



**The Stanford Natural Gas Initiative**  
**Natural Gas in India: Markets**  
**and Influencers**

*Usua U. Amanam*

*(Revised 4-21-17)*

Pre-symposium white paper for:

**Reducing Energy Poverty with  
Natural Gas: Changing  
Political, Business, and  
Technology Paradigms**

May 9 & 10, 2017  
Stanford University, CA

# Natural Gas in India: Markets and Influencers

Usua U. Amanam\*

April 2017

## 1 Introduction

With an estimated population of 1.3 billion people and the world's 7th largest economy [1], India's continued development will be an integral part of the global economic, political, and environmental discourse in the coming decades. Though ambiguous in its definition and difficult to quantify, the approximately 310 million people who lack access to electricity provide a way to gauge energy access within the country [2]. One possible solution going forward is an increased utilization of natural gas. This paper, therefore, reviews India's gas market. Natural gas is a flexible resource with wide-ranging applications that will improve energy accessibility. The markets discussed in detail include natural gas vehicles and the power sector. Market influencers include the supply of liquefied and domestic natural gas, infrastructure, and pricing.

## 2 Current Energy Use

India's current primary energy<sup>1</sup> distribution shows the growth potential of the natural gas market. At 40 cubic meters per capita, domestic gas consumption is well below the world average of 470 [3]. Coal is responsible for the largest portion of energy consumption, accounting for a growing 58% of primary energy use in 2015 [4]. The country has one of the largest bituminous coal reserves in the world, but external pressure along with self-imposed restraints could complicate the deployment of coal as the preferred energy solution for mass development in a manner similar to China<sup>2</sup>. Oil and natural gas provide 28% and 6% respectively of the total energy used for primary consumption [4]. Over the past 6 years, natural gas consumption has declined, with the majority of that unmet demand substituted and supplied by coal. Figure 1 shows a marked shift in the rate of change of coal consumption in 2010. In that same year, natural gas consumption totals peaked at 10%, then declined to 7% in 2014, and 6% in 2016 [3, 4].

Contributions from Sunjoy Joshi, Tisha Schuller, and Mark Thurber

<sup>1</sup>Primary energy sources are those extracted from the environment that have yet to be transformed into a useful form of energy, like electricity or heat. This energy statistic is the portion of total energy (e.g., energy used to generate electricity) used that originates from each respective source.

<sup>2</sup>India has an intended nationally determined contribution (INDC) pledge to reduce carbon emissions intensity by roughly 35% of 2005 levels by 2030 [5]. Despite this, coal consumption has continued to increase. This is a challenge faced by many developing nations whose first priority is to provide affordable, reliable energy to their populace, while also trying to make good on international climate change pledges. Thus, the INDC pledge should be seen as a hopeful goal that could be met once energy access levels have adequately increased.

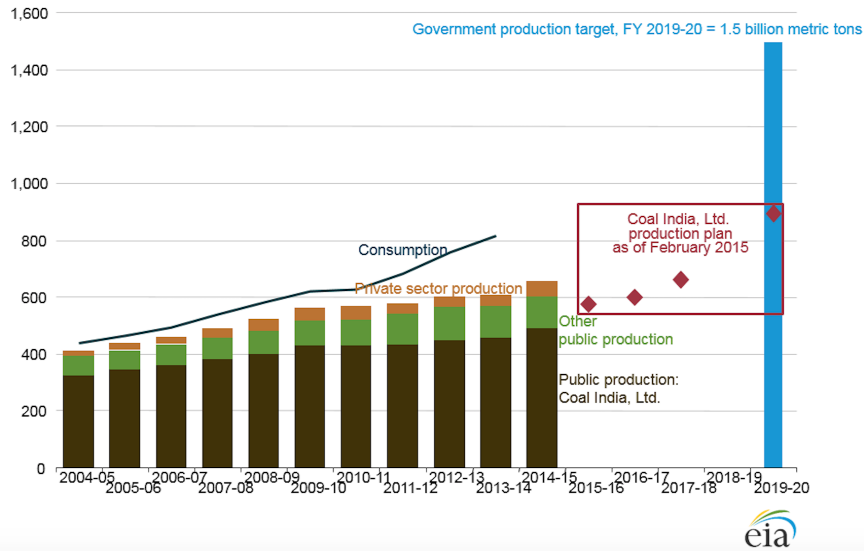


Figure 1: India’s domestic coal consumption, production, and production targets by fiscal year, 2004-2020 (million metric tons) [6].

The decline in consumption shown in Figure 2 is a strong function of waning domestic supply. Section 6 discusses how continued investment and development in offshore areas have proven to be unsuccessful [3], mainly due to unfavorable economics created by government involvement. Most of India’s conventional gas resource lies in difficult deepwater areas, and at government-regulated prices, certain fields are not feasible for production.

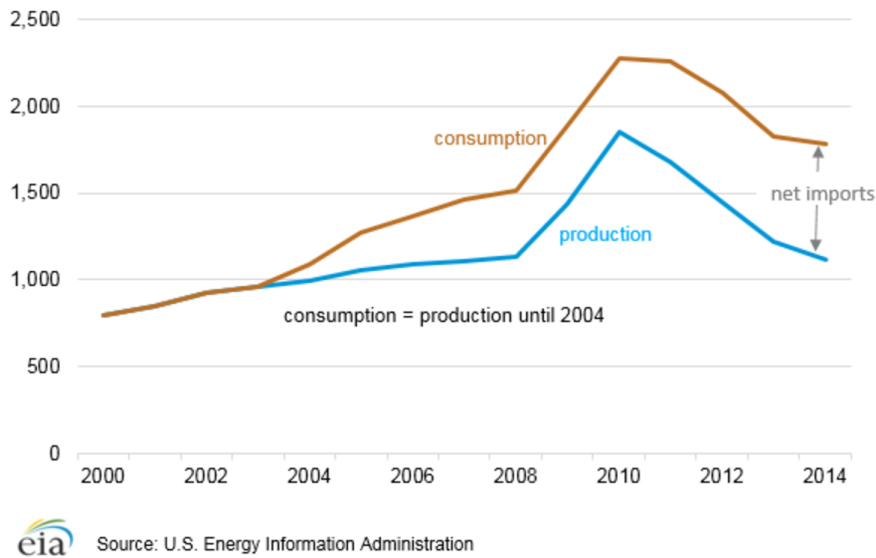


Figure 2: India’s domestic gas production and consumption, 2000-2014 (million metric tons)[6].

