Green Growth Background Paper

Draft Final Report

Green Growth Strategies for Oil and Natural Gas Sector in India

Supported by

Global Green Growth Institute

The Energy and Resources Institute

...towards global sustainable development

© The Energy and Resources Institute 2015

Suggested format for citation

T E R I. 2015
Green Growth Strategies for Oil and Natural Gas Sector in India
New Delhi: The Energy and Resources Institute. 49 pp.

Author Saahil M Parekh, Research Associate, TERI

Email: saahilm.parekh@teri.res.in

Siddharth Singh, Research Associate, TERI

Email: siddharth.Singh@teri.res.in

Reviewer Kaushik Ranjan Bandyopadhyay, Associate Professor, TERI University

Email: kaushik.ranjan@teriuniversity.ac.in

For more information

Project Monitoring Cell
T E R I
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail pmc@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

Table of contents

List of Tables

List of Figures & Boxes

1 Introduction

Resource constraints, price volatility and the climate crisis necessitate a serious re-examination of the existing resource- and carbon-intensive growth strategies being adopted globally. Asia has been the driver of growth in the past decade, witnessing a compound annual growth rate (CAGR) of 7.5% from 1990 to 2012. It is poised to grow at a rate of 5.1% up to 2040, with India leading the growth phenomenon at 6% (IEA, 2014). In order for the region to sustain high economic growth required to achieve the development goals, while keeping a check on the climate change goals, the regional governments need to chalk out strategies that improve resource efficiency of energy consumption. Projections have shown that 80% of the reduction in global carbon dioxide (CO_2) emissions will come from improving energy efficiency (IPIERCA, 2007). Thus, in order to achieve sustainable economic growth, improving efficiency and investments in natural capital should become the drivers (UNESCAP, 2012).

From 1990 until 2012, India has witnessed a CAGR of 6.5%, and its growth is expected to continue at more or less the same pace up to 2040 (IEA, 2014). However, there are questions about the sustainability of this growth. Perhaps a pertinent question that needs to be addressed is whether economic growth has reduced the disparities in income levels in the country, or increased access to energy. There is a strong correlation between human development and per capita energy consumption (TERI, 2014). India, when compared to Brazil, Russia, China, and South Africa, ranks the lowest in Human Development Index (HDI). Similarly, India's scores on the Energy Development Index (EDI), developed by the International Energy Agency (IEA), are also low. India ranks 41st among the 80 countries ranked by IEA in 2012 (TERI, 2014).

A study of India's energy sector would be worthwhile under the combined context of sustainability and economic growth. One of the fundamental principles on which the notion of sustainable development rests is the Environmental Kuznets' Curve (Stern, 2003). Theory states that various indicators of environmental degradation tend to get worse with modern economic growth until average income reaches a certain point over the course of development. A prominent example where this has been observed is China. Its economic growth pathway has been heavily carbon-intensive and many of the major Chinese cities now suffer from extreme pollution (Kahn & Yardley, 2007). There have been several efforts at a global level focused towards mitigation of climate change, while ensuring economic growth is not compromised. To do this, a new strategy needs to be formulated which can turn the trade-off between economic development and environmental protection into a win-win synergy in which 'going green' drives economic growth.

The oil and gas sector of India is one such sector which requires an overhaul. Most of the producing fields in the country have matured and oil production has more or less been stagnant in the last few years. This has led to India's demand being met by imports, which has impacted the state's finances and the nation's energy security, not to mention the unsustainable nature of energy consumption. Further, due to a techno-institutional 'carbon lock-in' of the global economy (see Box 1), the dependence on fossil fuels will remain for decades to come, even after renewables meet grid parity with coal and hydrocarbons.

Under such circumstances, the sector needs to undertake investments in improving production efficiency. India's oil and gas exploration and production (E&P) companies are already undertaking initiatives to improve energy efficiency and reduce resource wastage. While such exploration and production companies have explicitly stated sustainability and environmental goals, there are also significant cost savings in the adoption of such efficiency measures lending strong justifications for the firms.

This chapter is a review of various avenues of green growth in the oil and gas sector in India, along with selected best practices adopted globally towards making the oil and gas sector less carbon intensive. It also presents a case for the state to step in to create the necessary institutional frameworks to guide the industry to a more environmentally sound path in order to foster 'green growth' in the economy at large.

The remainder of the chapter is organized as follows. Section 2 presents an overview of India's oil and gas industry and the regulatory structure, which will help understand the avenues of green growth and contextualise the proposed policy framework presented later. Section 2 analyses the scope for and avenues of green growth. Section 3 looks at measures currently being undertaken by the domestic oil and gas industry, and global best practices in those domains. Section 4 provides a policy outlook and presents an institutional framework to improve production efficiency in the sector. Section 5 concludes.

Box 1: Carbon Lock-In and the Indian Context

The existing global economic and institutional set-up is "locked into" fossil-fuel based energy systems. This carbon lock-in has occurred globally through the systemic "co-evolution" of technology and institutions, thus creating a "Techno-Institutional Complex" (Unruh, 2000) of high fossil fuel intensity in the economy. This "co-evolution" has been driven by path-dependent increasing returns to scale. Such carbon lock-ins create market and policy failures that become roadblocks to the diffusion of carbon-saving technologies, even when they have apparent environmental and economic advantages.

In the case of India, coal provides 53% of the total energy supply; oil provides 29% and natural gas, 10% (as of 2011). In all, fossil fuels therefore contribute 92% of India's total energy supply (TERI, 2014). In fact, fossil fuels contribute to 81% of India's electricity generation, where arguably the application of alternate energy is technically most viable. The resulting carbon lock-in in India's energy system is thus apparent.

2 An overview of India's oil and gas sector

Of India's total energy supply in 2012-13, oil and gas had a share of 42.2%, at 193.4 million tonnes of oil equivalent (MTOE). Coal had the largest share in the energy mix at 54.4 % (TERI, 2014).

The country's oil and gas sector is marked by high import dependence and rising demand of these fuels. Domestic production has not been able to keep up with the growing demand, leading to a rising fuel import bill. Over the last eight years, India's imports of crude oil have increased by 8% (MOPNG, 2013). On the other hand, the nation's oil refining capacity has done much better, which has led to India becoming a net exporter of refined petroleum products.

This section of the chapter is divided into six sub-sections. The first two will look into regulatory institutions, companies in the sector, and the fiscal scenario of the sector. Next, the "upstream" sector will be looked at, which deals with the extraction of oil and gas resources, after which, the "midstream" sector, which describes the fuel transport between the extraction and refining units, and finally, the "downstream" sector, which deals with oil transformation (i.e. refining) and the final leg of the supply of oil and gas to consumers. This section will end with a brief look at the oil and gas sector in the states of Himachal Pradesh and Punjab.

2.1 Regulatory institutions and companies

The oil and gas sector in India is governed by the Ministry of Petroleum and Natural Gas (MoPNG) and is dominated by state-run firms, although the private sector has a growing share in the operations of the industry. The exploration and production of hydrocarbons is regulated by the Directorate General of Hydrocarbons (DGH). The DGH has implemented the New Exploration and Licensing Policy (NELP), which is the exploration licensing regime in India currently. India's largest E&P companies are the state-owned Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL), and private run Reliance Industries Limited (RIL) and Cairn India.

The petroleum refining segment of the industry is also dominated by public sector companies such as Indian Oil Corporation Limited (IOCL) and Hindustan Petroleum Corporation Limited (HPCL), although private sector Reliance Industries Limited (RIL) and Essar have over the past several years grown at a steady pace.

When it comes to the processing and distribution of natural gas, state-run Gas Authority of India Limited (GAIL) is the largest player in the segment. Other companies include Gujarat State Petroleum Corporation (GSPC) and private sector player Adani Gas. India's largest LNG importer is the public-sector Petronet LNG Limited. The downstream regulator is Petroleum and Natural Gas Regulatory Board (PNGRB), which regulates the pipeline infrastructure in India.

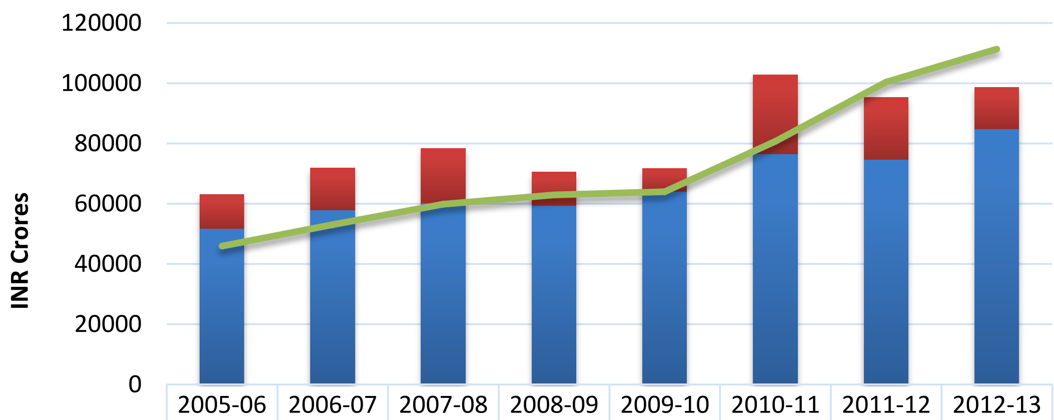
Apart from regulators DGH and PNGRB, the MoPNG has also constituted bodies to look at other aspects in the sector. This includes the Petroleum Conservation Research Association (PCRA), which promotes energy efficiency, and also conducts energy audits of industrial units, including those in the oil and gas industry. Other MoPNG-constituted bodies are the Oil Industry Safety Directorate (OISD), which works to promote safety procedures in the industry, and the Petroleum Planning and Analysis Cell (PPAC), which administers subsidies, tracks prices and disseminates data on the industry.

2.2 Taxes and subsidies

India's oil and gas sector is characterised by significant tax revenues on the one hand, and a large quantum of fuel subsidies on the other. In 2012-13, the total excise and custom duties earned by the central government from crude oil and petroleum products amounted to INR 98,599 crores. Additionally, the total sales tax collected by the state governments on crude oil, petroleum products and natural gas amounted to INR 1,11,355 crores in that fiscal year. Figure 1 shows the revenues earned through excise and custom duties from 2005-06 to 2012-13.

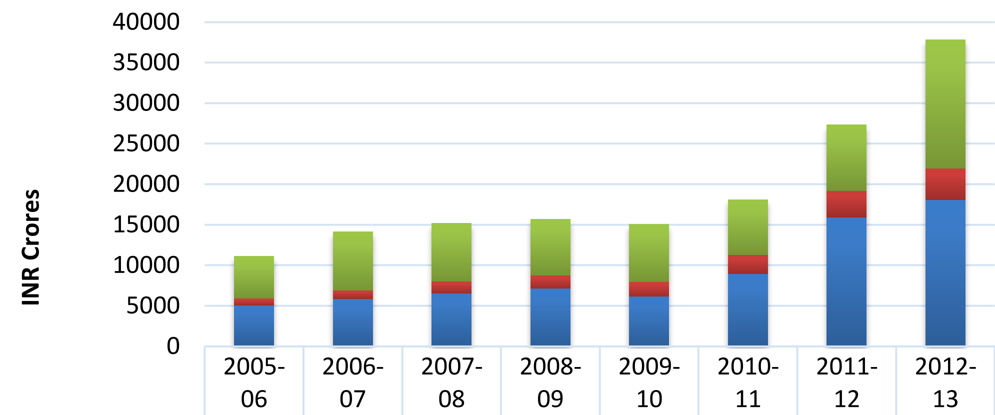
Apart from excise and custom duties, the central government also receives royalties and oil development cess from upstream oil and natural gas extraction companies. In the year 2012-13, the total royalty paid by such companies on crude oil was INR 18,082 crores and on natural gas was INR 3,880 crores. In addition to this, the oil development cess amounted to INR 15,892 crores. Note that there is no cess levied on the development of natural gas. Figure 2 shows the revenues from these three sources since 2005-06.

