth in this sector is severely constrained by infrastructure – there are roughly 3 million CNG vehicles[51] but only 1,167 CNG filling stations, leaving just one filling station for every 2,438 vehicles.[52] CNG infrastructure is also disproportionately skewed towards three states: the National Capital Territory of Delhi (418 stations), Gujarat (317 stations), and Maharashtra (230 stations).[53] The same companies operate in the PNG segment across the same states, and there are plans to develop one hundred 'smart cities' through the expansion of city gas infrastructure to semi-urban areas.[54] There are 3.35 million PNG connections (consumers)[55], of which 99 per cent represent the household/residential segment, with the remainder being industrial and commercial consumers. The infrastructure constraint is partly

[49] The breakup of CNG prices into costs, margins and taxes was unavailable and the graph shows the retail price of CNG in Delhi, measured in US$/MMBtu at different domestic gas prices. The graph utilises assumptions on CNG costs from Sen (2015, p.49). It should be noted that India levies a multitude of taxes on products, including varying state taxes and federal taxes. India is due to implement a 'Goods and Services Tax' reform in July 2017.

[50] The price breakup (into costs and taxes) was obtained from MGL (2016).

[51] This represents roughly 1.7 per cent of the fleet of two wheelers, cars, jeeps and buses (181 million); and 12.4 per cent of the fleet of cars and buses (24 million).

[52] Data from PPAC (2016a).

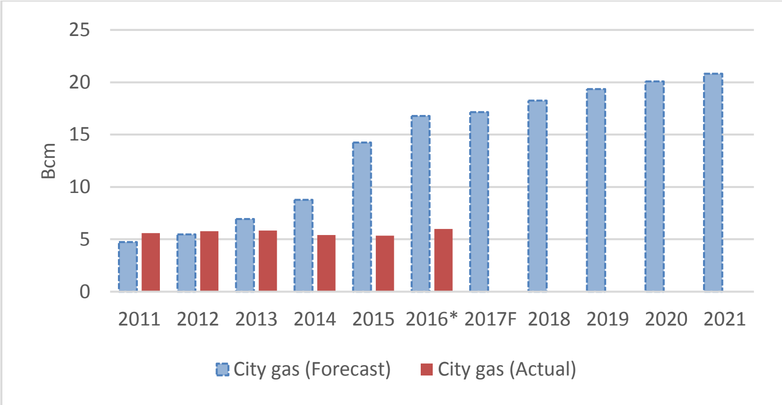
[53] PPAC (2016a).

[54] We return to infrastructure in Section 4.

[55] PPAC (2016c). As disaggregated data is unavailable we assume that every connection represents one household.

illustrated by the difference between forecast and actual gas consumption in this sector, as seen in Figure 13. In 2015 and 2016, for instance, only around a third of forecasted consumption was realised.[56] Given the above dynamics, it can be stated with a reasonable degree of confidence that gas consumption (both domestic and imported LNG) will continue to grow in the city gas sector; at the same time this growth will be strongly beholden to the speed at which city gas distribution infrastructure is extended to new consumers, which has historically been slow.

Figure 13: Forecast and Actual Gas Consumption in City Gas Sector



Source: India Energy (2017); WG (2011) *Apr-Sept

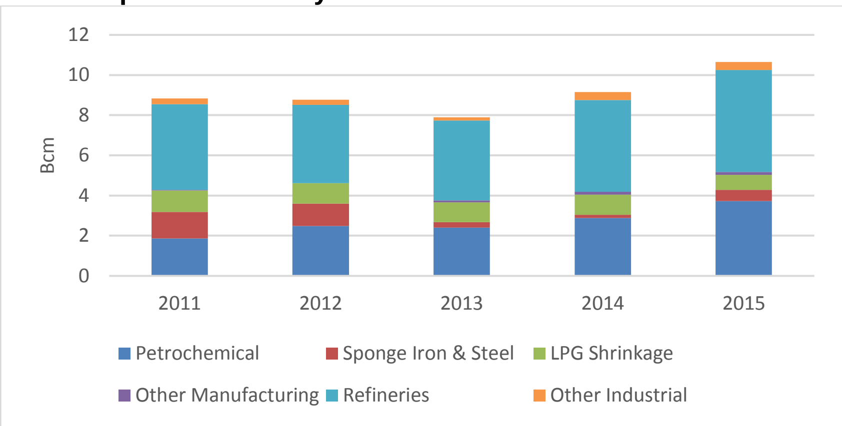
3.4 Industry

The industry sector (which in the discussion in this sub-section excludes fertilisers) accounted for around 22 per cent of gas consumption in 2015 (up from 15 per cent in 2011). It is difficult to accurately disaggregate the drivers of gas consumption in industry, but one can consider four discernible segments: petrochemicals, refineries, LPG shrinkage, and sponge iron and steel (Figure 14). Growth in the petrochemicals sector is driven by growing demand from the textile, automobile and food packaging industries (polypropylene and polyethylene), and the main competing fuels to gas in this sector are naphtha, domestic coal and imported ethane (some Indian companies such as GAIL and Reliance have recently preferred cheap ethane imports from the US).[57] In the refineries sector, with the fourth largest refining capacity in the world (4.62 mb/d)[58] and the second largest in Asia (next to China), India turned from net importer to net exporter of refined products in the early 2010s. There are plans to more than double refining capacity into the next decade. Strong domestic demand for gasoline, diesel and LPG (with oil demand growth doubling from a 10 year average of 150 kb/d[59] per annum over 2003-13, to 300 kb/d from 2015 onwards)[60] has however led to a drop in exports, and larger amounts of refined products being diverted to the domestic market. Gasoline demand is being driven by a rise in vehicle ownership, and diesel demand mainly by industrial use.[61] Similarly, growth in LPG consumption is being driven by a programme to replace kerosene used for cooking in rural and semi-urban households with LPG cylinders, and an increase in the number of LPG consumers by 42 per cent is targeted from current levels (around 190 million) by 2020. Gas competes with naphtha, fuel oil and coal in the refining sector, and until the recent downturn in oil prices, this sector absorbed high-priced LNG imports as these were still cheaper when compared with higher priced fuel oil and naphtha. Gas consumption in the sponge iron and steel sector has fallen, partly due to the global overcapacity in steel, despite the fact that India was the only country amongst the world's top ten steel

[56] As noted in Section 2, past government forecasts have tended to overestimate demand.
[57] See Wainberg et al (2017).
[58] Million barrels/day.
[59] Thousand barrels/day.
[60] This surge has taken place despite the deregulation of retail petroleum product prices. See Sen and Sen (2016).
[61] Sen and Sen (2016).

producers to report growth in steel production in 2015. Despite new capacity being brought online, many industry observers are of the view that future growth of gas consumption in the sponge iron and steel sector may be muted, as the increasing use of blast furnaces for steelmaking no longer necessitates sponge iron as an input.[62]

Figure 14: Gas Consumption in Industry



Source: India Energy (2017)

The underpinning driver for gas consumption in industry is a target to expand the share of manufacturing from 15 per cent of GDP to 25 per cent, by the year 2022. This is primarily motivated by concerns over employment, given the country's large working-age demographic (60 per cent of the population). India's manufacturing sector currently comprises roughly 11 per cent of total employment, in contrast with other emerging markets where the share of manufacturing employment ranges from 15 to 30 per cent, and the 'Make in India' programme aims to generate 100 million additional manufacturing jobs by 2022. In order to do so, it has been estimated that India's manufacturing sector as a whole will need to grow at a rate that is 2 to 4 percentage points higher than GDP growth, a pattern that is visible in most other emerging market economies, where manufacturing sector growth has equaled or exceeded GDP growth. In contrast, India's manufacturing sector has historically generally grown at a rate below that of its GDP.