The production deficit underscores India’s reliance on liquefied natural gas (LNG) to

meet consumption needs. Supply has not been the only variable that has influenced consumption, however. Lack of affordability, uncompetitive pricing of foreign LNG, and inadequate distribution infrastructure are other factors that have impacted consumer use.

The most important actors in the downstream value chain include the fertilizer industry and the power sector. Both receive preferential access to domestic gas at lower prices, which, as will be shown in later sections, has a strong impact on market dynamics. Figure 3 presents the distribution for all sectors as they relate to overall gas consumption [7, 8].

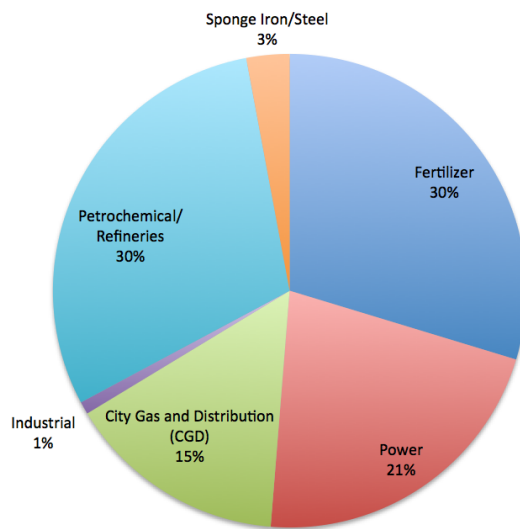


Figure 3: Natural gas consumption mix by downstream sector, January 2017 [9].

Thirty percent of the available gas is consumed by one of the world’s largest fertilizer industries [10]. In this sector, gas is the primary feedstock for the production of ammonia, a principal component in the formation of many fertilizers<sup>3</sup>. The power sector is another leading consumer of natural gas, and the current usage of 21% is expected to grow in the coming years [11]. In 2016, the country eclipsed 24 GW of utility-based installed natural gas generation capacity [7]. Another visible sector, city gas distribution (CGD), consumes roughly 15%, including gas used in the home and that on the road as a transportation fuel. The former has fueled an increase in piped natural gas (PNG) consumption and is used as a substitute for liquefied petroleum gas (LPG). Figure 4 shows the fuel distribution of the latter. LPG is responsible for 3% of the total fuel consumed in the transportation sector.

<sup>3</sup>Methane is used as the hydrogen source in the Haber-Bosch process for ammonia production through steam reforming.

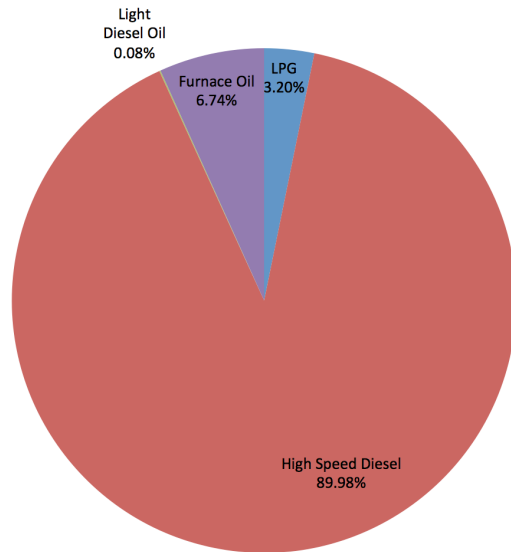


Figure 4: Transportation sector fuel consumption, FY2014-15 [12].

### 3 Demand Projections

Most of the demand in India over the coming decades will be driven by the "Make in India" campaign. In India, this program seeks to increase the country's manufacturing capacity and create jobs across 25 sectors of the economy [13]. This initiative is an energy-intensive undertaking that has and will continue to change energy consumption and demand forecasts. The campaign will also certainly add pressure on the government to continue to look for swift solutions to curb supply deficits and meet the needs of the ever-increasing natural gas demand. Figure 5 shows IEA projections of natural gas demand over the next 25 years.

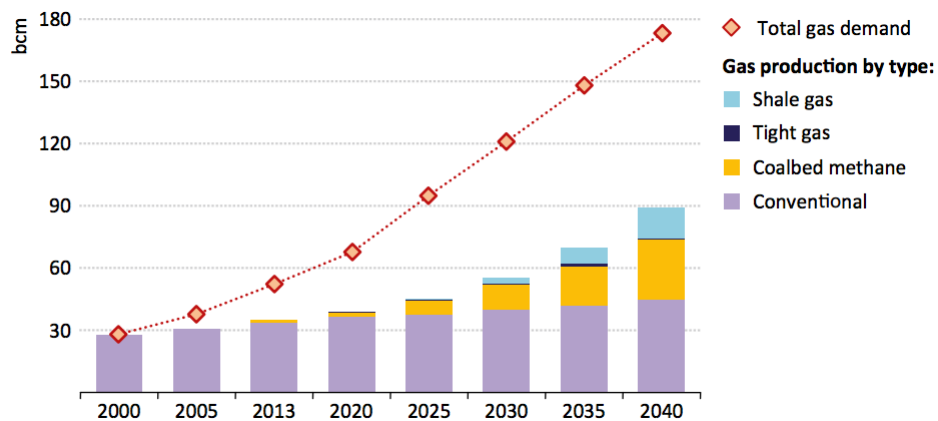


Figure 5: Natural gas production in India in the International Energy Agency New Policies Scenario [14].