Petroleum subsidies touched INR 96,880 crores in 2012-13. It is a significant rise since 2008-09, when it was only INR 2,852 crores. In order to curb the unsustainable growth of subsidy payments, the government has recently begun to deregulate the prices of petroleum products and intends to boost domestic production in order to reduce the size of the current account deficit, which has grown primarily due to rising fuel imports. Figure 3 shows the petroleum subsidies budgeted by the Government of India from 2005-06 to 2013-14.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Custom Duties	11394	14009	18142	11174	7755	26282	20520	13703
Excise Duties	51749	57884	60231	59383	64012	76546	74710	84896
Sales Tax	45934	53086	59890	62962	63949	80709	100375	111355

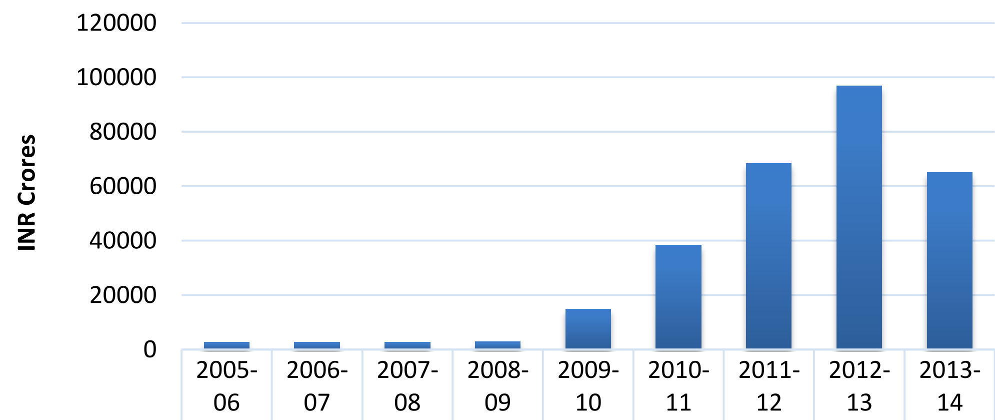
Figure 1: Custom and Excise duties on crude and refined petroleum products between 2005-06 and 2012-13
Source: MoPNG, 2013



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Oil Development Cess	5195.62	7177.34	7156.26	6885.8	7096.05	6782.6	8118.83	15892.26
Royalty Paid on Natural Gas	863.66	1074.75	1486.85	1624.21	1799.79	2355.23	3294.07	3880.24
Royalty Paid on Crude Oil	5067.4	5857.2	6544.33	7155.02	6154.93	8957.95	15921.38	18082.09

Figure 2: The royalties paid on oil and natural gas, and the oil development cess received from E&P companies

Source: MoPNG, 2013



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Petroleum Subsidy by the Government of India	2683	2724	2820	2852	14951	38371	68484	96880	65000

Figure 3: Petroleum subsidies budgeted by the government of India[1]

Source: MoPNG, 2013

2.3 Upstream: Domestic Oil and Gas production

2.3.1 Oil

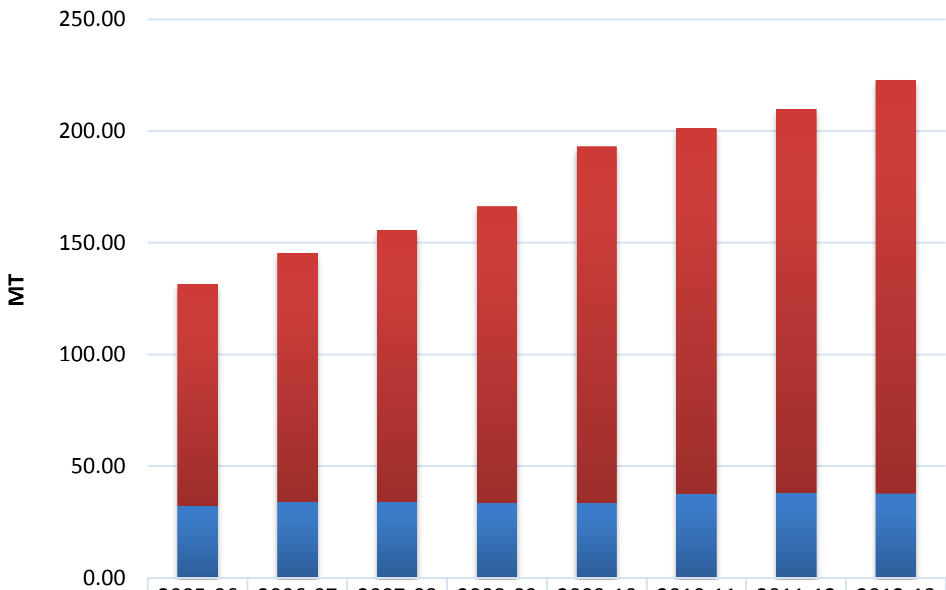
Led by growing demands, India's crude oil supply increased at a CAGR of 6.8 % since 2005-06, reaching 222.6 million tonnes (MT)[2] in 2012-13 from 131.6 MT in 2005-06. However, in this period, domestic production has grown by only 2% CAGR, from 32.19 MT in 2005-06 to

[1] 2013-14 is a budget estimate, 2012-13 is a revised estimate while the rest of the years are actual subsidies eventually paid out. The budget estimates have traditionally been unrepresentative of the actual subsidies eventually paid out.

[2] The authors have used this notation throughout the chapter. However, an alternate notation for the same unit is million metric tonnes (MMT).

37.86 MT in 2012-13. Consequentially, India's crude oil imports have had to rise at a CAGR or 8.1 %, from 99.41 MT to 184.8 MT in this period. The crude oil import dependence has thus risen from 75.5% to 83%. Figure 4 shows domestic production and imports of crude oil from 2005-06 to 2013-14.

Domestic production growth has largely come from the private sector. The production of crude oil by the public sector fell by 1.4 MT, from 27.6 MT in 2005-06 to 26.2 MT in 2012-13. This translates to a fall in the share of the public sector from 85.9% to 69.3%. This fall in public sector production came largely from ONGC, which is India's largest exploration and production company, whose production fell by 1.9 MT, from 24.4 MT to 22.5 MT in this period (MOPNG, 2013). This can be attributed to the falling production of the fields operated by ONGC and OIL, all of which have passed their peak levels (TERI, 2014), including the Bombay High fields operated by ONGC, which has the largest production share in India. On the other hand, the private sector grew remarkably from producing 4.5 MT to 11.6 MT of crude oil, raising its share to 30.7 % of India's output in 2012-13 from 14.1 in 2005-06 (MOPNG, 2013). This growth in production comes largely from the rise in production by private sector player Cairn India in the Rajasthan fields, the production of which began in the year 2009. Figure 5 shows the domestic production trend from 2005-06 to 2013-14.

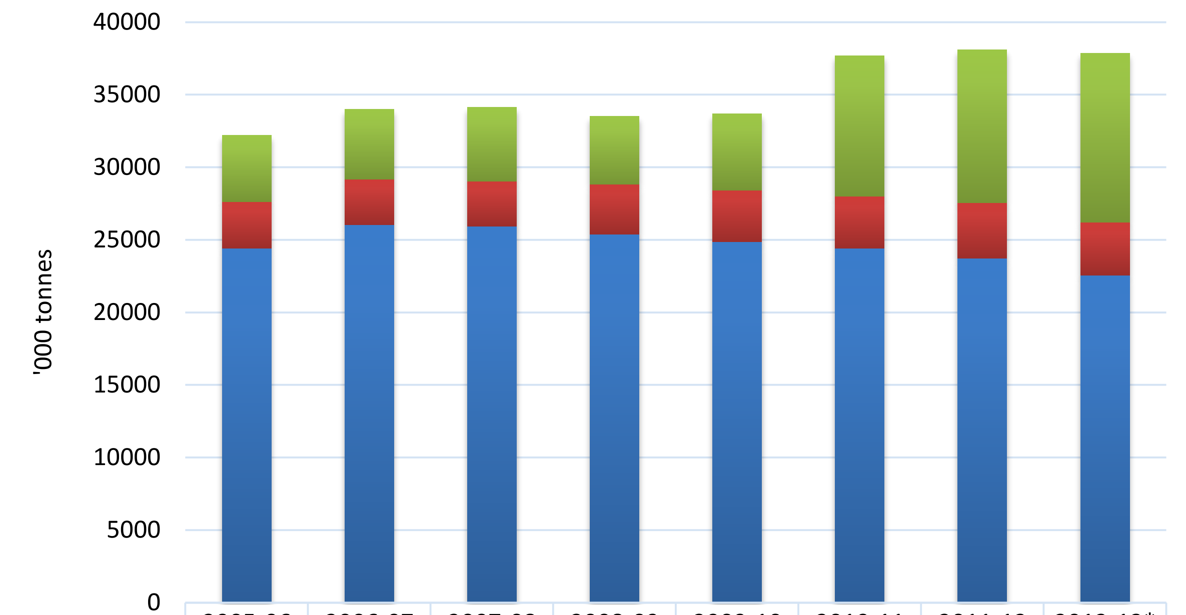


	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Crude oil imports	99.41	111.5	121.67	132.78	159.26	163.6	171.73	184.8
Domestic crude oil production	32.19	33.99	34.12	33.51	33.69	37.68	38.09	37.86

Figure 4: Domestic production and imports of crude oil

Source: MoPNG, 2013

India's domestic crude oil output is sourced nearly evenly from onshore and offshore fields. The onshore fields contribute to 51.3 % while offshore fields contribute to 48.7 % of the crude oil production. However, India's offshore production largely comes off the West coast, where the Bombay High fields are located. The onshore production overwhelmingly comes from Gujarat and Rajasthan, which contribute to 71.6 % of the onshore production, followed by Assam which contributes to 25 % of the onshore production.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13*
Private/JV	4552	4830	5077	4674	5263	9682	10527	11640
OIL	3234	3107	3100	3468	3572	3582	3847	3661
ONGC	24404	26051	25941	25366	24855	24420	23716	22561

Figure 5: Company-wise domestic crude oil production

Source: MoPNG, 2013

2.3.2 Natural gas

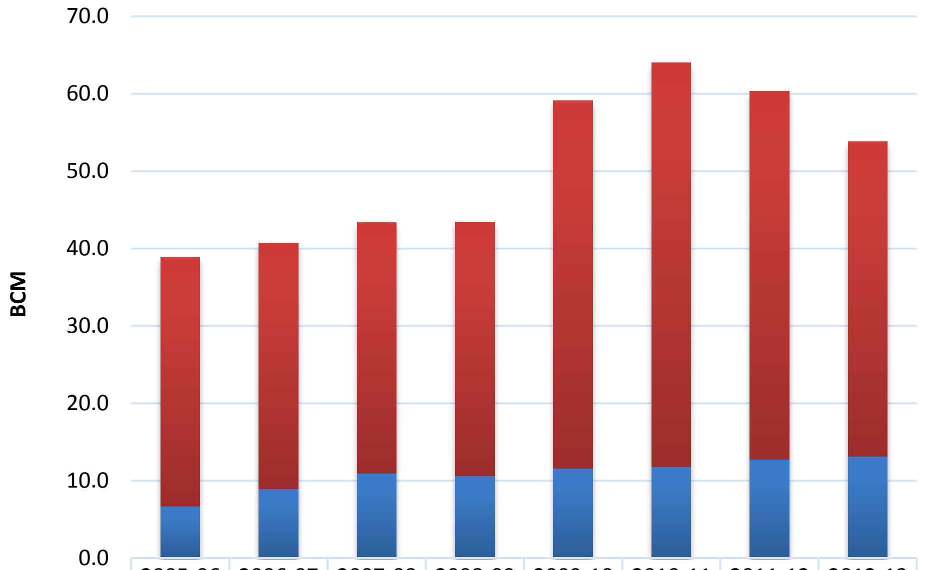
India's natural gas supply, on the other hand, is dominated by domestic production, although the quantum of liquefied natural gas[3] (LNG) imports has risen from 6.6 billion cubic metres (BCM) in 2005-06 to 12.1 BCM in 2012-13, which translates to a compound annual growth rate (CAGR) of 8.9 %. Imports thus formed 24.4 % of the total supply in 2012-13. Domestic production of natural gas, on the other hand, has risen from 32.2 BCM in 2005-06 to 40.7 BCM in 2012-13. However, production peaked in 2010-11 at 52.2 BCM, and production has fallen at a CAGR of 3.1 % since. Figure 6 shows domestic natural gas production and LNG imports from 2005-06 to 2013-14.