The push towards manufacturing through 'Make in India' aims at raising the manufacturing growth rate to 12–14 per cent by 2025. It appears to be targeted at replicating China's success: China's manufacturing sector currently comprises 30 per cent of GDP, and its manufacturing output as a percentage of world output has risen from below 5 per cent in 1970 to roughly 19 per cent in 2010. Export-oriented manufacturing has formed an important part of China's economic boom; its merchandise exports rose from a figure of 2 per cent of world merchandise exports in 1990, to 12 per cent in 2014. In contrast, India's share of world merchandise exports rose from less than 1 per cent to under 2 per cent during the same period. 'Make in India' is targeted towards specific segments of manufacturing industry: employment-intensive industries, capital goods industries, strategically important industries (the development of 'national capabilities'), industries where India is seen as already having a competitive advantage (through existing indigenous expertise and cost effective manufacturing), Small and Medium Enterprises (SMEs), and public sector enterprises. Table 1 below details the estimated growth rates deemed necessary within specific sub-sectors of manufacturing in order to achieve these manufacturing targets. This is based on a target annual average growth rate of 12 per cent for the manufacturing sector as a whole during the (erstwhile) Twelfth Five-Year Plan (2012–17) and until 2025. Thus, gas demand in the industry sector will be driven primarily by government policy in the short-term.

[62] Wainberg et al (2017).

Table 1: Sectors Targeted in India's Push to Expand Manufacturing

		% of Manufacturing GDP	*Existing CAGR*[63]	*Target CAGR*[64]
1	Food products & beverages	8.7	7.3	8.8
2	Tobacco products	1.7	4.7	4.7
3	Textiles	9.2	3.8	11.5
4	Wearing apparel	3.9	7.3	11.5
5	Leather products and others	1.3	4.6	24.0
6	Wood and others	2.2	12.0	12.0
7	Paper, publishing, and others	2.7	5.8	8.7
8	Coke, petroleum products, nuclear fuel, rubber, and plastics	10.6	7.5	10.7
9	Chemicals and chemical products	12.2	9.0	12.0
10	Other non-metallic mineral products	6.8	13.6	13.6
11	Basic metals	9.7	1.9	10.3
12	Machinery and equipment	11.1	8.1	16.8
13	Electrical machinery and apparatus, telecoms, and others	6.0	12.8	12.8
14	Motor vehicles and other transport equipment	7.7	6.0	13.0
15	Furniture and other manufacturing	6.3	6.3	6.3

Source: Sen and Sen (2016)

4. Long-term determinants of the future of gas in India's energy mix

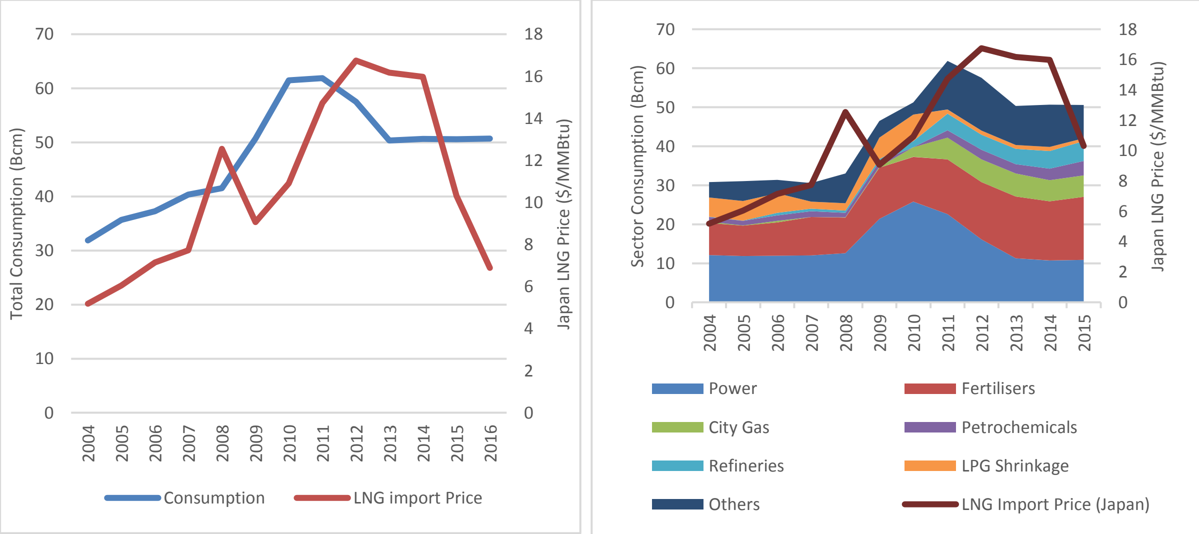
While the discussion above sets out the economics of demand in India's main gas consuming sectors, this section identifies longer-term factors that are likely to influence the aforementioned economics, thereby shaping the broader outlook for gas demand. There are *four* main factors: the level and direction of globally traded gas prices, India's commitments to the UNFCCC 21st Conference of the Parties in 2015 (the Paris climate agreement, or 'COP21'), the future of coal (the main competing fuel to gas) in India's energy mix and associated air pollution issues, and the outlook for gas infrastructure in India.

4.1 Global Gas Prices

As Rogers (2017a) points out, given the less than firm commitment to the growth of gas in many Asian countries' energy policies, future LNG price levels will be an important determinant of gas demand. This also holds true for India. Rogers (2017a) also posits a growth in global LNG supplies from 2017-2020, as major projects begin to gain access to the globally traded gas market. This could potentially keep LNG import prices depressed for a period of time depending on how quickly the market rebalances – and rebalancing is likely to be largely determined by the dynamics of gas demand in Asia. As Figure 15 shows, changes in gas consumption in India have tended to lag changes in gas prices – this is seen in the graph on the left.[65] The graph on the right in Figure 15 shows a sectoral breakdown of changes in gas consumption alongside changes in the LNG import price.[66] The figures show an inverse relationship between LNG import prices and India's gas consumption – with a clear cessation in falling gas consumption, as well as a slight uptick, in response to the post-2014 plunge in prices, although the full effect of the latter (including the 2016 upsurge discussed in Section 2) is not clearly discernible due to the lag.

[63] Compound Annual Growth Rate during Eleventh Five-Year Plan (2007–12).
[64] Compound Annual Growth Rate to 2025.
[65] As domestic gas prices have remained at low, controlled levels, the figure focuses on the price of the incremental source of gas supply, namely Asian LNG imports.
[66] It should be noted that the 'hump' in consumption in 2010 was primarily driven by a surge in domestic gas production rather than low LNG import prices.

Figure 15: Changes in Gas Consumption (Total & Sectoral) to Changes in LNG Import Prices



Source: Indian PNG Statistics (2011; 2015); BP (2016)

Should gas prices remain low in the medium to long-term, it is reasonable to expect that gas consumption in key Indian economic sectors will continue to rise, particularly in fertilisers where over 90 per cent of feedstock is gas-based, and possibly in city gas (albeit subject to infrastructure). However price formation mechanisms as well as price levels will be critical to the outcome. If imports continue to be primarily based on oil-linked contracts, low gas prices would presumably lag low oil prices – and given that oil products are key competitors to gas in several industry sectors such as petrochemicals and refineries (as discussed in Section 3 above) – this will limit the potential for gas to grow across the Indian economy, even at low LNG import prices. The recent equalisation (to nearly 50:50) in the proportions of short-term/spot to long-term contracted LNG imported into India (discussed in Section 2) from around 20:80 prior to 2014, indicates a preference for flexibility in supply terms among Indian LNG buyers, as does the recent domestic gas pricing reform which includes three hub-based price benchmarks in its formula. This implies that structural changes on the supply side of the global LNG market, such as the rise of LNG portfolio players who organise their sales strategies around contract length mix and price formation to better suit their buyers[67], will also play a key role in direct relation to global gas prices as a determinant of future gas demand in India.