The graph shows the continued growth in disparity between demand and domestic sup-

ply despite the growth of unconventional gas like coalbed methane (CBM) and shale gas. Sections 6 and 7 provide insight into how the government plans to increase the amount of available gas, with an understanding that first relief will be provided for those in metropolitan areas where infrastructure is already in place. For those who live outside of easily accessible population centers, other options are available as infrastructure advances. For example, the state-owned Gas Authority of India Limited (GAIL) has partnered with Silicon Valley-based Bloom Energy to deploy natural gas-based fuel cell technology that, if commercialized, would be effective at delivering electricity to areas that are not connected to the electric grid. Distributed generation using micro LNG is another viable solution.

## 4 Natural Gas Vehicles

Demand in CGD is dependent on the natural gas vehicle (NGV) fleet [12, 15]. NGV programs have been in place for over 20 years to help fight pollution created by automobiles run on diesel and petrol in India's biggest cities [16]. With 2.8 million compressed natural gas (CNG) vehicles on the road, they comprise the bulk of the NGV in use [17]. As of September 2016, there were 1,167 CNG stations in the country, with many of these concentrated in Delhi (36%), Gujarat (32%), and Maharashtra (20%) [12]. Due to pollution incentives and infrastructure availability within each state, the majority of these vehicles have to be used in population centers. Though CNG stations can be constructed outside of urban areas, for example along freight corridors for heavy commercial vehicles, they are inherently more difficult to maintain than traditional filling stations, and thus are not currently seen as a viable option.

Solutions using different forms of more easily transportable gas, like LPG and LNG, may usurp some of the diesel market since these fuels can be supplied to areas without pipelines [17]. In 2015, there were 2.1 million vehicles on Indian roads capable of running on Autogas (LPG), but the dual-use of these cars (with petrol) make it difficult to accurately estimate those consistently using LPG [18]. When used, refueling occurs at one of the 1,200 LPG filling stations located across the country [18]. Among other activity in the alternative fuel market, India's largest commercial vehicle manufacturer, Tata Motors, launched the country's first LNG-powered bus in 2016 [19]. French-based company Engie has also proposed the development of a chain of LNG stations, that would primarily be used for heavy duty vehicles filling up while traveling from the Mundra port to the National Capital Region (NCR) [17]. In large cities like Delhi and Maharashtra, federal and state legislators have already passed directives that mandate public transportation vehicles to run on natural gas-based fuels<sup>4</sup>. As a result, if LNG is accessible and affordable, it provides another alternative for drivers.

<sup>4</sup>Government policies have helped incentivize fuel switching. In 1998, the Supreme Court passed an injunction for all taxis and three-wheeled vehicles to convert to CNG or 'other clean fuels' in Delhi. It mandated the entire bus fleet to be completely fueled by CNG by 2001. The wording of the directive also allowed for taxis to run on cleaner diesel with lower emissions [20]. So in 2016, the Supreme Court ruled that all diesel-run taxis must convert to CNG, preventing any further delay of the original mandate. Similarly, the 2016 Maharashtra City Taxi Scheme mandates all app-based city taxis use CNG/LPG.

As has been shown, the regulation of pollutants in cities like Mumbai and New Delhi is a driver for NGV, and thus natural gas itself. Bharat Stage emission standards have been instituted by the federal government to regulate motor vehicle air pollutants. Each stage is associated with a respective Euro emission standard and becomes more stringent with the adoption of every successive step. India 2000 norms (BS-I) was the first instituted for passenger and commercial vehicles in 2000 [21]. In February of 2016, the Indian Ministry of Road Transport and Highways (MoRTH) announced that it had opted to skip the next immediate standard, BS-V norms, and instead directly adopt BS-VI norms [22]. This is the first time a country has attempted to accelerate meeting emissions standards in this manner. Figure 6 shows the change in allowable limits that will be imposed by the new standard.

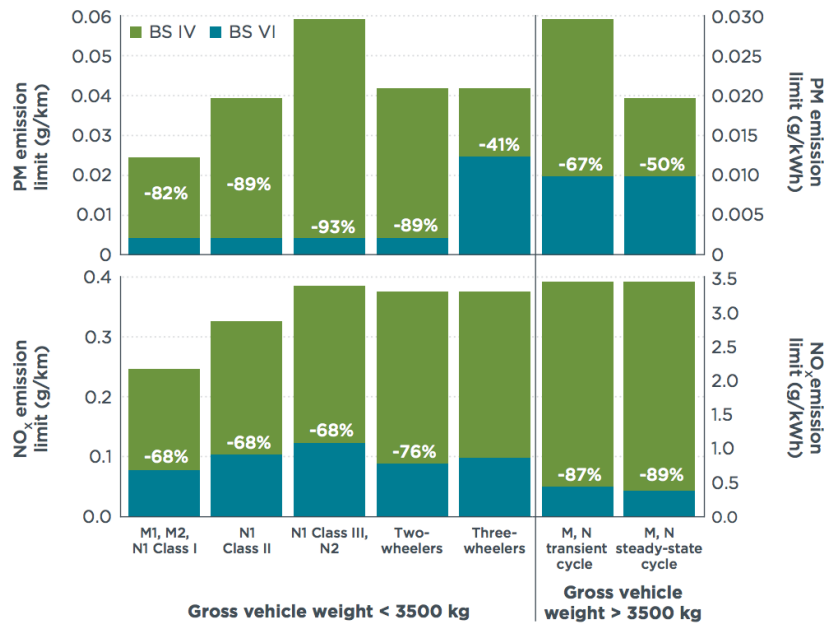


Figure 6: BS IV and VI emission limits for diesel engines.