Natural gas production has traditionally been dominated by ONGC through its Bombay High fields off the western coast and Oil India Limited's (OIL's) onshore Assam fields. With Reliance Industries Limited's (RIL's) KG-D6 block becoming operational in 2009, India's domestic production of natural gas grew significantly since 2008-09. The overall decline of production since is attributed to the decline in production from the KG-D6 field.

As of 2012-13, 53.1% of the total production in India came from the western offshore fields where ONGC's Bombay High is located, while 25.1% of it came from the eastern offshore, where RIL's KG-D6 is located. Offshore fields therefore contributed to 78.2% of the total output. Onshore production mainly came from Assam, which contributes to 32.8% of the

[3] Natural gas (which is predominantly methane) can be transported either in the gaseous form through pipelines, or in a liquid state by cooling it to −162 °C. In a liquid state, natural gas takes over 600 times less storage space, and is thus convenient to transport via ship where pipelines do not or cannot exist.

total onshore production, followed by Gujarat with 22.9% of the onshore production. Tamil Nadu, Andhra Pradesh, Rajasthan and Tripura are other major onshore natural gas producing states.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Domestic natural gas prodution	32.2	31.7	32.4	32.8	47.5	52.2	47.6	40.7
LNG Imports	6.6	8.9	10.9	10.6	11.6	11.8	12.7	13.1

Figure 6: Domestic natural gas production and LNG imports

Source: MoPNG (2013)

2.4 Midstream: oil and gas pipelines and gas imports infrastructure

The midstream sector comprises of the transport infrastructure, which includes crude oil and natural gas pipelines, pumping stations, ports and regasification facilities at LNG terminals.

2.4.1 Crude oil pipelines

Crude oil pipelines connect the centres of hydrocarbon extraction to refineries. India's crude oil pipeline length as of 2013 was 9785 km. ONGC and IOCL operate three crude oil pipelines each. Additionally, Hindustan Mittal Energy Limited (HMEL), BPCL, IOCL and Cairn operate one each. Figure 7 shows a map of the crude oil pipelines in India.

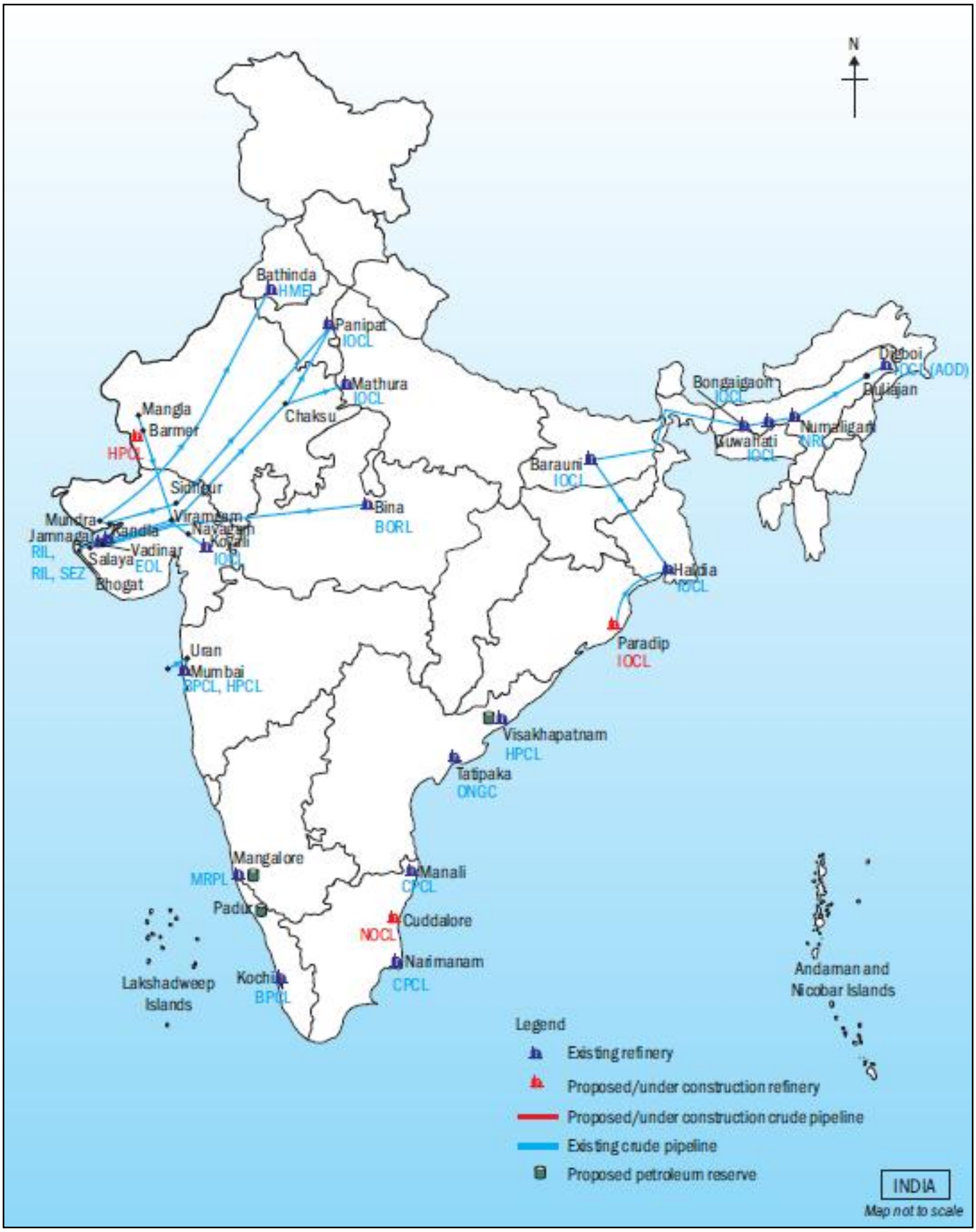


Figure 7: Existing and proposed crude oil pipelines and refineries

Source: TEDDY 2013-14, TERI (2014)

2.4.2 Natural gas import infrastructure and pipelines

As discussed above, India's LNG imports have been rising. This has been made possible by the port infrastructure as well as natural gas pipelines. Port infrastructure primarily includes re-gasification terminals and supplementary facilities. Currently, India has such terminals in

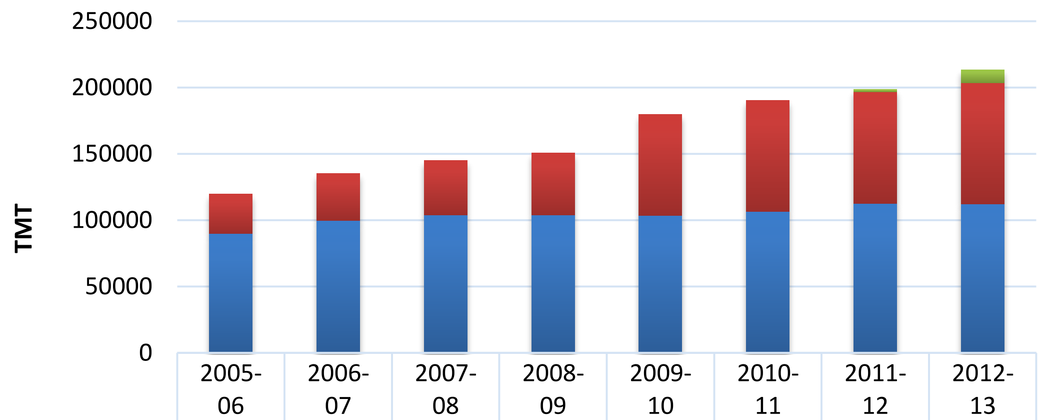
Dahej (run by Petronet LNG) and Hazira (run by Shell) in Gujarat, Dabhol (RGPL) in Maharashtra and Kochi (Petronet LNG) in Kerala. They have a combined capacity of over 23.6 million tonnes per annum (MTPA). There are others under construction in Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh and Orissa with a combined capacity of over 23.5 MTPA.

The existing LNG terminals are connected to each other via pipelines and to major cities including Delhi. These pipelines were close to 15,283 km in length in 2013 and most of them are operated by GAIL. Other pipelines are under construction from existing as well as from the proposed terminals, criss-crossing the country, including all the way up to Srinagar in Kashmir. These new pipelines would increase the length of natural gas pipelines further by 12,650 km (TERI, 2014). A map of the existing and proposed natural gas infrastructure is shown in Figure 9.

2.5 Downstream: refining and the final legs of supply

2.5.1 Refining

There are 22 refineries in India, 17 of which are owned by public sector companies. However, the three private sector refineries contribute to 37% of India's total refining capacity. The other two refineries are joint ventures. The public sector IOCL operates eight refineries in all, including India's oldest - the Digboi refinery in Assam which was commissioned in 1901. The private sector refineries are on average much larger in refining capacity than the rest, with the largest one being RIL's Jamnagar refinery in Gujarat with a capacity of 33 MTPA. Figure 8 shows production of petroleum products in India by Joint ventures, private sector and by public sector.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Joint Ventures							1716	9692
Private Sector	29957	35546	40921	46583	76127	83887	84328	91197
Public Sector	89793	99714	104009	103933	103641	106429	112518	112329

Figure 8: Production of petroleum products in India

Source: MoPNG (2013)