4.2 India's COP21 and Renewables Commitments

India's main challenge in relation to climate change is best described in the *IEA World Energy Outlook 2015,* namely to 'demonstrate serious intent to reduce emissions, while still preserving sufficient headroom to allow for economic growth'. Although the principle underpinning India's position in climate change negotiations ('common but differentiated responsibility and respective capabilities'[68]) has remained unchanged, there has been a distinct policy shift towards a 'climate-as-development' narrative (as opposed to the historical 'climate-or-development' debate). India is currently pursuing one of the most ambitious renewable energy programmes in the developing world, albeit with a proviso that its renewable energy goals are contingent upon 'low-cost technological assistance from the developed world.'[69] The country has two sets of climate-related policy targets. The first set is

[67] See Rogers (2017b).
[68]Given the limited amount of 'carbon space' available before the safe temperature threshold is breached, developing countries should be allocated a 'fair and equitable' share of this to enable them to pursue critical development and poverty alleviation goals. See UNFCCC (1992).
[69] See INDC (2015).

enshrined within its Intended Nationally Determined Contribution (INDC) as part of the COP21 agreement and therefore constitutes a firm international commitment. This is:

- To reduce the emissions intensity of GDP by 33-35 per cent from 2005 levels by 2030;
- To achieve 40 per cent of cumulative electric installed capacity from *non-fossil fuel* sources by 2030 'with the help of technology transfer and low cost international finance; and
- To create an additional carbon sink of 2.5–3.0 billion tonnes of CO_2 equivalent by 2030.

Notably, the INDC contains no specific mention of natural gas as a mitigating option. The second set of targets reflects the Indian government's ambitious domestic policy targets. These include:

- A more than threefold increase in renewables installed capacity to 175 Gigawatts (GW) by 2022;
- Of this, 100 GW will be from solar, 60 GW from wind, and 15 GW from other sources; and
- A 10 per cent reduction in total energy consumption (from current levels) by 2018-19.

The first set of targets (INDC) are eminently achievable. India's emissions intensity of GDP (measured in kilograms of CO_2 per 2011 PPP$ of GDP) is estimated to have fallen by around 7.5 per cent from 2005 levels, while the INDC estimates that energy intensity has declined by a much higher 17 per cent.[70] It is likely to continue to decline as India expands its National Mission on Energy Efficiency[71] and one assessment puts the likely emissions intensity of GDP at 41.5 per cent below 2005 levels by 2030.[72] Non-fossil fuel sources (which include nuclear and hydro) already comprise around 30 per cent of India's overall installed capacity, the majority from hydroelectricity and from wind within ex-hydro renewables. The 2016 *IEA New Policies Scenario* for instance, predicts that non-fossil fuel capacity will reach 46 per cent of installed capacity in 2040. The INDC targets can therefore be seen as a continuation of the status quo, without considerable influence on the future of gas. The second set of targets - especially the 175 GW renewables domestic policy target[73] - could on the other hand be a significant determinant of a future role for gas, in terms of balancing intermittency as well as potentially 'bridging' the ensuing energy deficit if the target is not fully met. India currently has 17.4 per cent of installed capacity based on (non-hydro, non-nuclear) renewables; if the target was met, this could rise to 33 per cent of total installed capacity by 2022.[74]

Table 2: Capacity Addition Targets for Renewables, 2017-21

	Total Renewable Capacity as of March 2017 (GW)	Annual Capacity Addition Targets (GW)				
		2017	**2018**	**2019**	**2020**	**2021**
Solar	12.29	15	16	17	17.5	15.74
Wind	32.28	4.7	5.3	6	6.7	6.33
Biomass	8.31	0.75	0.85	0.95	1	1
Small Hydro	4.38	0.1	0.1	0.1	0.1	0.1
Total	57.26	20.55	22.25	24.05	25.3	23.18

Source: CEA (2017); NEP (2016)

70 WDI (2016).
71 See Jain (2015).
72 India Climate Action Tracker (2015).
73 This is being implemented in phased auctions under the Jawaharlal Nehru National Solar Mission. See http://www.mnre.gov.in/file-manager/UserFiles/mission_document_JNNSM.pdf
74 Based on assumptions in NEP (2016, 5.23).

The success of the renewables target will depend on adequate capacity addition, the ability to contract solar capacity at competitive tariffs, and the capacity of grid infrastructure and regulations to handle intermittent renewables. As shown in Table 2, in order to meet the target, roughly 20 GW of renewables capacity must be added each year until 2021, the majority from solar. There is a subtle distinction to be made between the tendering of solar capacity and capacity addition (specifically the utilization of this capacity). For instance, while India *tendered* around 20 GW of solar projects in 2015, it *added* 3 GW of solar capacity. There has been no dearth of interest in India's solar projects – its first summit for renewables investors ('Re-invest 2017') reportedly attracted investment commitments totalling 266 GW.[75] Recent solar auctions have seen the tariffs for solar electricity tumble by around 70 per cent from their 2010 levels – a 2017 auction for 500 MW of solar capacity resulted in a record-low tariff of ₹2.44/kWh ($0.038), compared with the average electricity tariff of ₹3.20/kWh.[76]

However, these tariffs may exclude the full cost of intermittency, and some solar projects are based on a government-backed guarantee mechanism ('Viability Gap Funding') which bridges the capital costs of 'economically viable' solar projects, based on a series of assumptions, including a 17 per cent capacity utilisation factor.[77] There have subsequently been some reports of aggressive bidding by companies to win solar tenders, casting doubt over whether these projects have adequately priced in risk, and about the ability of developers to complete them on schedule.[78] There are also concerns surrounding the ability of power off-takers (utilities) to clear their dues on time with solar companies, potentially creating liquidity problems. An issue of longer-term concern, however, is the balance of falling solar equipment costs versus the rising costs of large-scale solar integration as solar energy begins to be scaled up beyond 17 per cent. This has implications for electricity tariffs (which could go up), and for grid infrastructure. India's draft National Electricity Plan envisages a 20.3 per cent penetration of renewable energy in total electricity generation by 2021, rising to 24.2 per cent by 2026, but it is as yet unclear whether this is realistic. These uncertainties reflect the broader global questions being explored in ongoing research on the re-design of electricity markets to integrate an optimal share of renewables.[79]

Arguably, the role of gas has not been seriously taken into account in relation to India's renewables target. Balancing and 'ramping up' requirements to complement the expansion of renewables can be sourced, in order of priority, from hydro plants, pumped storage plants, open cycle gas turbines and closed cycle gas turbines. Given the inflexibility of coal, India's draft National Electricity Plan considers hydropower as playing a key balancing role to the intermittency of renewables. However, hydro projects have experienced high rates of slippage, partly due to contentious issues over land and resettlement, and delays in environmental clearances.[80] High dependency on monsoons is another constraint to hydropower, as 60 per cent of hydro capacity consists of storage projects, and 30 per cent consists of run-of-river projects which offer no storage options. Gas can provide a flexible balancing option, with start-up times of 40 minutes compared with 5-7 hours for inflexible coal, and minimum output limits[81] of 15-30 per cent compared with 40-60 per cent for inflexible coal.[82] India's draft National Electricity Plan however envisages an addition of just 4.34 GW of gas-based capacity that has already been commissioned or will be under construction as of 2017, with no new capacity additions thereafter. The renewables target will be a key determinant for the future of gas in India, but it requires a carefully considered study of what is realistically achievable in renewables, and the consideration of a strategic role for gas in the power sector.

[75] NEP (2016). It is unclear whether these were firm commitments, or expressions of interest to participate in the tendering process.
[76] See PV Magazine (2017).
[77] See GoI (2015).
[78] See Livemint (2017b).
[79] See Keay et al (2013).
[80] For instance, only 5.25 GW out of a planned 10.9 GW of hydro projects were completed over 2012-17 (NEP, 2016).
[81] The minimum output below which a plant has no high frequency response capability.
[82] NEP (2016).

4.3 Coal in the Energy Mix and Associated Air Quality Issues

Coal dominates India's energy mix, comprising 58 per cent of primary energy consumption and 59 per cent of total installed power capacity.[83] The majority is consumed for energy production (steam coal).[84] Consumption doubled between 2005 and 2015, and was roughly 828 Mt in 2015. The expectation has been that coal consumption will continue to grow over the next decade, but at a slower rate. The IEA (2016) for instance predicts that it will drop to 46 per cent of primary energy demand and 41 per cent of total installed capacity by 2040, but will still form a high proportion of fuel in the energy mix.