Note: An independent BS IV NO<sub>x</sub> limit is not defined for three-wheeled vehicles. Shown here is the combined NO<sub>x</sub>+HC limit equal to 0.380 g/km [22].

BS-VI norms are estimated to cost consumers between \$1,000 to \$1,500 more for each diesel passenger vehicle [23]. This is not an insignificant amount for many of India’s middle class, where baseline annual wealth is \$13,700 [24]. The increased cost comes from the technology installed to meet new standards and the new fuel. The majority of this cost is passed down from manufacturers and refiners to consumers. Future bans on diesel engines, like the one instituted in the Delhi-NCR in 2016<sup>5</sup>, also incentivizes drivers to choose NGV over traditional automobiles. Even more so, the end of long-term diesel and gasoline subsidies has made LPG and CNG much cheaper than petrol and

<sup>5</sup>For the majority of 2016, diesel-run engines with over 2,000 cubic centimeters of engine capacity were not allowed within the city [25].

diesel<sup>6</sup>. Though a push for clean air has worked in favor of NGV, continued growth faces two challenges: ineffective enforcement of emission standards and possible disruption introduced by electric vehicles. Non-rigorous enforcement of emission standards may limit the preference of NGV. For example, despite the adoption of BS-IV norms as early as 2010 in certain major cities, the sale and registration of non-compliant four-wheeled vehicles were only banned in 2017. Regarding disruption resulting from electric vehicles, the revised interest in electric-powered vehicles has increased the prevalence of metro lines and electric autorickshaws across Indian cities.

## 5 Power Generation

India's goal of universal energy access by 2030, as per the United Nations' Sustainable Energy for All Initiative, will prove especially challenging unless steps are taken to resolve the country's sub-optimal use of its power plant fleet, namely gas-fired generation. These plants suffer from insufficient domestic supply and unaffordable regasified LNG. Despite a reported 80% electrification rate, a significant amount of people still do not have access to the grid, with 93% of those concentrated in rural areas [2]. Gas-fired generation is an effective way to meet electrification goals for two reasons: there is a generous amount of previously installed, unused capacity and new emission standards for thermal power plants that greatly limit the amount of NO<sub>x</sub> (-48%), SO<sub>2</sub> (-48%), and particulate matter (-40%), make coal-fired generation more expensive [26, 27].

Gas-fired power generation is becoming increasingly dependent on the delivery of regasified LNG. The government allocates the limited supply of cheap domestic natural gas based on sector, with the majority of it split between the fertilizer and power industries [28]. This has caused power shortages within the latter due to lack of supply. In 2014 there were 6 GW of commissioned and 1 GW of uncommissioned gas-based generation capacity offline due to lack of availability [8]. This contributed to gas-fired power plants operating at less than a 25% capacity factor (CF) [14] in that same year, further decreasing to 21% [3] by 2015.

There is a mandate to comply with more stringent emissions standards by the end of 2017, and this means an increase in the cost of coal-fired electricity generation. The levelized cost of electricity (LCOE) is fuel price-dependent for gas plants and proves favorable in a low-priced environment. Fuel cost accounted for nearly 75% of total natural gas generation costs in 2010 [29], while construction and operations and maintenance costs were considerably lower than that of coal [29]. Currently, if externalities<sup>7</sup> associated with coal-fired generation are taken into account, then the gas-fired power plants in India are more cost-competitive [32].

<sup>6</sup>Comparison of a rupee per liter was done using data from [www.petroldieselpri.com](http://www.petroldieselpri.com) and [www.engineeringtoolbox.com](http://www.engineeringtoolbox.com).

<sup>7</sup>These costs include adverse health effects due to mining pollution, increased greenhouse gas emissions, and water pollution, among other factors [30, 31].



## 6 Supply

### 6.1 LNG

The majority of the LNG imported to India comes from two countries. In 2015, 60% originated in Qatar and 15% in Nigeria [33]. Import capacity is the main barrier for regasified LNG entering the domestic market. There are multiple planned projects that would increase the country’s import potential. Two 5 million metric tons per annum (MMTPA) receiving terminal projects and one 5 MMTPA expansion project at Dahej are underway. A floating storage regasification unit (FRSU) will add an additional 4.5 MMTPA of capacity to the Kakinada terminal [33]. Figure 7 shows both the current and future LNG landscape in India.