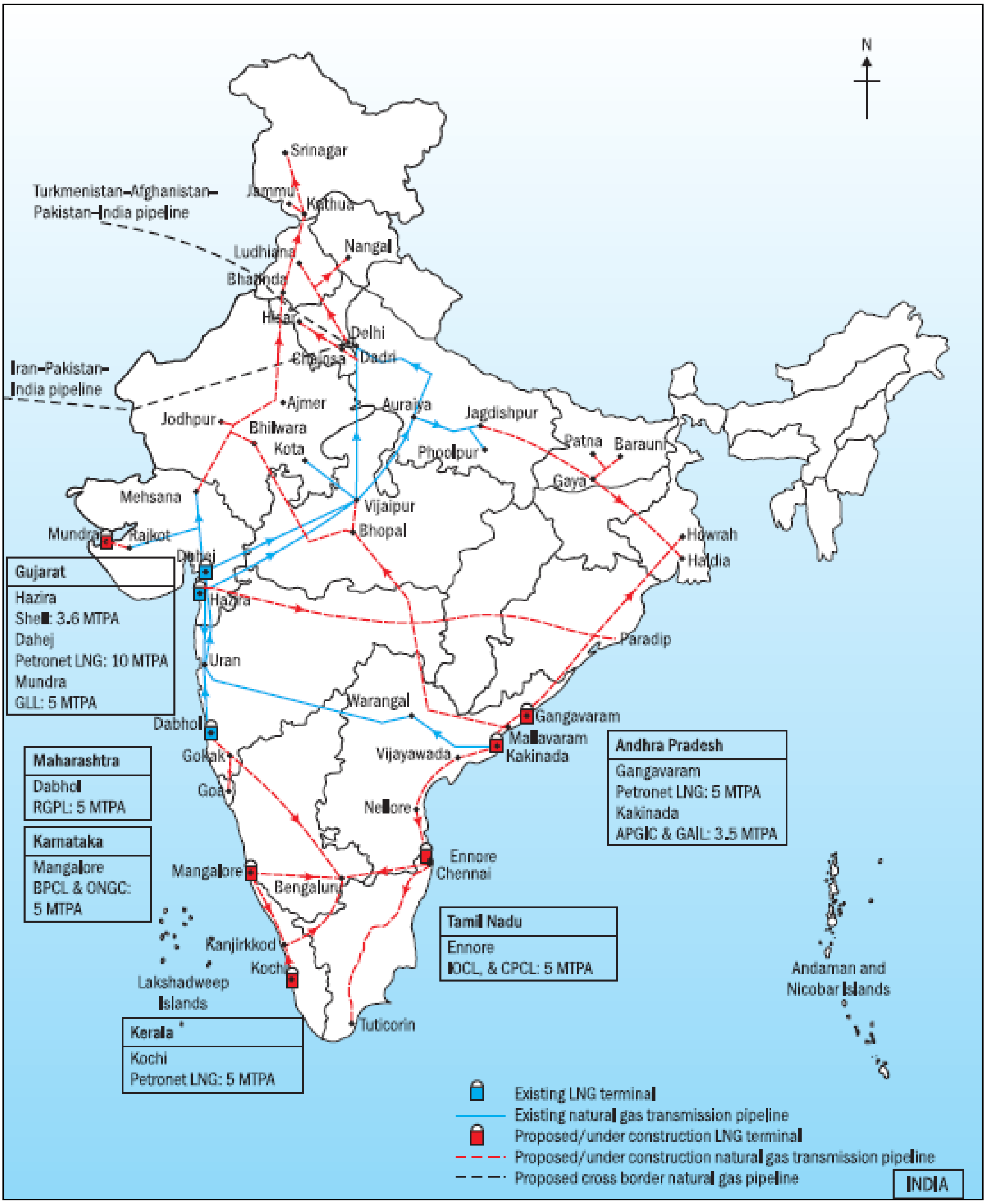


Figure 9: Existing and planned LNG facilities and pipelines

Source: TEDDY 2013-14, TERI (2014)

Overall, the production of petroleum products in these refineries has being growing over the past decade. However, production growth has come largely from the private sector, which has grown from producing 29,957 thousand metric tonnes (TMT) of petroleum products in 2005-06 to 91,197 TMT in 2012-13 (MOPNG, 2013). In this period, two of the three private sector refineries were commissioned (RIL-SEZ Jamnagar in 2008 and Essar Vadinagar in

2006). No new public sector refinery was commissioned in this period, although a few new ones are under construction (TERI, 2014).

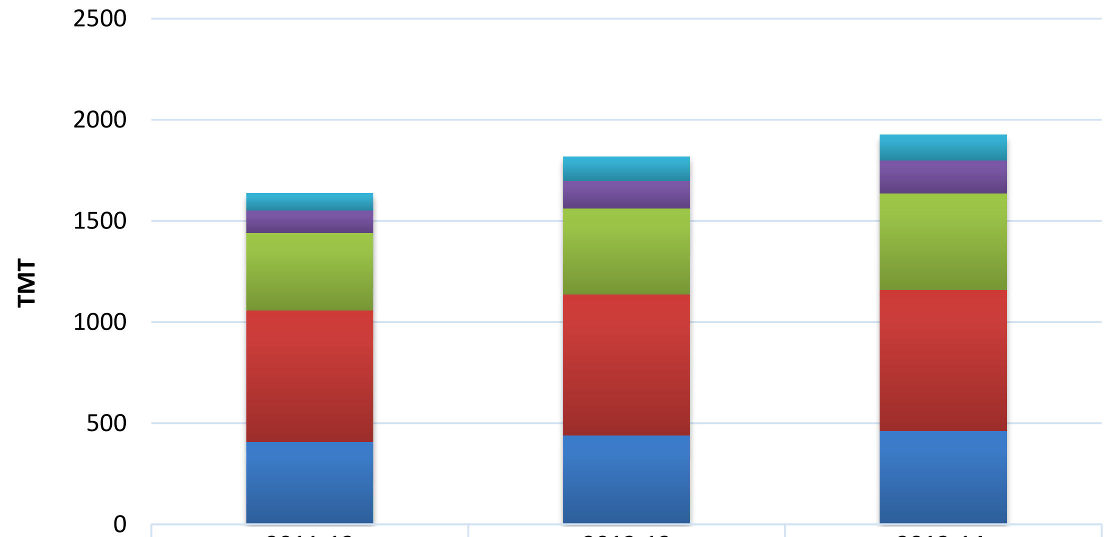
2.5.2 Petroleum product pipelines and fuel retail outlets

A majority of petroleum product pipelines are operated by IOCL, while HPCL is the second largest operator of such pipelines. India's total petroleum pipelines measure around 14,000 km in length (MOPNG, 2013). They connect refineries to major centres of demand (TERI, 2014).

This refined petroleum is then sold at retail outlets, of which there are over 46,000 in India as of 2013, up from over 25,000 in 2005. IOCL again leads in this category, with over 22,000 such retail outlets in 2013 (MOPNG, 2013).

2.5.3 City gas distribution

City gas distribution network exists in 10 Indian states, across 37 cities. Over 2.5 million homes and commercial establishments have access to piped natural gas (PNG) in India. The total compressed natural gas (CNG) sales in India rose from 1.6 MT in 2011-12 to 1.9 MT in 2013-14. The total number of CNG stations in India was 966 in March 2014, and the total number of CNG vehicles was 2.22 million. Figure 10 shows CNG sales from 2011-12 to 2013-14 and Table 1 shows the city gas distribution in India.



	2011-12	2012-13	2013-14
Other	83.9	118.1	126.8
U.P.	112.6	137.7	162.6
Maharashtra	382.8	425.1	476
Delhi	649.3	695.1	697.6
Gujarat	409.1	441.8	463.5

Figure 10: CNG sales (as of March 2014)

Source: PPAC (2014)

Table 1: City gas distribution in India (as of March 2014)

State	PNG City Covered	Companies	Domestic PNG	CNG Stations in the state
Delhi	Delhi, Noida, Greater Noida, Ghaziabad.	IGL	4,34,009	325
Maharashtra	Mumbai, Thane, Mira-Bhayandar, Navi Mumbai, Pune, Kalyan, Ambernath, Panvel, Bhiwandi	MGL, MNGL	7,18,550	198
Gujarat	Ahmedabad, Baroda, Surat, Ankaleshwar	GSPC, Sabarmati Gas, Gujarat Gas, HPCL, VMSS, Adani Gas	12,97,068	334
Uttar Pradesh	Agra, Kanpur, Bareilly, Lucknow,	Green Gas Ltd., CUGL	11,298	35
Tripura	Agartala	TNGCL	14,650	4
Madhya Pradesh	Dewas, Indore, Ujjain, Gwalior	GAIL, AGL	2,583	16
Rajasthan	Kota	GAIL	189	2
Assam	Tinsukia, Dibrugarh, Sibsagar, Jorhat	Assam Gas Co. Ltd.	26,043	0
Andhra Pradesh	Kakinada, Hyderabad, Vijaywada, Rajamundry	BGL	2,102	30
Haryana	Sonepat, Gurgaon, Faridabad	Gail Gas, Adani Gas, Haryana City Gas	17,124	15
Total			***25,23,616***	***966***

GSPC - Gujarat State Petroleum Corporation; VMSS - Vadodara Mahanagar Seva Sadan; TNGCL - Tripura Natural Gas Company Limited; AGL - Aavantika Gas Limited; BGL - Bhagyanagar Gas Limited;
Source: PPAC, 2014

3 Avenues of green growth in the oil and gas sector

Oil and gas together are the world's leading fuels, providing 57% of the global demand of energy (BP, 2014). This demand for oil and gas is set to rise as populations around the world increase and growth in developing countries is achieved. Figure 11 shows projections for fuel-wise demand of primary energy. Oil remains the single largest energy source throughout the projection period, though its share of total demand falls from 31% in 2012 to 26% in 2040 – just ahead of coal and natural gas.

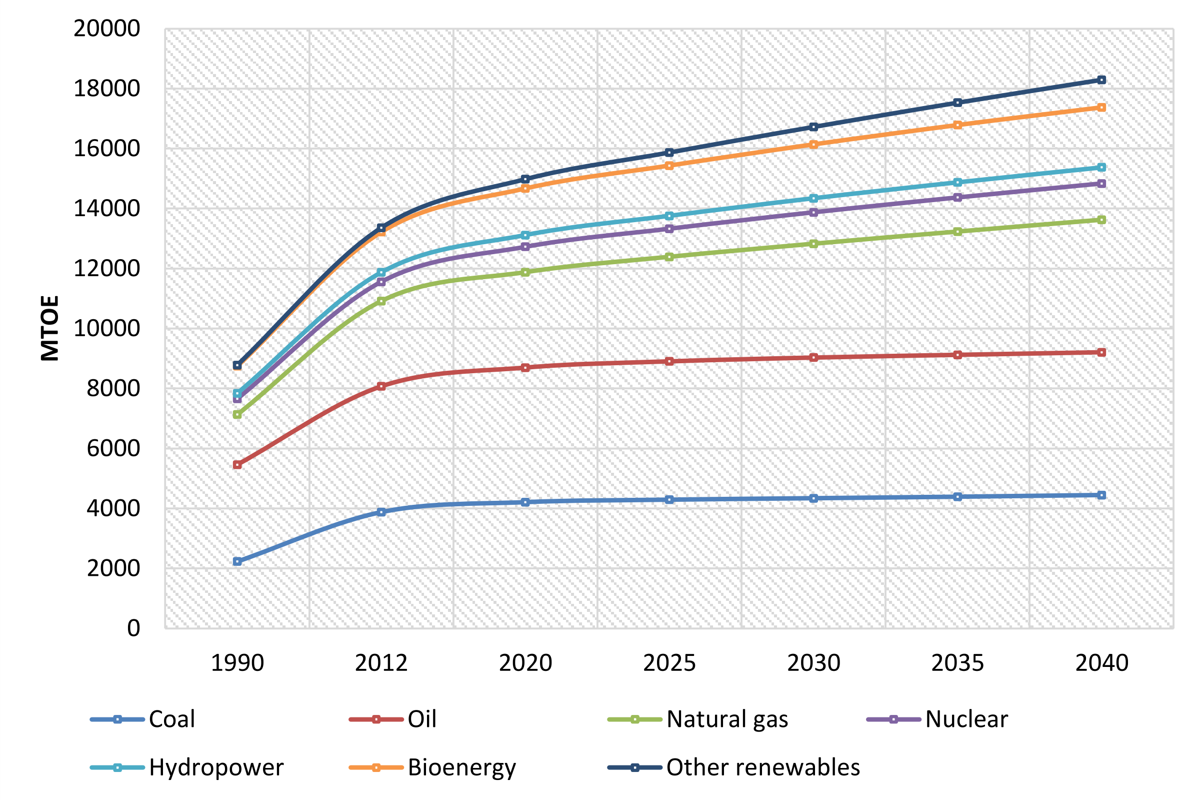


Figure 11: World primary energy demand projections

Source: World Energy Outlook 2014, International Energy Agency

3.1 Oil and gas supply projections for India

While oil and gas together provided for 37% of India's energy needs in 2013 (coal remains the primary source of energy, at 55%), this figure is poised to increase as the Indian economy undergoes rapid urbanization and petroleum product demand increases through the transport and industrial sectors. TERI (2014) has analysed three different scenarios for India's future energy basket in their Energy Security Outlook. Figure 12 exhibits the projected domestic crude oil production; and Figure 13 illustrates the projected domestic natural gas production. Figure 14 shows projections of the oil and gas sector contribution to India's primary energy supply. Broadly, oil consumption is seen to increase much faster than natural gas consumption under all three scenarios. However, the projected contribution of the oil and gas sector to the energy basket remains constant at 39%. The dependence of the Indian economy on oil and gas and the consequential carbon lock-in is thus evident. The three scenarios are described in details below.