Figure 16: Coal Production and Imports

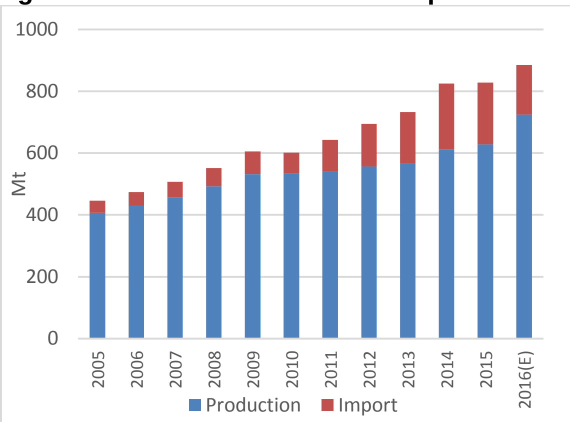
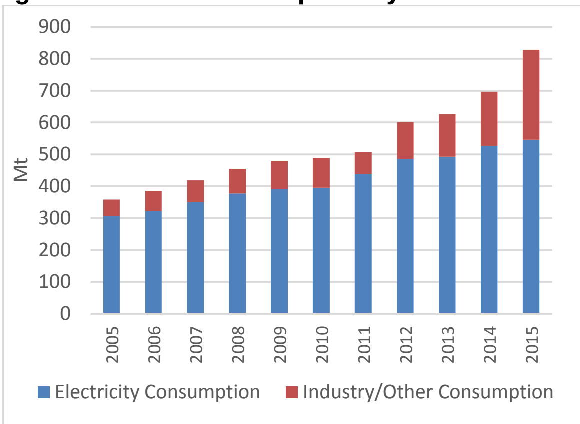


Figure 17: Coal Consumption by Sector



Source: Energy Statistics (2015); CEA (2017); BP (2016); Platts (2017)

At 300 billion tonnes, India has the world's fourth largest coal reserves and 80 per cent of domestic production comes from state-owned Coal India Limited. Figure 17 shows that the majority of coal is consumed in the electricity sector, in which gas is a competing fuel. There are two main countervailing factors which will shape the future outlook for coal, in relation to gas:

- on the one hand, a push by the federal government to increase coal production, cease coal imports, supply the electricity sector with sufficient fuel to mitigate shortages, and provide universal and reliable access to electricity to all households by the end of this decade, and
- on the other hand, the imposition of fiscal measures and environmental restrictions on the burning of coal in order to reduce air pollution and particulate matter emissions, partly in response to litigation brought at the state and city levels by citizens concerned over worsening urban air quality.[85]

With regards to the first factor, as Figure 16 shows, India's coal imports began rising from 2010 onwards, driven largely by a shortage of domestic coal supplies due to severe inefficiencies in the supply chain. In 2012, the generation loss from the inability of companies to supply power utilities with coal was estimated at 15 Billion kWh.[86] In 2014, a major reform of the coal sector was undertaken, targeted at removing supply chain inefficiencies and permitting private sector participation in the sector.[87] A target was set to increase coal production to 1.5 Bn tonnes by 2020, and to cease imports

[83] BP (2016); CEA (2017).
[84] CCO (2015).
[85] According to the World Health Organisation, India hosts 11 of the world's top 20 most polluted cities, with rising pollution levels estimated to have killed around 1.1 million people in 2015. See Singh (2016); FT (2017).
[86] NEP (2016).
[87] See Cournot-Gandolphe (2016) for a detailed analysis of these reforms and their impact.

for plants that are meant to be run entirely on domestic coal supplies.[88] As a result of these measures, India's coal imports are expected to be 20 per cent lower in fiscal year 2016/17 (as seen in Figure 16), and the overall power deficit has narrowed to 1.6 percent from double digits a few years ago. Interestingly, however, there has been a recent spate of cancellations of coal projects, and the average PLFs of coal based power plants remain relatively low, at 65 per cent. This could indicate that the 'coal juggernaut' may be slowing, despite improvements in supply chain efficiency.

With regards to the second (and countervailing) factor, measures have recently been announced to regulate the environmental impacts of coal. A tax was introduced on coal production in 2014, which currently stands at US$6/tonne – nowhere near enough to encourage coal to gas switching in electricity. CO_2 emissions in the Indian power sector account for half of total emissions, and increased by 35 per cent in absolute terms from 2010-14, primarily due to an increase in coal-based generation and a concomitant decrease in hydro and gas-based generation.[89] Table 3 below shows that emissions from gas are, on average, half those of coal for fossil fuel stations in India.

Table 3: Weighted Average Specific Emissions for Fossil Fuel Stations in 2014 [tonnes of CO_2/Megawatt-hour (net)]

Coal	Gas	Diesel	Lignite	Oil
1.01	0.58	0.49	1.35	0.64

Source: NEP (2016)

New emissions standards were announced in December 2015 for coal-based power plants in order to improve Ambient Air Quality (AAQ) around coal stations. Existing plants were given two years to comply, whereas all new plants beginning operations after 1 January 2017 have had to comply from the outset.

Table 4: New Emission Standards for India's Coal Power Plants (in mg/Nm^3)

Plants installed:	Particulate Matter	SO_2	NO_x	Mercury
Prior to 2003	100	< 500 MW: 100 >= 500 MW: 200	600	>= 500 MW: 0.03
2004-2016	50	< 500 MW: 600 >= 500 MW: 200	300	0.03
From Jan 2017 onwards	50	100	100	0.03

Source: CSE (2016)

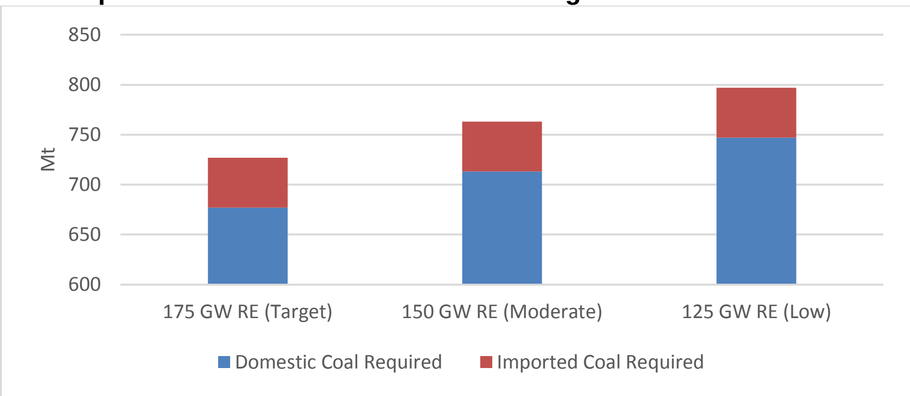
Table 4 shows the new standards, which are far more detailed than a previous requirement to limit particulate matter emissions from 150-350 milligrams (mg) per Normal cubic metre (Nm^3).[90] Under the new standards, power plants are required to reduce particulate emissions by 90 per cent, nitrogen oxide emissions by 70 per cent, and mercury emissions by 75 per cent.[91] These standards come with associated costs – for instance, roughly 8 GW of coal plants under 500 MW have no facilities for installing Flue Gas Desulphurization (FGD) plants, thus requiring new installations which could shut down capacity for at least 4-6 months.[92] Coal based power plants have reportedly been finding it challenging to apply these emissions standards, due to the high associated costs and even more so,

[88] In an effort to reduce power shortages in the early 2010s, India launched an 'Ultra Mega Power Plant' (UMPPs) policy, aimed at setting up nine privately operated 4,000 MW coastal power plants supplied exclusively through imported coal. Rising international coal prices and restrictions on the pass-through of escalated fuel costs into tariffs, has put the future of these coal plants into question.
[89] NEP (2016). Absolute power sector emissions stood at 805.4 $MtCO_2$ in 2014.
[90] CSE (2016).
[91] FT (2017).
[92] NEP (2016).