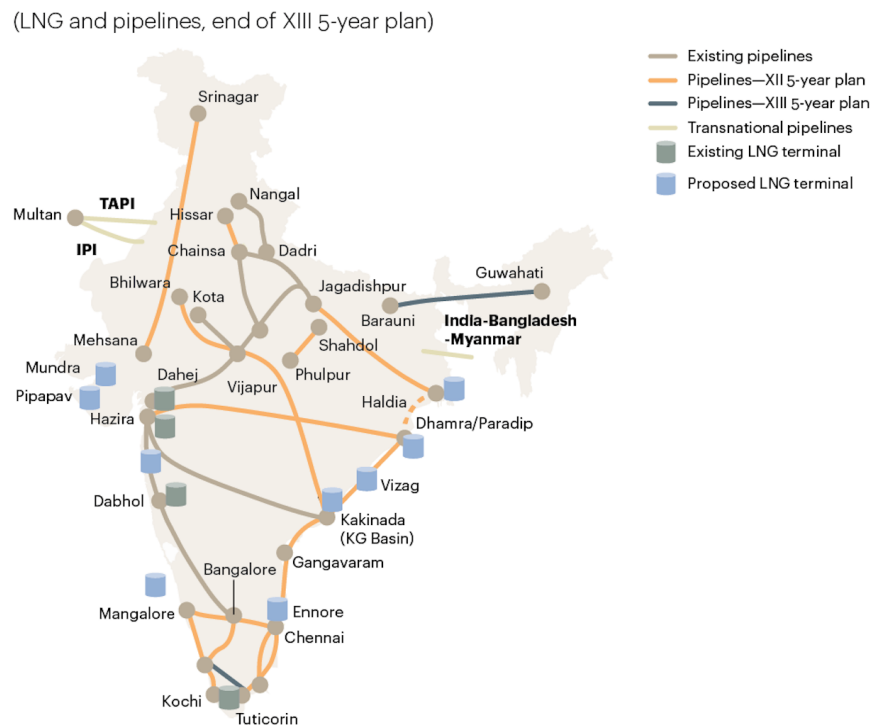


Figure 7: India’s current and future LNG-related infrastructure [34].

The country plans to reach 100 MMTPA capacity by 2020 [33, 35]. This is based on (pledged) new projects, brownfield work<sup>8</sup>, and the introduction of FRSUs. Based on the past rate of regasification expansion, increasing capacity by such a large margin over a short time period is certainly doable. The majority of the new capacity will be met by state-owned companies like Petronet, Oil and Natural Gas Corporation (ONGC), and GAIL. There are, however, multiple projects being undertaken by those in the

<sup>8</sup>Terminals that are being expanded or upgraded.

private sector. For example, Hiranandani Group/H-Energy will add 16 MMTPA by 2019 [35].

## 6.2 Domestic Natural Gas

Domestic production has suffered setbacks since peaking in 2010, but there is renewed hope because of unconventional resources: coalbed methane and shale gas. The Ministry of Petroleum & Natural Gas (MOP&NG) estimates the total CBM resource to be just above 90 TCF [12], while recoverable dry shale gas totals roughly 60 TCF [36]. Despite this optimism, as is the case with conventionals, government involvement can negatively affect the market. Investments in the Indian upstream sector have slowed due to artificially administered domestic prices. The absence of a free market has made certain exploration and development projects unfeasible. As discussed in greater detail in Section 7, any change in the regulatory environment will directly affect gas availability. There are existing reserves that are currently out of production due to the prices administered. With this in mind, the government has recently opted to deregulate CBM with the hopes of having a positive effect on investments. Tables 1 and 2 provide geographic and volumetric details on the resource.

<b>Basin</b>	<b>Risked<sup>9</sup> Recoverable Dry Gas (TCF)</b>	<b>Risked Recoverable Wet Gas (TCF)</b>
Krishna-Godavari	41.5	15.2
Cambay	19.8	6.1
Cauvery	–	4.5
Damodar Valley	–	5.4
<b>Total</b>	<b>61.3</b>	<b>31.2</b>

Table 1: Shale gas resources of India [36].

<b>State</b>	<b>Estimated Coalbed Methane Resource (TCF)</b>
Jharkhand	25.5
Rajasthan	12.7
Gujarat	12.4
Odisha	8.6
Chattisgarh	8.5
Madhya Pradesh	7.7
West Bengal	7.7
Tamil Nadu	3.7
Telangana/AP	3.5
Maharashtra	1.2
North East	0.3
<b>Total Coalbed Methane Resource</b>	<b>91.8</b>

Table 2: Distribution of CBM resource by state in India [37].

As shown, the resource is sizable, but success greatly depends on the proper development of the reserves<sup>10</sup> and, as is the case in every development project, favorable economics. For example, one area in the Krishna-Godavari Basin, known as the KG-D6 block, was expected to supply a significant amount of offshore gas to the domestic market, but two factors have prevented current goals from being met. First, a lack of experience managing a complex reservoir, stemming from the desire to develop the resource alone, led to complications and limited production. In response, BP has been brought in as a partner to help improve output. Second, the field has reserves that are intentionally left undeveloped due to the regulated price environment that has made some gas production unfavorable.

The majority of the upstream sector is dominated by state-owned companies like ONGC, Oil India Limited (OIL), and GAIL. Reliance Industries Limited is among the most active exploration and production companies in India, while Essar Oil Limited (private sector) is the country’s leading CBM producer. From 2007 to 2013, an increased number of companies began development and production on CBM blocks; however, because of permitting delays the total volume of CBM produced domestically was limited to 0.2 billion cubic meters (BCM) [14]. In an effort to accelerate development, the open acreage licensing policy (OALP) was passed in 2017 to help streamline activity in exploration blocks. With 7 blocks expected to begin commercial production in the near future, the government predicts that CBM can help increase domestic production [14, 38]. These projections are shown in Table 3.

CBM Block	Operator	Actual FY 2014-15	Actual FY 2015-16	Actual FY 2016-17	Actual FY 2017-18
Jharia	ONGC	0.006792	0.005571	0.014948	0.055507
Raniganj (North)	ONGC	0	0	0.007261	0.100125
BK-CBM-2001/I	ONGC	0	0	0.117214	0.156291
NK-CBM-2001/I	ONGC	0	0	0.033855	0.143852
Raniganj (South)	GEECL	0.362605	0.417822	0.684932	0.849315
RG (East)-CBM-2001/I	Essar Oil	0.250222	0.646167	2.356164	3.328767
SP (East)-CBM-2001/I	RIL	0.001567	0.000066	0.001644	0.002466
SP (West)-CBM-2001/I	RIL	0.004126	0.003776	0.0756164	1.134247
<b>Total</b>		<b>0.618521</b>	<b>1.073402</b>	<b>3.972183</b>	<b>5.770569</b>

Table 3: Current and projected CBM production (Million standard cubic meters per day) [37, 39].