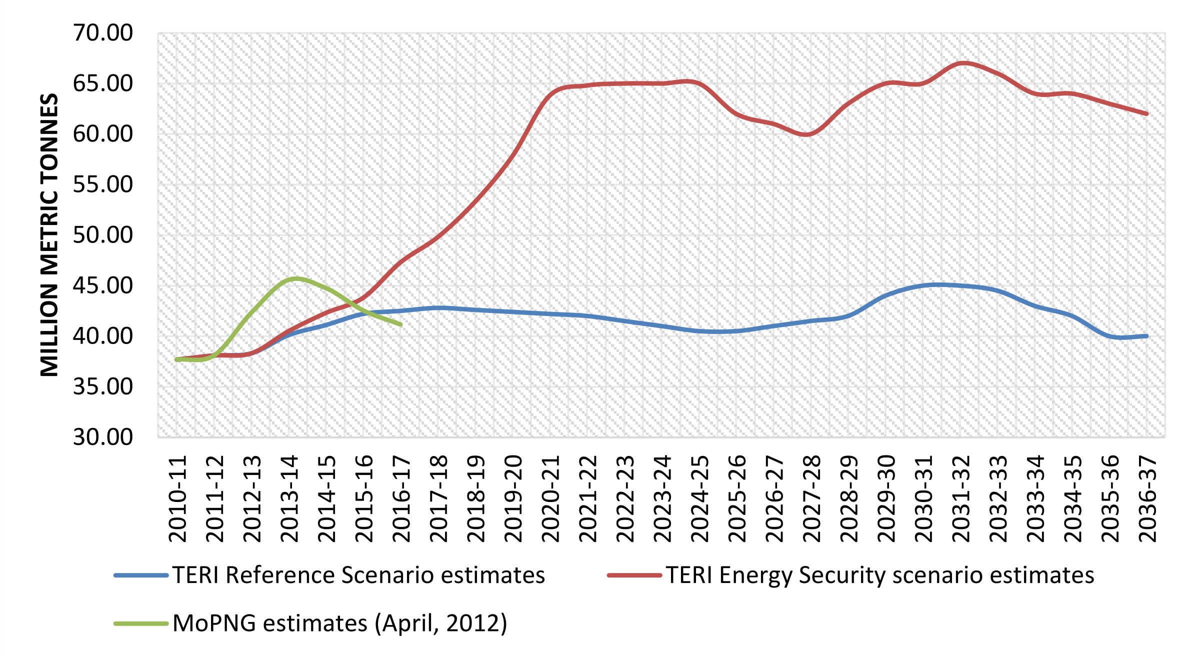


Figure 12: Projected Domestic Crude Oil Production

Source: TERI analysis, Petroleum & Natural Gas Statistics, MoPNG

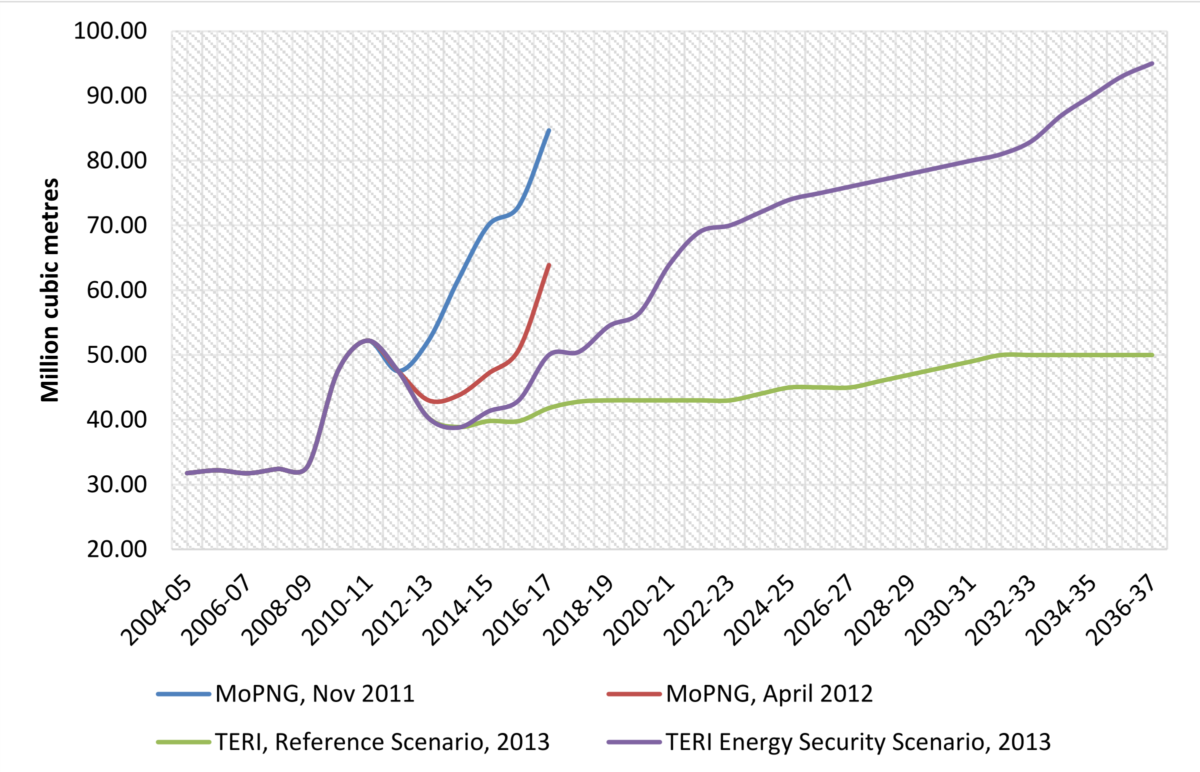


Figure 13: Projected Domestic Natural Gas Production

Source: TERI estimates, Petroleum and Natural Gas Statistics, MoPNG

3.1.1 Reference Energy Scenario (RES)

The Reference Energy Scenario (RES) provides a trajectory that shows how the nation's energy pathway would evolve if current trends in energy demand and supply are not changed. It takes into account existing policy commitments and assumes that those recently announced are implemented. RES projections have been undertaken keeping in mind the following assumptions in the short and medium terms.

3.1.1.1 Short term (up to 2021-22)

- ONGC's offshore crude output will remain constant. The gradual decline in output from Bombay High and Heera fields will be compensated by production from the new oil discovery in the contiguous D1 field. The onshore crude output, on the other hand, will continue to decline steadily. ONGC's gas output will stay constant and increase moderately after 2015-16 due to new discoveries coming on-stream.

- OIL's onshore output from Assam will continue to decline gradually. However, the company's new exploration in Rajasthan will help the company maintain crude production at around 4.5 MT. Natural gas output will stay constant at 3 BCM till 2018-19.

- Private/JV onshore crude output will increase steadily up to 10 MT in 2015-16 driven by an increase in production by Cairn from Rajasthan. Offshore crude output by private/JV companies will continue to decline as has been the case over 2000-01 to 2011-12. Private/JV companies' production of natural gas will remain constant at 11 BCM from 2016-17, with reduction in D6 output being somewhat arrested by increase in Cairn's natural gas output from Rajasthan and other private/JV discoveries. Reliance's KG-D6 gas output will continue to fall steadily.

3.1.1.2 Medium-Long term (2021-22 to 2036-37)

- Total crude oil production will remain relatively stagnant at a little above 40 MT over 2021-22 to 2036-37. Domestic crude production will rise slightly from 2026-27 to 2031-32, plateau off and then decline after 2031-32. This is in keeping with the estimated production trend over the previous decades.
- The only addition in natural gas production in the medium-long term will be from unconventional gas resources (especially Coal Bed Methane). As a result, domestic gas production will rise insignificantly. Domestic production is assumed to be 45 BCM in 2026-27 and will rise up to 50 BCM in 2031-32 and stay constant at this level till 2036-37.

3.1.2 Energy Security Scenarios (ESM and ESA)

The Moderate Energy Security Scenario (ESM) enables one to envisage an energy trajectory of the nation that would ensure energy security in the future. This in broad terms implies that efforts are provided here for energy efficiency improvements both on the supply and demand sides. There is an accelerated push for diversifying the energy mix, fuel substitution, and penetration of new technologies, met with moderate reduction of imports.

The Ambitious Energy Security Scenario (ESA) considers energy security to be paramount. The main objective is to drastically reduce the energy imports of the country by 2031. This entails faster implementation of efficiency measures, rapid penetration of new technologies, and increased electrification of the economy. The role of renewables is crucial in this scenario. ESM and ESA projections have been undertaken keeping in mind the following assumptions.

3.1.2.1 Short term (up to 2021-22)

- ONGC will arrest the decline in production from Bombay High and Heera fields and ramp up offshore production through its new discovery in the contiguous D1 field. Its offshore crude oil production will increase to 18 MT in 2015-16 and finally to 25 MT in 2021-22. It will be able to maintain its onshore production constant at the level reached in 2012-13 (7.2 MT) till 2021-22. In the natural gas sector, it will be able to increase its output beyond what has been envisaged in the Reference scenario. The company's total production will reach 30 BCM in 2016-17 and up to 40 BCM in 2020-21.

- OIL's new discovery in Rajasthan (which is slated to produce around 30,000 barrels of oil per day) will help the company ramp up its onshore crude production to 5.5 MT. It will be able to increase its natural gas production to 4 BCM as against 2.8 BCM assumed in the Reference Scenario. MoPNG estimates that OIL will be able to produce 4.2 BCM by 2016-17. However, the projections assume a slightly more conservative view.

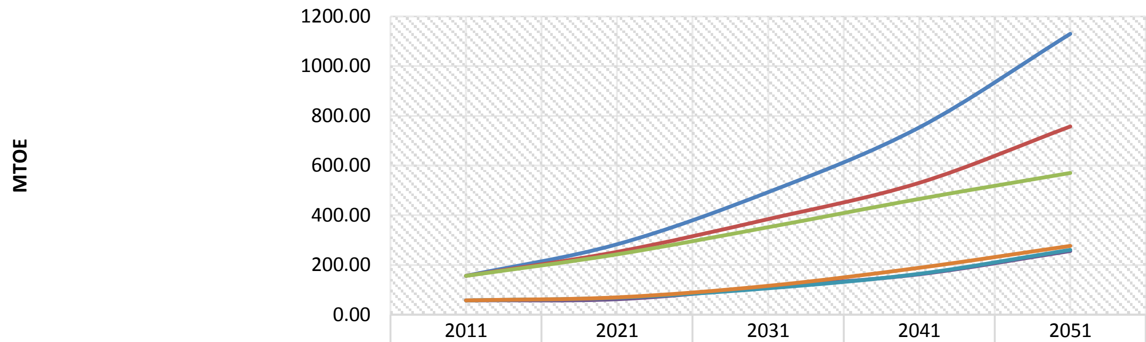
- Private/JV onshore production will increase more than what has been assumed in the reference scenario. Total private/JV onshore production will reach 10 MT in 2015-16 and increase to 13 MT in 2020-21 and 2021-22. Reliance will be able to arrest decline in KG-D6 production and then turn around its production due to commercialisation of new discoveries in this basin. In the ES scenario, the government's gas pricing policy will be reworked to encourage more competition and increase private investment. Therefore, overall private/JV production will increase to 17 BCM in 2016-17 and to 25 BCM in 2021-22.