a lack of clarity over whether these costs would be passed through into tariffs. This has resulted in India's Power Minister recently admitting that there would be delays in implementation.[93]

The government has mandated supercritical technology for all coal-based power plants commissioned from 2017 onwards, in addition to an existing 34.9 GW of existing supercritical plants as of March 2016 (representing roughly 20 per cent of the coal fleet). Furthermore, coal transported beyond a distance of around 750 kilometres from the pithead will not be permitted to have an ash content of more than 34 per cent. This could constrain coal supplies to markets located far from mines, as only 20 per cent of India's high-ash coal is washed, and imports are being discouraged. Therefore, a slippage in the application of environmental constraints on coal plants is evident, but Indian policymakers appear to be banking heavily on the renewables target to mitigate any increased requirements for (and negative externalities from) coal, rather than considering gas as a transition fuel. India's draft National Electricity Plan assumes that at least 125 GW of renewables will be achieved by 2021 and posits three separate potential demand scenarios for coal (including imports for coastal UMPPS) based on the same. These are shown in Figure 18: the achievement of the full 175 GW target, a 'moderate' realisation of 150 GW, and a 'low' realisation of 125 GW. In the 175 GW RE scenario, the amount of coal required will be 12 per cent lower than 2015 levels, whereas in the 'low' (125 GW) scenario it will be 4 per cent lower than 2015 levels.

Figure 18: Coal Required under Different Renewable Target Scenarios



Source: NEP (2016)

The draft National Electricity Plan assumes that the 175 GW renewables target *will* be met, growing to 275 GW by 2027 and therefore no new coal-based power plants, beyond those already under construction (amounting to around 50 GW and expected to be made operational during 2017-22), will be required until at least 2026-27. Given that India had around 178 GW of coal project proposals in the pipeline in 2016, there has been a spate of cancellation of coal projects. For instance in May 2017 alone, coal projects amounting to 14 GW were cancelled across three states.[94] This reflects the wider interplay of coal and renewables, demonstrating that the determinants of gas in India's future energy mix cannot be considered in isolation. Should the renewables target not be met, and if there is insufficient coal plant capacity to call on to bridge the deficit, this opens up potential opportunities for gas, subject to infrastructure. At the other extreme, if the target is met, it excludes any substantial expansion in the role of gas in the power sector, bar that of limited peak shaving. We will return to this later.

4.4 Infrastructure

Infrastructure lies at the heart of optimising India's potential as a major gas market. There are two main bottlenecks: firstly, pipeline infrastructure is not being built quickly enough to support demand in

[93] Singh (2016) estimates the cost of implementation at US$37 Bn. Also see FT (2017).
[94] IEEFA (2017).

growing regional markets and secondly, parts of the existing infrastructure remain underutilised. There are also regional imbalances: 40 per cent of infrastructure is concentrated in two western states (Gujarat and Maharashtra), whereas five north-eastern states, and the eastern, southern and central regions have limited to no pipeline infrastructure[95] (see Appendix A for a map of gas infrastructure in India). In comparison, India's gas reserves are largely located in the eastern and western offshore basins, and onshore in the north-eastern states. Table 5 contains details of the capacity of the existing pipeline network (around 141 Bcm). As of September 2016, average pipeline capacity utilisation was 40 per cent.

Table 5: Existing Pipeline Infrastructure

		Pipelines – Length (km)	Pipelines - Capacity (MMScm/d)
Total		**16,065**	**386**
Of which (%):	**GAIL**	69	63
	RGTIL	9	21
	GSPC	15	11
	Others	7	6

Source: PPAC (2016b)

A further 13,821 km of pipeline is under construction but has faced hurdles.[96] India has four LNG regasification terminals: Dahej (10 Mtpa), Hazira (5 Mtpa), Dabhol (5 Mtpa) and the recently completed Kochi (5 Mtpa) terminal, all located on the west coast (see Appendix A). Of these, Dabhol has been unable to operate at high capacity due to the prolonged lack of a breakwater facility, and Kochi has had a low utilisation rate as a result of long delays in being connected to regional markets. There are reportedly seven new terminals planned, five of which are on the east coast, but little progress has been made.[97] Floating Storage Regasification Units (FSRUs) have been proposed as a way to bypass the problems faced in constructing LNG regasification terminals, and at the time of writing, we have identified 8 proposed FSRU projects, including 5 on the east coast and 3 on the west coast, amounting to 46.6 Mtpa, the earliest of which has a proposed start date of 2018. India has been attempting to expand gas infrastructure (including the creation of a national gas grid) since 2012. But three main factors have impeded progress:

- Firstly, infrastructure companies have been hesitant to lay pipelines without an anchor consumer in place (also referred to as the 'commodity versus carrier' problem).[98] At the same time, anchor consumers (such as fertiliser plants) are reluctant to contract future offtake in the event that the infrastructure does not develop to schedule, thereby stranding their assets. This has occurred in the past, partially due to misallocation under the 'gas utilisation policy'.[99] A recent survey by PWC (2016) concluded that there is a strong consensus within India's gas sector that gas storage, transmission and distribution infrastructure development are needed to spur gas demand (the 'carrier first' principle).
- Secondly, companies utilise a legislative provision called the 'right to use' land, where land is temporarily acquired (without ownership) for laying pipelines after due compensation to landowners. This has met with public protests and litigation in the process of land acquisition. For instance, GAIL's pipeline to connect the Kochi regasification terminal to the southern state of Tamil Nadu encountered protests by farmers, prompting the state government to suggest an alternative route alongside a national highway, rather than through farmland. GAIL rejected this as it breached certain project norms, such as not laying pipelines through populated areas. The

[95] Wainberg et al (2017).
[96] PPAC (2016).
[97] Ibid. Also see Sen (2015).
[98] PWC (2016).
[99] See Sen and Jain (2011).

case went to the Supreme Court, which found in favour of GAIL.[100] The delays however led to the Kochi terminal operating at less than 5 per cent of capacity in 2016.[101]

- Lastly, there is a lack of clarity around the downstream regulatory framework. India's Petroleum and Natural Gas Regulatory Board (PNGRB) is the regulator of downstream infrastructure, but has on occasion been superseded by the federal government on pipeline network decisions.[102] The PNGRB administers tenders for city gas infrastructure and for retail city gas sales licenses. A general lack of coordination between the federal government and the PNGRB has led to the postponement of bidding rounds for gas infrastructure in specially designated 'smart cities'.[103] At the time of writing, the PNGRB was responsible for administrating bidding rounds for city gas infrastructure for a total of 228 new cities demonstrating the heavy reliance of gas infrastructure on clear downstream regulation.

The outlook for gas infrastructure is a fundamental determinant (enabling or constraining the potential) for gas in India's energy mix. It is worthy of a separate and detailed analysis – perhaps focusing on the resolution of the three 'bottlenecks' identified above – that is beyond the scope of this paper, but it will strongly qualify any future outlook for gas.

5. Outlook for Gas Demand Post-COP21: Three Potential Cases

The four key determinants of gas demand described above can be combined with the dynamics of gas demand in each sector described in Section 3, in any number of permutations, to yield a potential outlook for gas. Based on the discussion thus far, this section briefly sets outs three broadly illustrative cases based on current policy, tentative timeline and likelihood of outcome.