## 7 Pricing

At the most fundamental level, low prices are good for consumers like utilities and the fertilizer industry, while high prices benefit producers and facilitate upstream development. As a stakeholder on both sides<sup>11</sup>, the Indian government has tried to adjust prices

<sup>10</sup>The Society of Petroleum Engineers defines reserves as the quantity anticipated to be commercially recovered from a resource from a given date forward.

<sup>11</sup>State-owned Petronet contracts nearly half of the imported LNG supply [40].

to benefit downstream users, greatly impacting and distorting demand preference. Policies have been instituted to address supply deficits caused by lack of affordable gas. Specifically, a reverse bidding scheme has been used for gas-fired power plants [3]. This scheme reduces pipeline tariffs on the gas by 50% for transporters that purchase regasified LNG through e-bids. This effort alone resulted in 7.6 million standard cubic meters per day (MMSCMD) more of regasified LNG being transported to 9 power plants in 2016 [35]. Additionally, the fertilizer industry also suffers from a lack of affordable supply that has limited urea yields. In an effort to increase urea production, a gas pooling policy has been employed. Uniformly priced natural gas allows urea plants to purchase their required feedstock. In the past, prices have been too high for plants to consistently produce a specified volume. This increase in domestic urea production will save the government roughly \$1.5 billion on subsidized urea imports [3].

The relationship between LNG and domestic gas has complicated the intended outcomes of well-meaning legislation, however. Instead of being treated as a single commodity, LNG and domestic gas are traded as alternatives. As a result, each serves as a substitute for the other. This has made investment decisions in infrastructure like regasification terminals and pipeline distribution networks more difficult because of the strong dependence on domestic gas availability for project economics. LNG importers are subject to unpredictable demand trends because of regulations for the power and fertilizer industries. Though volumes are contracted for the suppliers, offtake agreements with the consumer industry remain highly uncertain. Thus, whether LNG displaces diesel in the transportation sector, serves as a leading fuel for the power sector, or as an adequate feedstock in fertilizer plants depends on which sector(s) has preferential access to lower-priced domestic gas. Table 4 provides more information about gas pricing in India<sup>12</sup>.

<sup>12</sup>Information provided by Ernst and Young

<b>Mechanism Classifier</b>	<b>Type of Fuel/Field</b>	<b>Details</b>
Administered Pricing Mechanism	Natural gas produced out of existing fields from certain state-owned oil company blocks	The price is set by the government by way of cost-plus pricing.
Non-Administered Pricing Mechanism	Imported LNG	Market-based pricing control. In 2016, Petronet’s contract with Qatari-based RasGas was restructured, dropping the purchase price significantly. Prior to 2016, their LNG price point was linked to a 60-month average of Japan Crude Cocktail (JCC) [3]. LNG is now indexed to a 3-month Brent average that initially dropped the per unit price to roughly half of what was previously paid [41].
Administered Pricing Mechanism	Domestically produced gas from pre-NELP fields/gas from Panna-Mukta-Tapti (PMT) and Ravva fields	All of this gas is sold to the state-owned distribution company GAIL at an agreed upon production sharing contract price. For PMT, these came to be further negotiated
Administered Pricing Mechanism	Domestically produced gas from NELP fields/fields leased during NELP bids (1997-2016)	The price is approved by the government and is a function of market price, though the government used its approval powers later to determine prices and mandate the sale of gas to specific entities. These contracts are multiple-license, profit-sharing.
Non-Administered Pricing Mechanism	Domestically produced gas from HELP fields (2016- )	The contractor is now given pricing freedom (as well as marketing freedom) of the gas produced. These contracts are single-license, revenue-sharing. In the past year, the government has announced plans to launch its open acreage licensing policy (OALP) which will work under HELP. This policy allows companies to streamline the selection of exploration blocks without having to wait for formal bid rounds.
Non-Administered Pricing Mechanism	Coalbed methane	In March of 2017, the Cabinet Committee on Economic Affairs (CCEA) granted gas producers pricing freedom. This allows them to price gas from CBM fields at market rates.

Table 4: Pricing framework for Indian gas market [8].

A good impetus for sustainable development is to properly manage and ensure company risk. Recently MOP&NG has tried to create a more favorable upstream environment for

private companies. The changes in pricing introduced by HELP<sup>13</sup> not only give producers more autonomy over pricing their asset, but the changes also reward companies that plan to develop larger, riskier fields. Royalty rates will be small, if not non-existent, in capital-intensive areas. For example, in onshore fields royalties will be paid at a set rate of 10%. In deepwater, however, royalties will be 0% for the first 7 years, and 5% thereafter [42]. Similarly, in ultra-deepwater, the rate will be the same until year 7, increasing to 2% after that [42].

It has been shown that commodity pricing and regulation by the government has affected the development of India's gas resource. The new HELP commitments and the decision on pricing CBM shows a trend toward price liberalization. It will be important to track how the government honors these price scheme commitments, given that regulation was naturally reinstated during NELP despite initial hopes to minimize involvement. It is clear that a sustainable gas future depends on the development of competitive gas trading and open markets, which is effectively achieved through deregulation.