3.1.2.2 Medium-Long term (2021-22 to 2036-37)

- The increase in crude oil production till 2021-22 will plateau off at 65 MT and decline in 2025-26 and 2026-27. Aggressive private investment in domestic E&P (facilitated by enabling government policies), combined with some new oil discoveries will allow India's domestic crude oil production to rise from a trough of 60 MT in 2026-27 to reach a peak of 67 MT in 2031-32. Thereafter, production is assumed to decline to 62 MT in 2036-37.

- The Krishna-Godavari basin will produce well above the current levels due to application of improved technology to enhance gas recovery. Aggressive investment will be undertaken by domestic private players (RIL, GSPC) and international players (British Petroleum). Significant increase in non-conventional gas (especially coal bed methane) production will assist in increasing domestic production up to 80

BCM in 2031-32 and finally to 95 BCM in 2036-37. Year-on-year increments are assumed to occur at a steady rate of 1-2 BCM till 2031-32, with a spurt of 15 BCM in the period between 2031-32 and 2036-37 due to production of non-conventional gas.



	2011	2021	2031	2041	2051
Reference Scenario (Oil)	156.28	283.29	492.92	753.10	1129.65
Moderate Energy Security Scenario (Oil)	156.33	252.76	384.44	530.46	757.01
Aggressive Energy Security Scenario (Oil)	156.27	242.87	351.92	465.71	570.18
Reference Scenario (Gas)	57.75	62.51	110.91	162.74	256.29
Moderate Energy Security Scenario (Gas)	57.75	68.62	106.41	164.67	260.80
Aggressive Energy Security Scenario (Gas)	57.75	69.82	116.20	188.82	276.81

Figure 14: India's primary energy supply scenarios – Business as usual & energy security scenario

Source: TERI analysis

3.2 Rationale for green growth

Projections of world energy-related CO_2 emissions abatement by IEA show that energy efficiency measures account for about half of cumulative CO_2 emissions savings, with the share being even higher in the short term. The largest efficiency savings in 2040 come from end-use sectors, with buildings accounting for most (37%), followed by transport (32%) and industry (28%). Efficiency gains in energy supply, including power plants, transmission and distribution, refineries, and oil and gas extraction, are responsible for 9% of cumulative savings throughout the projection period. Table 2 shows projections of world energy-related CO_2 emissions abatement.

Thus, saving energy through improved efficiency has a central role to play in inclusive and sustainable growth. The cost to implement policies directed towards increasing energy efficiency might be steep, but it can be offset by the positive spill-over effects of decreased emissions that will come from reduced fuel consumption (IPIERCA, 2007).

The remaining 23% reduction, which comes from increasing use energy from renewable sources and nuclear power, should also be a prerogative of the fossil fuel sectors. To this extent, various companies in India have undertaken initiatives for developing and harnessing renewable sources of energy for their internal energy consumption, thereby minimizing the use of conventional sources of energy. Apart from measures to increase efficiency and deployment of renewable technologies, oil and gas companies have also undertaken various initiatives, such as waste and water management, to mitigate other environmental risks.

Table 2: World energy-related CO_2 emissions abatement

CO_2 abatement	**2020**	**2040**
Energy service demand	19%	11%
End-use efficiency	46%	39%
Supply efficiency	9%	11%
Fuel and technology switching in end-uses	2%	3%
Renewables	17%	24%
Biofuels	3%	3%
Nuclear	3%	7%
CCS	1%	2%

Source: World Energy Outlook 2014, International Energy Agency

Such initiatives have not been unorganized or unplanned. The public sector oil and gas companies have come up with their own action plan to enable India meet its emission reduction targets, which were voluntarily committed to by the Government of India. Under the ambit of the National Action Plan for Climate Change (NAPCC), the government had stated that it would aim to reduce carbon emission intensity in India by 20-25 % by 2020 over the emission intensity of 2005.

These companies have in turn incorporated emission reduction and water management goals in to their sustainability policies. As a part of such policies, these companies allocate adequate budgetary resources to promote and implement various sustainable development projects on an annual basis. These projects are targeted towards mitigation of environmental risks through investments in increasing energy efficiency, development of renewable technologies to aid conventional oil and gas production, and management of waste and water resources.

ONGC, for instance, states that its sustainability vision is to "gradually work towards reducing carbon and water footprint, innovate beyond compliance management of waste and prudent energy management and biodiversity conservation". It adds that "sustainable management of water, materials and energy, and addressing climate change through carbon management are the key broad responsibilities towards environmental sustainability" (ONGC, 2013).

Box 2: Sustainable development policy of OIL

OIL's sustainability policy lists out goals within the three pillars of sustainability it identifies, which are the environment, society and economics.

Environment

- Adheres to the requirements of national environmental laws and regulations, international standards and industry guidelines at all times.
- Preserves biodiversity, especially in its areas of operation.
- Continuously strives for reduction of its carbon and water footprints so as to combat the challenges of climate change.
- Continuously strives for improvement of energy efficiency in its operations.
- Explores avenues of alternate energy sources and cleaner technologies.
- Committed towards reducing the risk of accidents and oil spills in operations.

Society

- Engages with the local communities to constantly work towards sustainable social, economic and institutional development of the region where it operates.
- Strives for excellence in business as well as human resource through quality, health and safety in every aspect.

Economics

- Adheres to the highest standards in ethical business practices and sound systems of corporate governance.
- Diversifies as an integrated energy company with footprint into non-conventional energy like coal-bed methane (CBM), shale gas, shale oil, LNG etc.
- Incorporates sustainable development considerations within corporate decision making process.

Note: *The boxes containing information on various initiatives by public sector oil and gas companies have been obtained from the annual sustainability reports of these companies. These can be found in the References section at the end of the chapter.*

Similarly, the sustainable development policy of OIL states that the company "aims to bring about inclusive growth to its stakeholders by promoting and implementing projects of sustainable development and integrating its diverse activities under the three pillars of sustainability – environment, society, and Economics." OIL further elaborates on its "three pillars", details of which are in Box 2 (OIL, 2013).

All major upstream and downstream oil and gas firms have such sustainability policies which play around similar themes. For instance, natural gas supply leader GAIL's "Sustainable Aspiration 2020" has targets related to the reduction of emission intensity, improvement of energy efficiency, and fresh water and waste recycling. Box 3 gives a snapshot of GAIL's sustainability targets.

In order to meet such targets, these companies have dedicated carbon management and sustainability groups that oversee various sustainable development projects, facilitate impact assessment and subsequent value generated by the projects. ONGC, for example, has a team that overlooks all sustainable development projects undertaken by the company. This team is supported on-site by Sustainable Development Officers (SDOs), with whom the core team ensures rigorous interaction for training and awareness on sustainability issues. Similarly, GAIL has a Sustainable Development Board which undertakes the planning and execution of the projects, and monitors the on-site team implementing it.

Box 3: GAIL's Sustainability Aspirations 2020

Sustainability Focus Area	Aspiration 2020	Action Plan
Reduction in green-house gases (GHG) emissions intensity (Scope 1 and Scope 2)	33% reduction in greenhouse gas (GHG) emission intensity (total GHG emission/gross sale) in comparison to the baseline year (2010-11)	• Process optimizations • Reduction in fugitive emissions and venting of GHG in operations • Afforestation to sequester GHG emissions from operations
Energy efficiency	5% reduction in specific energy consumption in comparison to the baseline year (2010-11)	• Adoption of Integrated Energy Management Systems • Incubation of internal energy audit groups at corporate and site level • Focused energy audits • Adoption of energy efficient technologies • Enhanced adoption of renewable energy • Reduction in flaring and flare gas recovery
Fresh water consumption and waste water recycling	• 45% reduction in water consumption intensity (Total water consumption/Gross sales) in comparison to the baseline year (2010-11) • 5% increase in waste water recycling from current levels of 45% in the baseline year (2010-11)	• Establishing a robust water accounting systems at all operational units • Increased focus on utilizing treated waste water to meet plant process requirements • Impetus on rain-water harvesting at all sites • Robust water audits to establish improvement opportunities and minimize losses

Projects with a possibility of large-scale application are usually undertaken as pilots in various sites. After successful implementation, they are eventually scaled up for the entire organization.

While the sustainability projects that these companies have undertaken are a part of their larger policies, many of them also have economic merits. However, in spite of measures already being taken, the government has a role to play in further fostering the adoption of a framework that promotes green growth in the form of greater efficiency of resource use and carbon reduction.

In order to look at the specific avenues of green growth within the industry, the next sub-section looks at the oil and gas value chain and identifies channels where policy frameworks promoting sustainability can be adopted.

3.3 Assessing the oil and gas value chain

The oil and gas industry not only produces energy, but is also a major consumer of energy. In 2011, the total oil and natural gas consumed globally by the energy industry was 480.69 MTOE; or in other words, 6.9% of the oil and natural gas produced was consumed by the energy industry itself, for heating, pumping, traction, and lighting (IEA, 2013). India lags behind the world efficiency rate at 8.6 %. This presents a case for a scope of further improvements in the domestic oil and gas sector. The total oil and natural gas consumed by the energy industry in 2009 was 17,832 thousand tonnes of oil equivalent from a total production of 2,07,348.80 thousand tonnes of oil equivalent (IEA, 2012). To provide a comparison, Table 4 and Table 5 provide snapshots of energy consumption by various energy sectors globally and for India.

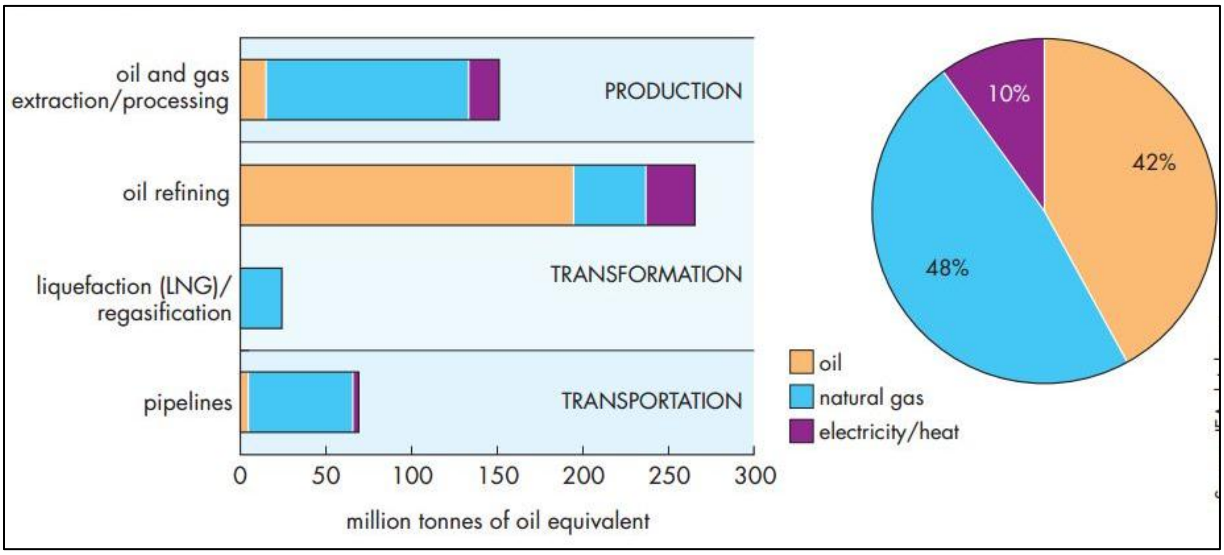


Figure 15: World energy consumption along the oil and gas supply chain, 2004

Source: IPIERCA, 2007

The oil and gas sector value chain consists of exploration and production, transformation of crude to a variety of products, and distribution activities. As can be seen in Figure 15, oil refining segment is the most energy-intensive. Large amounts of energy, albeit lesser than refining, are required in the upstream activities as well. Transportation of fuels is the least energy-intensive.