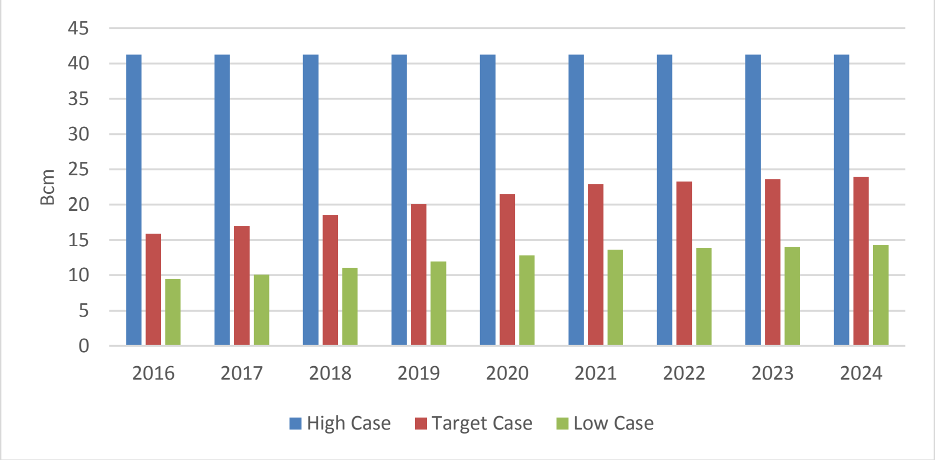
Outlook 1 – A continuation of the status quo to 2024, underpinned by sector-specific growth targets

This Outlook is a continuation of the recent status quo, in which gas demand continues to be driven by the fertiliser, industry and city gas sectors, underpinned by policy targets. These sectors are relatively price-inelastic: they will either continue to be shielded from price volatility (as in fertilisers), or can pass through price increases to consumers (as in city gas and industry). In fertilisers, recent targets to expand urea production to 38 Mtpa and to cease urea imports (assumed here to occur over a period of five years), are taken into account to estimate the potential demand for gas to 2024. Figure 19 depicts a 'high' case (based on optimistic projections from the erstwhile 12th and 13th Five Year Plans), a 'target' case (based on the recent policy announcements to expand urea production), and a 'low' case.[104] The 'target' case is assumed as the most likely case to be realised and could lead to a 48 per cent increase (from 2015 levels) in industrial gas demand.

Figure 20 presents projections for gas demand in the industrial sector, based on the assumption that this will be underpinned by policy to expand manufacturing to 25 per cent of GDP (from 15 per cent at present) by 2022. This Outlook utilises historical data and projections for manufacturing GDP from the IMF World Economic Outlook, along with historical estimates on gas consumed in industry, to obtain projections of gas demand to 2024 based on a simple linear extrapolation.[105] The projections show that by 2024, gas consumption in manufacturing could increase by 30 per cent, over 2015 levels, if policy targets are met.

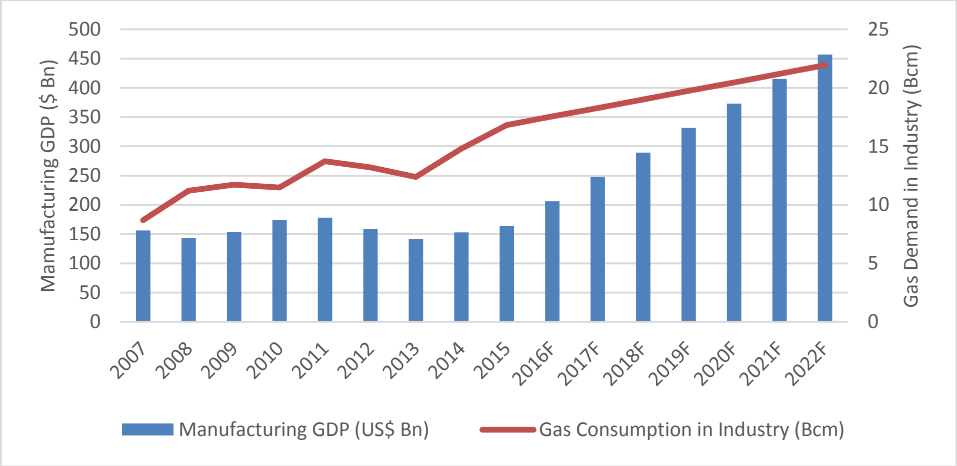
[100] See The Hindu (2016).
[101] See ET (2016).
[102] See ET (2017).
[103] See Business Standard (2017).
[104] The low case assumes that 60 per cent of targeted urea production is achieved, based on a five year historical average achievement rate (2009-14). However, this historical average is arguably not reflective of trends over the last 2 years and therefore this case may be underestimating gas demand in fertilisers.
[105] The method is based on Sen and Sen (2016, 18-19) which utilises a similar technique to estimate oil demand.

Figure 19: Outlook 1 - Assumed Projections for Gas Demand in Fertilisers



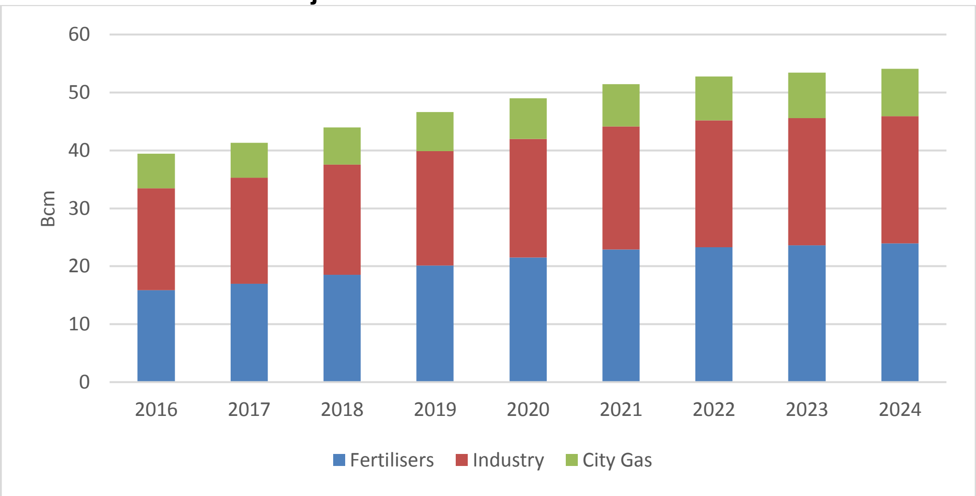
Source: WG (2011); Indian Fertiliser Scenario (2015); Author's estimates

Figure 20: Outlook 1 - Assumed Projections for Gas Demand in Industry



Source: Indian PNG Statistics (2015); India Energy (2017); IMF (2016); Author's estimates

Figure 21: Outlook 1 - Overall Projections for Gas Demand



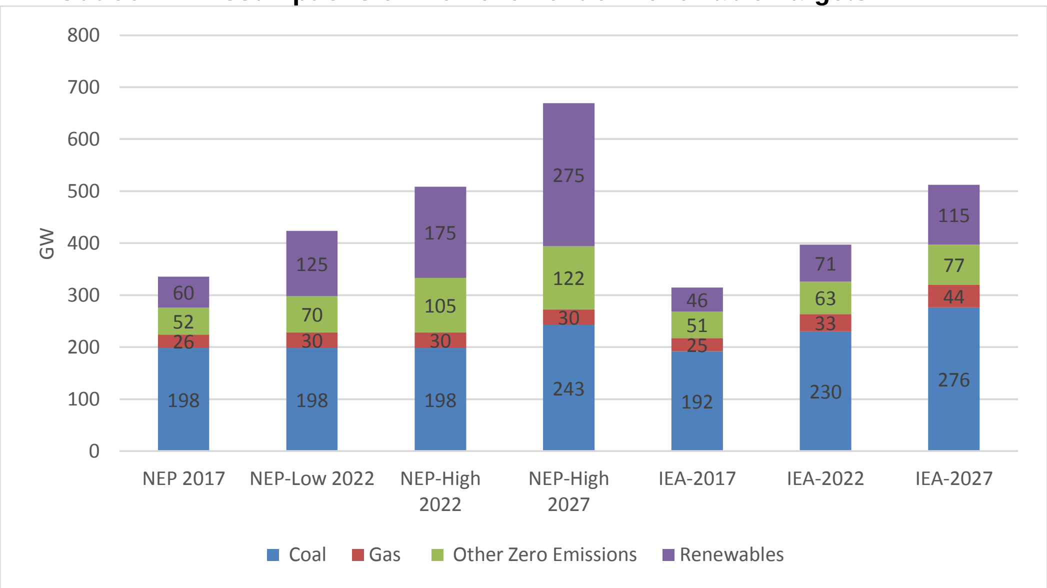
Source: Author's estimates

It is much more difficult to forecast future demand in the city gas sector, as although it is underpinned by government policy, the success of policy targets depends more heavily upon the speed of infrastructure development. This Outlook therefore uses 'optimistic' projections from 2017-2021 from India's (erstwhile) 12th and 13th Five Year Plans (which cover the period 2012-22) and adjusts them downward to reflect a historical 35 per cent achievement of targets, on average. Projections for 2022-24 are obtained based on a 5 year CAAGR of these 'realistic' demand estimates. Given the uncertainty around infrastructure, it is possible that the projections for city gas might be underestimates. Figure 21 depicts the overall picture for gas demand under Outlook 1 and it suggests that demand in these three key sectors could potentially increase by 40 per cent by 2024, over 2015 levels. Outlook 1 therefore represents a limited but reliable demand base for gas, which will continue to grow comfortably in the short term, with some potential to scale up thereafter.