## 8 Piped Natural Gas

Supply is not only limited by domestic gas production and LNG regasification capacity, but also by the pipeline infrastructure that carries the gas to downstream users. The majority of PNG is supplied by imported LNG. An increased number of connections<sup>14</sup> has improved PNG sales. In fact, from April to September of 2016, the PNG consumption volume increased to 1,568 million standard cubic meters (MMSCM), surpassing that of CNG (1,433 MMSCM) during the same period. Though much positive work has been done thus far to increase gas availability, the uneven distribution of pipelines has negatively affected gas throughput. The Kochi terminal and its underutilized capacity is a good example. The volume of gas delivered to the terminal is limited because of insubstantial connectivity [33]. While pipeline infrastructure continues to improve domestically, the government is also considering regional pipelines that would rely on gas from neighboring countries to increase supplies.

<sup>13</sup>The New Exploration Licensing Policy (NELP) was a policy introduced in the late 1990's to incentivize private investment and boost oil and gas production. It was replaced by the Hydrocarbon Exploration and Licensing Policy (HELP) in 2016.

<sup>14</sup>Currently there are 3.3 million connections (Information provided by ORF).

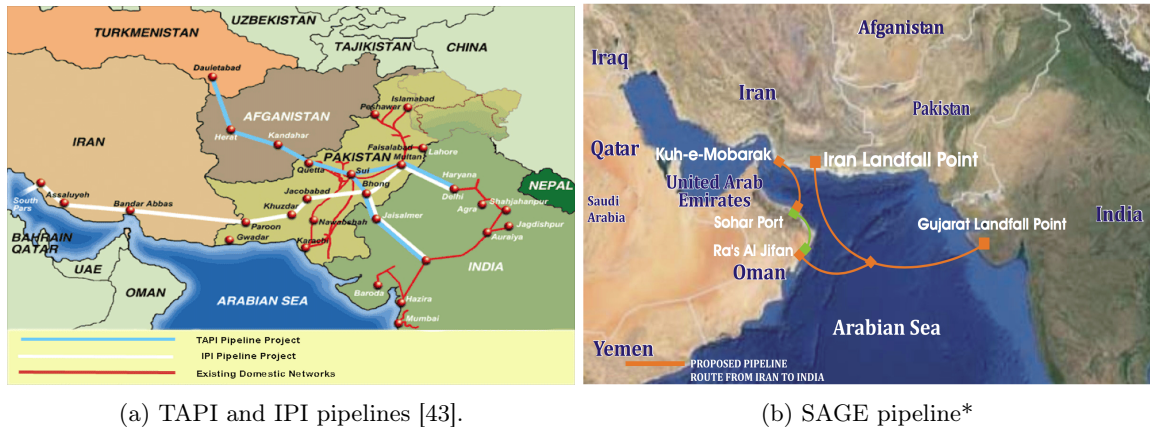


Figure 8: Proposed international pipelines aimed to increase gas supply within India.

\*Image from SAGE advertisement provided by Subodh Kumar Jain

Shown in Figure 8a is the international gas pipeline known as the Turkmenistan-Afghanistan-Pakistan-India Pipeline (TAPI). TAPI is expected to be operational by 2019 [45], though political instability in the region means delays are more than likely. When completed, the pipeline will be able to transport roughly 90 MMSCMD and 14 BCM per year to India [46]. Another pipeline project, known as the Middle East to India Deepwater Pipeline (MEIDP)/South Asia Gas Enterprise subsea pipeline (SAGE), will connect Iranian gas supplies to the Indian market by bypassing the Pakistani land route across the Arabian Sea. The proposed project will have a capacity of 31.1 MMSCMD per pipeline, and has been noted as the only transnational gas pipeline currently feasible outside of all conflict zones [47]. There is, however, uncertainty regarding the support of all Indian lawmakers. A third pipeline, known as the Iran-Pakistan-India (IPI) gas pipeline is also being considered. If completed, the line will carry 60 MMSCMD of gas to be evenly split between India and Pakistan. Currently, the Indian government is most focused on TAPI.

## 9 Conclusion

Natural gas in India has the potential to meet a growing percentage of its energy needs, improve development efforts, and reduce pollution. Domestic gas production will improve over the near future due to a concerted effort to break down barriers that have limited development and investment, including changing a strongly regulated gas pricing structure. The increase in unconventional gas production like CBM will add to supply now that the deregulated environment is more favorable for private and non-state players. This, along with the imported LNG and internationally piped gas, will serve as adequate supply once the advancing infrastructure is completed and in place. Both the power generation and natural gas vehicle fleets will also benefit significantly from the government's efforts to decrease emissions. As a result of the current activity in

the market, natural gas has emerged as a possible cost-effective fuel option for India's future.



## References

- [1] CIA. The World Factbook South Asia: India. Technical report, US Central Intelligence Agency, 2013.
- [2] Sudeshna Ghosh Banerjee, Douglas Barnes, Bipul Singh, Kristy Mayer, and Hussain Samad. *Power for all: electricity access challenge in India*. World Bank Publications, 2014.
- [3] Progress Harmony Development Chamber Ernst & Young. Gas markets in India: Overview and future outlook. pages 1–10, 2016.
- [4] Petroleum, British. BP statistical review of world energy. 2016.
- [5] Forests Ministry of Environment and Climate Change. India’s intended nationally determined contribution: Working towards climate justice. Technical report, Government of India, 2015.
- [6] U.S. EIA. EIA International Energy Outlook 2016. Technical report, US Energy Information Administration, May 2016.
- [7] U.S. EIA. India Country Analysis Brief. Technical report, US Energy Information Administration, June 2016.
- [8] Progress Harmony Development Chamber Ernst & Young. Natural gas pricing in India. pages 1–8, 2014.
- [9] Monthly Report on Natural gas production, availability and consumption–January, 2017. 2017.
- [10] Rakesh Kapur. *Gulf Petrochemicals and Chemicals Association Fertilizer Convention*. Fertiliser Association of India, September 2016.
- [11] Powering India: The road to 2017 (Executive Summary). *Electric Power and Natural Gas Practice*.
- [12] Archana S. Mathur. Petroleum and Natural Gas Statistics 2014-2015. Technical report, Ministry of Petroleum and Natural Gas, September 2015.
- [13] Rahul Anand, Kalpana Kochhar, and Saurabh Mishra. Make in India: Which exports can drive the next wave of growth? 2015.
- [14] Directorate of Global Energy Economics. India Energy Outlook. Technical report, International Energy Agency, France, October 2015.
- [15] Worldwide NGV statistics. *NGV Journal*.
- [16] Urvashi Narain and Alan Krupnick. The impact of Delhi’s CNG program on air quality. 2007.
- [17] Charles Ellinas. Promoting natural gas vehicles in India. *Natural Gas World Magazine*, (1):18–20, August 2016.