In the upstream sector has various energy-intensive activities from driving pumps to extract hydrocarbons and to re-inject water, to driving turbines to generate the electricity and heat needed for on-site operations and living quarters. Oil and gas extraction consumes close to 30% of the energy used. In 2003, 3.6% of the global energy consumption was by the extraction sector (McKinsey, 2007). Besides, despite heavy investments to improve efficiency, energy-intensity of the extraction process has been increasing over the years. This is mainly due to two reasons. The growing maturity of the oil and gas fields leads to an increase in the use of energy since enhanced recovery techniques have to be used for extraction. In India too, the fields that produce a bulk of the nation's domestic oil have passed their peaks (TERI, 2014), leading to a fall in production. Moreover, the world's conventional oil resources are declining, requiring extraction from non-conventional sources like shale formations and oil sands, which are inherently more energy-intensive.

The transformation segment is the most energy-intensive, accounting for about half of all the energy consumed in the oil and gas sector. Three major factors contribute to the high energy-intensity of this segment. Consumers now demand low-Sulphur diesel and petrol for their vehicles, which is more energy-intensive to process. The demand for lighter products has increased over time, requiring refiners to re-process the heavy residues. According to IEA, the energy-intensity of oil refining segment has fallen by 13% since 1980 in Organisation for Economic Co-operation and Development (OECD) countries due to large efficiency improvements in processing (IEA, 2012).

Sea-going oil tankers, road tankers and rail cars, which are used to transport both crude oil and gas, and processed oil products, account for most of the energy required in the transportation segment. Pipeline, on the other hand, are much more efficient in terms of energy consumption. Recent advances have been made towards making this segment energy efficient, but as the oil and gas fields mature, production is being shifted to increasingly remote areas. As a result, savings in energy consumption are being offset.

Various initiatives have been undertaken towards sustainable development and growth of the oil and gas sector. The best practices adopted by industry leaders in these fields can be replicated at a nation-wide level through institutional frameworks such as mandates by regulators. The following sub-sections review the various strategies in achieving green growth in the oil and gas sector through the following key initiatives:

- Assessing and mitigating environmental risks
- Initiatives to increase energy efficiency
- Investments by the oil and gas sector in the renewable sector
- Water management strategies

3.4 Assessing and mitigating environmental risks

A critical area of environmental sustainability is mitigation of global greenhouse gases from operations. A study by ONGC shows that CO2 (88%) and methane (11%) are the most significant emissions for oil and gas companies. In order to bring down emissions, reduction in both direct and indirect emissions[4] is required. Table 3 shows emissions from direct and indirect energy consumption for various oil and gas companies (wherever reported)

[4] Often in reference to CO_2 emissions, direct emissions are those released by the product or the service itself, while indirect emissions are the result of its life cycle context. In the case of the oil and gas sector, direct emissions would be those resulting from operations of exploration and production, refining and transportation (depending on the company's position in the value chain) and indirect emissions are those resulting from consumption of electricity to run offices, business travel undertaken for official purposes etc.

Table 3: Direct and indirect emissions of oil and gas companies (in million tCO_2e)

		2008-09	2009-10	2010-11	2011-12	2012-13
Direct emissions (Scope 1)	**ONGC**	7.93	8.03	8.13	9.21	8.59
	OIL	-	-	-	-	-
	GAIL	-	2.23	2.26	2.36	2.38
	IOCL	-	12.73	13.99	14.15	14.23
	BPCL	-	-	3.99	4.33	4.24
	HPCL	-	-	0.66	1.12	1.13
Indirect emissions (Scope 2)	**ONGC**	0.2200	0.2400	0.4600	0.4700	0.5200
	OIL	-	-	-	-	-
	GAIL	-	0.2400	0.2600	0.2600	0.2400
	IOCL	-	0.0900	0.1000	0.1100	0.0600
	BPCL	-	-	0.0099	0.0149	0.0639
	HPCL	-	-	0.5119	0.9650	0.9607

Source: Various sustainability reports 2012-13

Table 4: World energy supply and consumption by the energy industry in 2011

	Coal/Peat	**Crude oil**	**Oil products**	**Natural Gas**	**Nuclear**	**Hydropower**	**Biofuels and waste**	**Other**	**Total**
Total Primary Energy Supply	3776.06	4219.57	(83.58)	2786.95	674.01	300.17	1312.15	128.05	13113.30
Oil refineries	-	(4023.86)	3989.31	(0.85)	-	-	-	-	(35.40)
Energy industry own use	(85.43)	(6.47)	(206.71)	(267.51)	-	-	(10.77)	(207.25)	(784.14)

Source: IEA (2013)
Note: The parentheses indicate the flow, i.e. consumption.

Table 5: India's energy supply and consumption by the energy industry in 2009

	Coal/Peat	**Crude oil**	**Oil products**	**Natural Gas**	**Nuclear**	**Hydropower**	**Geothermal**	**Biofuels and waste**	**Electricity**	**Total**
Total Primary Energy Supply	282776	201289	(41724)	48926	4857	8962	1756	167896	456	675195
Oil refineries	-	(198800)	199375	-	-	-	-	-	-	576
Energy industry own use	(981)	-	(13335)	(4497)	-	-	-	-	(4985)	(23798)

Source: IEA (2012)
Note: The parentheses indicates the flow, i.e. consumption

3.4.1 Clean Development Mechanism

The Clean Development Mechanism (CDM) is one of three flexible mechanisms introduced in the UN's Kyoto Protocol. Arguably the most efficient, CDM has two main goals: one, to assist countries without emission targets (developing countries) in achieving sustainable development and two, to help those countries with emission reduction targets under Kyoto in achieving compliance by allowing them to purchase offsets created by CDM projects (Sandbag, 2011). In effect, CDM allows firms to continue emit greenhouse gases, so long as they pay for reductions made elsewhere. The justification for this is based on the premise that it would be far more expensive to implement emission reductions in industrialized countries than in developing countries. Plus, the developing countries would gain sustainable development benefits from the entry of clean and more energy-efficient technologies (Marciano, n.d.).

For a project to receive CDM status, it must meet the "additionality" requirement, which means the emission reductions made must be additional to what would have been possible without CDM funding. Upon verification, the CDM awards these projects Certified Emission Reductions (CERs), each equivalent to one ton of carbon dioxide. CERs are then sold to developed countries, which use them to meet a part of their reduction commitments under the Kyoto Protocol. CERs are also called "offset credits" because they "offset" the developed countries' emissions with reductions in developing countries.

ONGC is the leader among Indian Public Sector Enterprises (PSEs) in CDM projects. Being the flagship company for fulfilling India's energy security, ONGC's primary focus is on enhancing the recovery factor, increasing reserves and equity oil and gas from overseas assets. Guided by the missions of energy efficiency and renewable energy in the National Action Plan on Climate Change (NAPCC), ONGC's various endeavours are towards becoming energy and resource efficient and pursuing alternative sources of energy through research. The company's sustainability policy aims to generate 30% of revenues through investments other than in exploration and production. The first CDM project was registered in February 2007. Since then, 8 CDM projects have been registered by March 2013. More projects have been offered for development. 1,32,417 CERs were credited in 2012-13.

The 726.6 MW gas-based power generation unit of ONGC in Tripura is one of the biggest CDM projects in the world. It is a fuel-substitution project jointly developed by ONGC and Tripura Government and would mitigate over 1.6 million tons of CO_2 emissions per year for the next 10 years (Stephan, 2013). Other projects include cutting emissions via a wind power plant, offshore grid interconnection, vapour and flue gas recovery as well as greener buildings and fuel substitution. In 2012-13, ONGC managed to reduce their GHG emission by 5% and fresh water consumption by 15% through their efforts towards sustainable growth. Box 4 gives a snapshot of ONGC's CDM projects.

Box 4: Snapshot of ONGC's CDM projects (as of March 2013)

CDM Project Areas	Carbon Credits	% of emissions
Energy efficiency measures	18,444	0.20%
Flare reduction and increased gas utilization initiatives	1,06,533	1.17%
Renewable energy investments	85,762	0.94%
Total	2,10,739	2.31%

Source: NGC, 2015, 'Sustainability Report, 2014-15', ONGC, Dehradun

3.5 Initiatives to increase energy efficiency

The Indian industry has achieved remarkable progress in energy efficiency. Average energy intensity in key sectors such as cement, and iron & steel has been declining consistently. In August 2009, India's Prime Minister unveiled an energy efficiency trading system designed to save 5% of the country's energy consumption, and 100 million tonnes of CO_2 annually by 2015. The initiative, which is expected to cover around 700 installations, is to be underpinned by a market in tradable energy efficiency certificates.

The Energy Conservation Act (2001) provides a legal mandate to implement energy efficiency measures through the Bureau of Energy Efficiency (BEE). The objective is to improve energy efficiency in various sectors and to this end, the BEE has conducted mandatory energy audits of large energy-consuming industries, developed demand-side management programs, and established benchmarks for industrial energy use (Center for Climate and Energy Solutions, 2008).

Improving energy efficiency is often the most cost effective and quickest way to curb emissions. It reduces the need to invest in energy supply infrastructure and investments often pay for themselves over the lifetime of the equipment through reduced energy costs (Marinho, 2007).

3.5.1 Energy efficiency measures in the upstream sector

The initiatives to improve energy efficiency in the upstream sector can be broadly classified into three categories: energy saving measures, improved/enhanced oil recovery measures and reduction measures in gas flaring.

3.5.1.1 Energy saving initiatives

Extraction companies globally have been adopting more efficient technologies. IPIERCA (2007) reports that advanced high efficiency motors are replacing older motors in the extraction sector around the world, thereby improving efficiency from 60-70% to 85-95%. Energy savings initiatives practiced by oil and gas companies in India include:

- Adoption of energy conservation measures at various installations
- Use of efficient lighting systems

- Use of bi-fuel technology
- Energy audits

ONGC focuses on increasing energy efficiency by installation of energy conservation systems. These initiatives include use of efficient lighting systems, use of bi-fuel technology, reduction in gas flaring, and implementing energy audits. In 2012-13, ONGC reports to have saved 7,14,750 MWh of electricity through its various energy conservation strategies. Box 5 lists the key initiatives undertaken by ONGC in 2012-13 towards energy conservation. The resultant savings from these initiatives were to the tune of INR 4.29 billion in 2012-13, up from INR 1.67 billion in 2008-09.

OIL undertakes energy conservation initiatives in all areas of operation. Under such initiatives, it is has taken up projects for the conservation of crude oil, recovery of condensate, conservation of natural gas, conservation of electricity, conservation of diesel, and reduction of flare gas. Through these endeavours, OIL has managed to meet the energy requirement from its own production of natural gas, crude oil and generation of electricity. Out of the total energy requirement in kWh, 97.7% is met from its own production of natural gas, crude oil and generation of electricity. OIL is almost self-reliant in meeting its primary and secondary energy needs. Besides, OIL has been trying to make the maximum use of natural gas, thereby keeping the demand on crude oil and other refined petroleum products to bare minimum. Box 6 lists the key initiatives undertaken by OIL in 2012-13 towards energy conservation.