Outlook 2 – Renewables targets are not met, potential for gas to fill the gap to 2027

The role of gas in the power sector is central in this Outlook, which is predicated on: (a) the failure to meet the 175 GW renewable energy installed capacity target by 2022; (b) slippage in hydropower projects based on historical delays in project completion, requiring an alternative energy source to provide necessary 'balancing' and bridge any shortfall; and (c) the unavailability of coal-fired power plants to bridge potential shortfalls based on the draft National Electricity Plan's assumption that no new coal-fired power stations will be required (or built) beyond the 50 GW already under construction, until at least 2027.[106] This Outlook implies a central role for gas in balancing intermittency as well as bridging any ensuing power deficit.

Figure 22: Outlook 2 - Assumptions on Achievement of Renewable Targets



Source: NEP (2016); IEA (2016)

Although the draft National Electricity Plan asserts that the high 175 GW target will be met by 2022, it also posits a 'moderate' (150 GW) and 'low' (125 GW) target achievement for purposes of comparison. Figure 22 shows the 'high' targets (175 GW) for 2022 and 2027, and the 'low' target (125 GW by 2022). The latter is far more optimistic than the IEA New Policies Scenario, also included in Figure 22, which assumes that only 71 GW of the renewables target will be met by 2022, rising only to 115 by 2027. Figure 23 shows the difference between the IEA's projections and the NEP-Low 2022 (125 GW), NEP-High (175 GW) 2022, and NEP-High (275 GW) 2027 scenarios, respectively, namely

[106] And the associated cancellations of coal projects.

the deficit in installed capacity. Figure 24 shows the corresponding potential for gas to bridge the deficit.[107]

Figure 23: Outlook 2 - Deficit in Installed Capacity

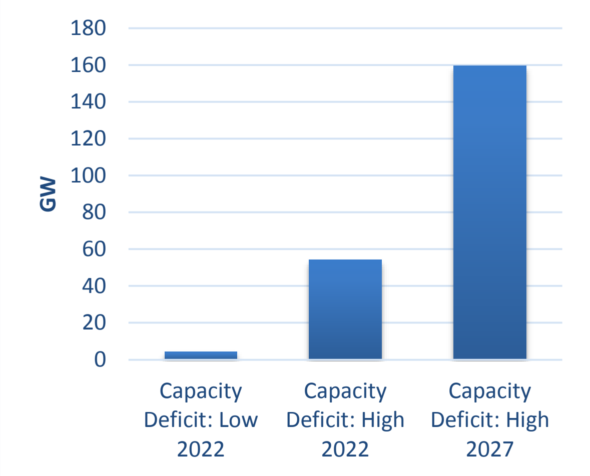
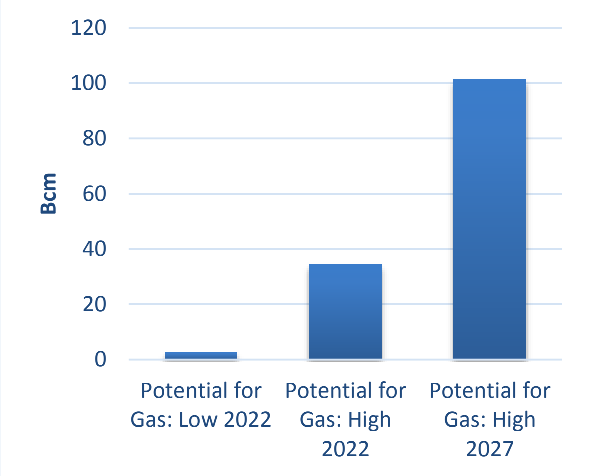


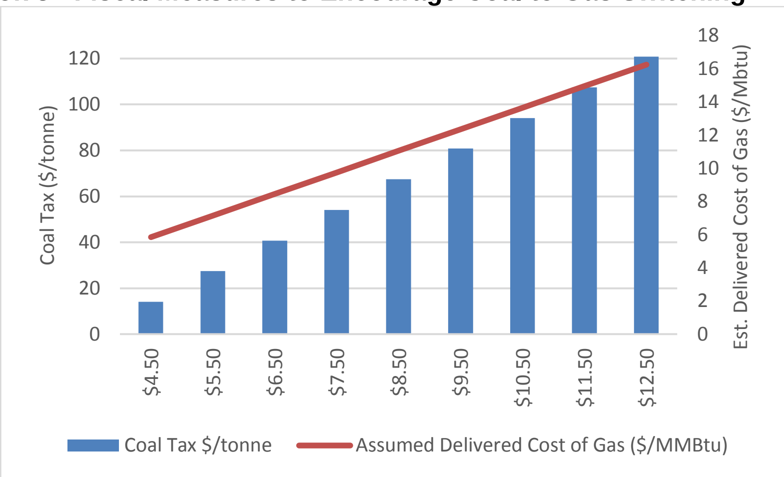
Figure 24: Outlook 2 - Potential for Gas to Bridge Deficit



Source: Author's estimates

The projections in both Figures take into account 50 GW of coal-fired capacity that is under construction and which will be commissioned between 2017 and 2022. The projections are qualified by the uncertainty over gas infrastructure in the electricity sector. The draft National Electricity Plan estimates that electricity from gas-fired power stations, which are currently running at a less than a quarter of their full capacity, could at present be ramped up by operating at 85 per cent PLF for 6 additional hours every evening, which would require around 20 Bcm of additional gas supplies. The projections in Outlook 2 show that the IEA scenario could imply a requirement for 35 Bcm of additional gas in the power sector by 2022, rising to nearly 100 Bcm by 2027. Historical experience in India's energy sector implies that ambitious targets are rarely achieved in their entirety, increasing the probability of this Outlook. However, the role of gas in this Outlook is also highly uncertain.

Figure 25: Outlook 3 - Fiscal Measures to Encourage Coal to Gas Switching



Source: Author's estimates

[107] This is worked out based on the assumption that roughly 39 Bcm (108 MMScm/d) is required to run India's 25 GW gas station fleet at 85 per cent PLF (NEP, 2016).

Outlook 3 – Coal is actively discouraged in the power sector, opening an important and immediate role for gas in the power sector to 2027 and beyond

The third broad outlook for gas in India's energy mix is predicated on an active policy to discourage the use of coal through fiscal disincentives, and induce a large-scale switching from coal to gas, which would also serve to create demand and encourage the development of infrastructure. Again, this Outlook is mainly focused on the power sector, and could come about in a scenario where environmental concerns and pressures (domestically or internationally) become critical. Figure 25 shows, a carbon tax in US$/tonne at different levels of gas prices, which would need to be imposed on coal in order to allow gas to compete with coal in power generation at those prices. The delivered cost of gas is illustrated on the right axis. The figure shows, for instance, that at a gas price of US$5.50/MMBtu (which is in the ballpark of the US$5.56 'ceiling' price for deep water gas in India), the tax per tonne of coal production would have to be roughly four and a half times its current amount (namely around US$27/tonne as opposed to US$6/tonne). This would be equivalent to a roughly 30 per cent increase in tariffs for coal-fired power, which would in present circumstances be politically difficult, if not impossible, to pass through to consumers. Therefore, although this Outlook would provide with a long-term substantial role for gas in India (in the power sector), it has a low probability of being realised at present.