- [18] Autogas Incentive Policies | India. *Auto-gas.net*, 2015.
- [19] Shally Mohile and Gireesh Prasad. Tata motors showcases India’s first LNG bus. *Livemint*, November 2016.
- [20] Anumita Roychowdhury. CNG programme in India: The future challenges. *Fact Sheet Series*, 2010.
- [21] Dharendra Mishra and P Goyal. Estimation of vehicular emissions using dynamic emission factors: A case study of Delhi, India. *Atmospheric Environment*, 98:1–7, 2014.
- [22] Anup Bandivadekar. India Bharat Stage VI Emission Standards. *The International Council on Clean Transportation*, pages 1–10, April 2016.
- [23] Adopting BS-VI norms will make diesel vehicles costlier? *The Hindu*, September 2016.
- [24] Anthony Shorrocks, Jim Davies, and Rodrigo Lluberás. Global Wealth Report 2015. Technical report, Credit Suisse Research Institute, Switzerland, October 2015.
- [25] Shreeja Sen and Amrit Raj. Sc lifts ban on sale of diesel cars in Delhi, imposes 1% green cess.
- [26] S. K. Paliwal. Environmental regulations for coal based thermal power plant.
- [27] Xing Zhang. Emission standards and control of PM2.5 from coal-fired power plants. *IEA Clean Coal Centre*, (37), July 2016.
- [28] Ministry of Petroleum & Natural Gas. Natural gas scenario in India. [petroleum.nic.in/docs/abtng.pdf](http://petroleum.nic.in/docs/abtng.pdf).
- [29] Matthew Wittenstein and Geoffrey Rothwe. Projected cost of generating electricity 2015 edition. Technical report, International Energy Agency, Nuclear Energy Agency, Organisation for Economic Co-operation and Development, France, September 2015.
- [30] Paul R Epstein, Jonathan J Buonocore, Kevin Eckerle, Michael Hendryx, Benjamin M Stout Iii, Richard Heinberg, Richard W Clapp, Beverly May, Nancy L Reinhart, Melissa M Ahern, et al. Full cost accounting for the life cycle of coal. *Annals of the New York Academy of Sciences*, 1219(1):73–98, 2011.
- [31] Sarath K Guttikunda and Puja Jawahar. Atmospheric emissions and pollution from the coal-fired thermal power plants in India. *Atmospheric Environment*, 92:449–460, 2014.
- [32] Ernst & Young. India: Clean development-Role of natural gas. pages 14–15, 2016.
- [33] International Energy Agency. 2016 World LNG Report. Technical report, International Gas Union, Norway, 2016.

- [34] Vikas Kaushal, Anshuman Maheshwary, Akshat Seth, and Ravi Swarup. Strategic Partnerships: The way to win in India's hydrocarbon sector - Oil & gas featured article - A.T. Kearney. *A.T. Kearney Oil & Gas: Ideas and Insights*, April 2014.
- [35] Sanjay Kumar Kar and Manish Vaid. India advancing LNG projects to bridge gas-supply gap. *Oil & Gas Journal*, 114(10):76–, October 2016.
- [36] U.S. EIA. Technically recoverable shale oil and shale gas resources: India and Pakistan. Technical report, US Energy Information Administration, September 2015.
- [37] Ministry of Petroleum & Natural Gas. *Unconventional Hydrocarbon*. 2016.
- [38] Ministry of Petroleum & Natural Gas. *Coalbed Methane*. 2016.
- [39] Pralhad Joshi. Production of Coalbed Methane (CBM). Technical report, Ministry of Petroleum and Natural Gas, August 2016.
- [40] Anupama Sen. Gas pricing reform in India: Implications for the Indian gas landscape. 2015.
- [41] Saket Sundria and Debjit Chakraborty. Global gas prices prompt India to cut domestic rates by 18%.
- [42] Ministry of Petroleum and Natural Gas. Resolution (of exploration and production policy in India). Hydrocarbon Exploration and Licensing Policy (HELP) Summary Document, March 2016.
- [43] Coyle, James J. Potential Backers Lose Interest in TAPI. *Potential Backers Lose Interest in TAPI*, August 2012.
- [44] Ian Simm. Indian Businesses Call For Iran Pipeline Action. *Oilpro*, September 2015.
- [45] Sanjay Kumar Kar and Manish Vaid. Tapi pipeline progresses, but future uncertain. *Oil & Gas Journal*, 114(5):88–, May 2016.
- [46] Tapi: A transnational pipe dream. *STRATFOR*, December 2016.
- [47] SAGE. *The Middle East to India Deepwater Pipeline*. South Asia Gas Enterprise PVT Ltd, February 2017.