Table 6 contains an illustrative summary of the discussion contained in the three Outlooks. This is not meant to be definitive, but rather illustrative of the interplay between the drivers and determinants of demand for gas in India's energy mix, based on the probability of different policy outcomes.

Table 6: Illustrative Summary of Outlooks for Gas

	(A)Main Driver(s)	(B)Determinants	(C)Relative Influence of (B)
Outlook -1	➢ Fertilisers ➢ Industry ➢ City Gas	▪ Prices ▪ Renewables Policy ▪ Coal and Environmental Policy ▪ Infrastructure	*Low* *Low* *Low* *High*
Outlook -2	➢ Power	▪ Prices ▪ Renewables Policy ▪ Coal and Environmental Policy ▪ Infrastructure	*High* *High* *High* *High*
Outlook -3	➢ Power	▪ Prices ▪ Renewables Policy ▪ Coal and Environmental Policy ▪ Infrastructure	*Low* *High* *High* *Low*

Source: Author

6. Conclusions

India is once again in the spotlight as a potential future growth market for gas, as demand elsewhere in the OECD and non-OECD recedes or grows increasingly uncertain. This is due to several factors, including declining European gas balances, the anticipated transformation of the US into a net energy exporter, and the tempering of economic growth in China. Yet, as this paper has argued, the view on gas from within India has been in constant flux over the last decade, with no realistic vision on its role in the energy mix. Furthermore, the complex interplay between India's two 'markets' for gas – one regulated, and the other market-oriented – has obfuscated any attempts to accurately assess future demand.

But in recent months, there has been an upsurge in India's consumption of imported LNG – driven largely by the fertilisers, city gas and industry sectors – prompting a revival in policy activity around the reconsideration of gas's role in the energy mix. At the same time, India has embarked on one of the developing world's most ambitious targets, specifically to increase its renewables installed capacity fivefold (to 175 GW) by 2022, as part of a series of domestic policy targets made alongside its firm international commitments following its ratification of the COP21 Paris climate agreement in December 2015. This paper has therefore disentangled the short-term developments and dynamics of demand in the main consuming sectors (power, fertilisers, industry and city gas), from the influence of longer-term determinants (prices, renewables policy, coal policy and pollution issues, and infrastructure) as enablers or constraints on the future outlook for gas. It has presented three illustrative outlook cases for gas:

- A continuation of the status quo to 2024, where gas demand growth will continue to be driven by underpinning policy targets in fertilisers, industry and city gas, which could form a limited but reliable demand base for gas, and which will continue to grow comfortably in the short term, with some potential to scale up thereafter. This outlook sees gas demand in these sectors growing by around 40 percent from 2015 levels, to 2024. The main constraint to this outlook is infrastructure.
- A role opening up for gas to 2027 in the likely event that India fails to fully meet its renewables target – although this would present significant opportunities for gas demand, which could increase by an additional 45 Bcm by 2022 and higher thereafter (to 2027), this role is constrained by prices, infrastructure, renewables policy and coal policy.
- An outlook in which coal to gas switching is proactively encouraged through fiscal policy in the power sector, opening up an important and immediate role for gas to 2027 and beyond. This could lead to a substantial and anchoring role for gas in the power sector, but would require a nearly fivefold increase in the 'coal tax' and a potential 30 per cent increase in associated electricity tariffs, which also makes this a highly improbable outlook. This outlook is constrained by renewables policy and policy on coal and air pollution.

A likely outcome is some combination of the first two outlook cases. More importantly, this paper has emphasised the highly dynamic nature of the Indian market post-COP21, making the point that the short-term dynamics and longer-term determinants could effectively be studied in a number of combinations and permutations, in order to garner a better understanding of the Indian market as it evolves and develops towards meeting India's key energy policy goals.

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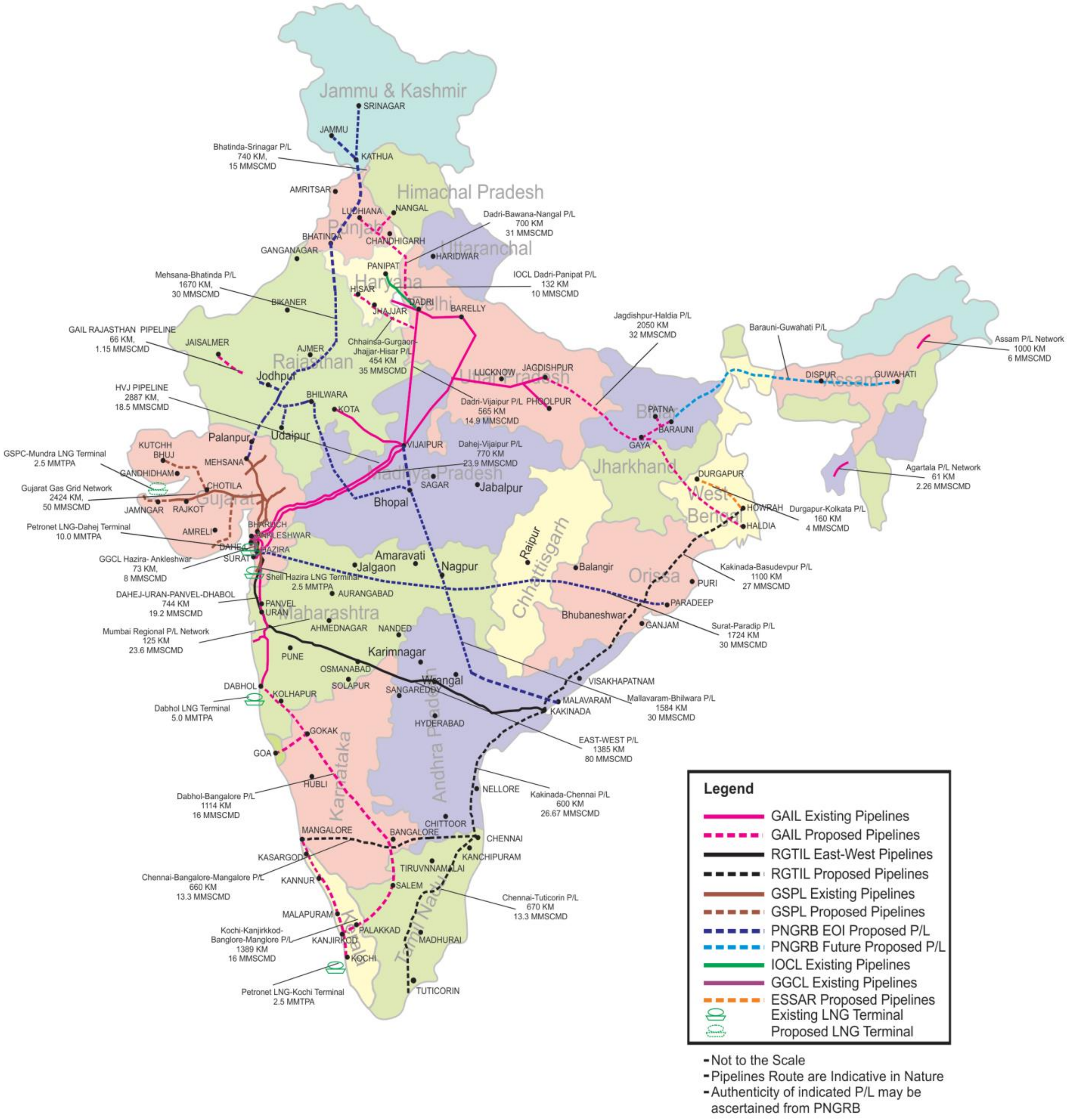
Appendix A: India Gas Infrastructure Map



Source: Petroleum and Natural Gas Regulatory Board, Government of India. [Accessed on 21 June 2017 from http://www.pngrb.gov.in/data-bank.html]