Under its Sustainability Aspirations 2020 plan, GAIL has set a 5% reduction target of its specific energy consumption in comparison to the baseline year (2010-11). Their action plan consists of adoption of integrated energy management systems, incubation of internal energy audit groups, adoption of energy efficient technologies, adoption of renewable energy, and reduction in flaring. Box 7 lists the key initiatives undertaken by GAIL in 2012-13 towards energy conservation.

Petrobras, which is Brazil's primary energy supply corporation, estimated in 2007 (the year when Petrobras' 2020 Strategic Plan was developed) that new energy efficiency measures in the exploration and production sector would lead to the avoidance of emissions of 5,51,500 tonnes of CO_2 (tCO_2)/annum (Marinho, 2007).

There is thus a strong case for the adoption of energy efficient technologies: not only does it curb energy use and therefore carbon emissions, it leads to cost cutting. The upstream regulator can therefore be made part of a larger framework to improve efficiency in the extraction sector. It could even be contractually mandated to adopt more efficient technologies, or tax based incentives can be offered for the same.

Box 5: ONGC's major energy saving initiatives in 2012-13

Adoption of energy conservation measures through optimizing existing systems:

- An energy conservation project to recover additional rich gas in Uran was completed successfully and will generate annual savings of INR 59 million.
- Shifts in gas supply to LPG plants were implemented to optimize its capacity utilization. Expected annual savings of INR 210 million will be generated through this initiative.
- Bi-fuel technology: A pilot project of bi-fuel technology for utilization of associated gas at the rate of 1,000 standard cubic metres per day (SCMD) from the extraction well for running drilling rig power packs was implemented, which resulted in 40 percent reduction of diesel consumption and additionally helped in reduction of gas flaring.

Use of efficient lighting systems at various installations:

- The power factor in Uran Plant was improved and will generate annual savings to the tune of INR 3.12 million.
- At various locations, lighting systems have been made more efficient through replacement of older, more energy-intensive fittings. These efforts resulted in a total saving of 556 MWh of electricity (INR 33.36 lakhs).

Box 6: OIL's major energy saving initiatives in 2012-13

Adoption of energy conservation measures through optimizing existing systems:

- Conservation of crude oil: A total quantity of 3468.63 kilolitres (KL) is crude oil was saved by way of regular maintenance of pipelines, treating the crude with flow improvement additives and heat application, and minimizing the power requirement for pumping crude.
- Conservation of natural gas: About 1.2 million standard cubic metres (MSCM) of low pressure natural gas was utilized for internal consumption by using a stabilizer booster at their Moran field. This gas was earlier flared. Moreover, 105.87 MSCM of high pressure natural gas, which was earlier flared, started to be supplied through distribution pipelines to Assam Gas Company Ltd. from Baghjan. Overall, gas flare in the fields was brought down to 0.15% of the total gas production in 2012-13 as compared to 0.29% in the previous year.
- Conservation of diesel: Use of solar lighting and solar gen-sets at gas collection stations and work-over locations. Installations of Exhaust Emission Reduction Devices in drilling engines. Introduction of fuel efficient vehicles in transport fleet and imparting fuel efficient driving techniques

Use of efficient lighting systems at various installations:

- 616 MWh of electricity was conserved through replacement of various electronic equipment like air conditioners, light fittings etc.
- Use of natural gas instead of conventional electric boilers for producing distilled water resulted in annual saving of approximately 1,920 kWh of electrical energy.

Some other solutions that have been offered, such as by Marinho (2007), include the promotion of qualification in energy efficiency courses by officials working in this industry. Secondly, the disclosures of best practices in energy efficiency can be made mandatory.

Thirdly, the calculation and disclosure of carbon emissions for each project can be made mandatory to promote transparency in this domain.

Box 7: GAIL's major energy saving initiatives in 2012-13

Adoption of energy conservation measures through optimizing existing systems:

- Engineering modifications were carried out at the Nitrogen plant in Pata which resulted in an annual savings of 4,48,560 KWh of electrical energy equivalent to INR 22.43 lakhs along with an equivalent reduction in production loss of 900 MT of liquid Nitrogen.
- A Waste Heat Recovery Steam Generation system (WHRSG) was installed for INR 62 crores and it generates savings worth INR 15.65 crores annually.
- A scheme was developed to utilize the cold generated due to pressure reduction of R-LNG supplied to South Gujarat pipeline, for cooling purposes elsewhere. The total investment for this project was INR 2.35 crore and the resultant savings are worth 5,600 MWH of energy annually with an additional recovery of 1,340 MTPA of LPG equivalent to INR 1.94 crore.
- An improved automated burner management system was to enhance efficiency. The total investment for this project was INR 83.44 lakhs leading to a 12.79% reduction in fuel gas consumption equivalent to INR 28 lakhs per year.

3.5.1.2 Reduction of gas flaring

Flaring refers to the burning of associated[5] natural gas while extracting crude oil and excess gas while extracting natural gas itself[6]. If flaring is avoided, such associated gas can alternatively be used for the generation of electric power for onsite consumption, the re-injection of the gas into the reservoir, and can be pooled into a single location of make available enough volume for commercial use (Clearstone Engineering, 2008).

Studies such as Elvidge, et al. (2007) have shown that approximately 150 BCM of gas is flared every year globally, which forms approximately 5% of the global natural gas production. This contributes to approximately 400 million metric tonnes equivalent of CO_2 emissions every year, which is approximately 2 % of global CO_2 emissions from energy sources (GE Energy, 2010).

In India, 0.9 BCM of gas was flared in 2012-13, as seen in Figure 16. This constituted 2.2 % of the total gas produced. The flaring of gas reduced between 1995 and 2000 (Elvidge, et al., 2007), however, since then, the rate of flaring has stabilized into a range of 1.9 to 3.3 % per year of the total gas produced.

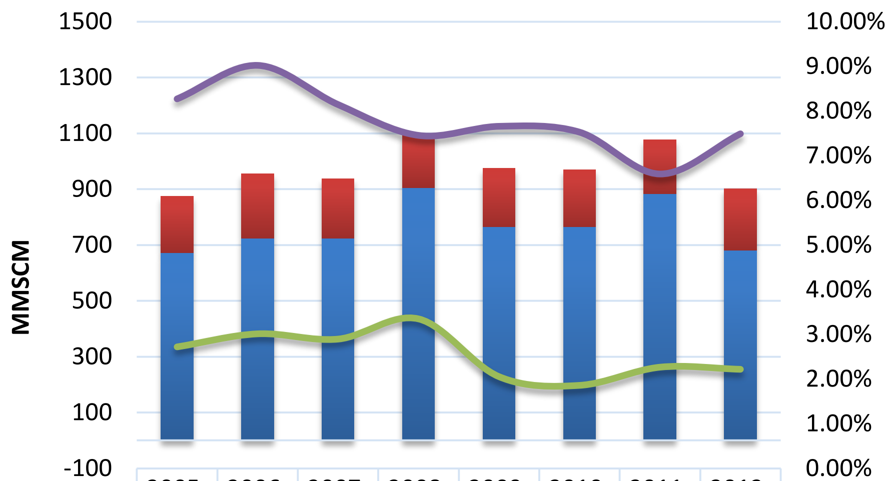
However, flaring is not consistently low across India. In particular, flaring is high in the fields of Assam. MoPNG (2013) data shows that Assam and Arunachal Pradesh taken together[7] flared 7.5% of the gas produced by them. Although these two states contribute a total of 7.2% of natural gas production in India as of 2012-13, they contributed to 24.5% of

[5] Associated gas is the gas that is a by-product of crude oil extraction. Non-associated gas reserves, on the other hand, are developed primarily to produce natural gas.

[6] Note that it is not viable to save all natural gas that is released during extraction of hydrocarbons. Some of it imperatively flared. In some cases, the associated national gas may be in too small a quantity to justify the building of infrastructure to commercialise it. In other cases, there may be unintentional and sporadic releases of natural gas during the process of hydrocarbon extraction.

[7] The production data of these two states available in (MOPNG, 2013) is clubbed together in the case of natural gas.

the total gas flared in India. Uppal and Raje (2007) estimated that in the year 2007, of the 14 million tonnes of CO_2 equivalent emissions that were emitted in India due to flaring, Assam contributed 3.14 million tonnes, which is 22.4% of the total.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13*
Assam	203	231	214	194	210	205	194	221
Rest of India	672	725	724	905	765	765	883	681
All India gas flared as a percent of the total (secondary axis)	2.72%	3.01%	2.89%	3.35%	2.05%	1.86%	2.26%	2.22%
Assam gas flared as a percent of total (secondary axis)	8.27%	9.02%	8.14%	7.45%	7.66%	7.53%	6.59%	7.49%

Figure 16: Gas flared in India (in MMSCM)

Source: MoPNG (2013)

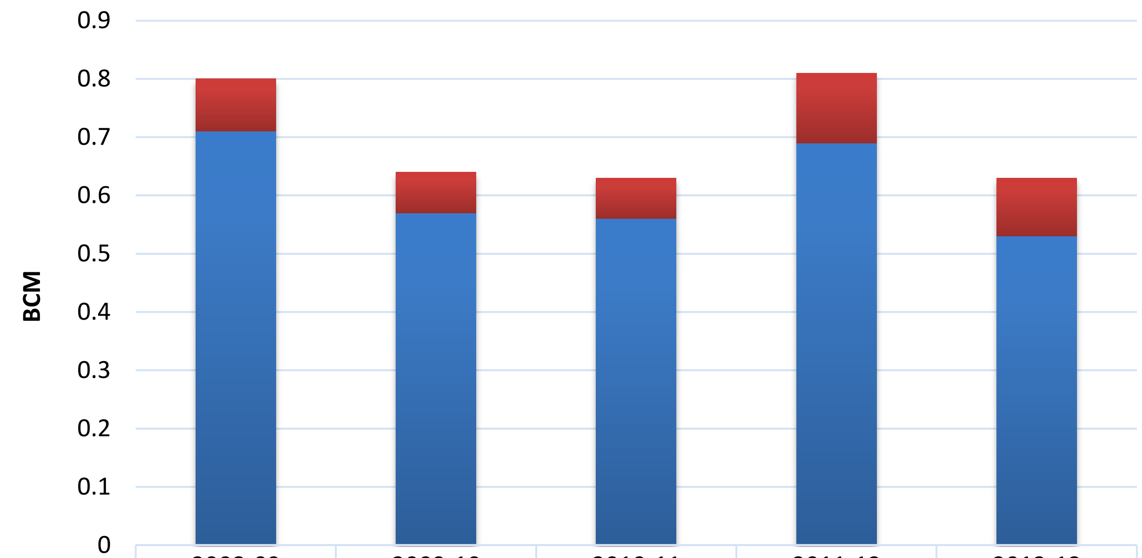
In India, ONGC has managed to reduce flaring by 22% in 2012-13 over 2011-12 (Figure 17), primarily through the installation and up gradation of facilities and technological interventions such as installation of compressors and pipelines, better utilization and marketing of low pressure gas, isolated low volume gas and adopting innovative measures as GTW (Gas to Wire), which refers to onsite power generation. Considering 2001-02 as the base year, these measures have resulted in meaningful utilization of 467 MMSCM of gas in 2012-13 alone.

Another region in India with high gas flaring is West Bengal, where Coal Bed Methane[8] is produced. Flaring there was as high as 93% in 2007-08, but has since been brought to under 10% in 2012-13. Coal Bed Methane extraction is new in India and the central government is intending to promote it further. Moving forward, regulators must therefore mandate the promotion and sharing of institutions and procedures to curb associated gas flaring among exploration companies.

India's existing regulations include disclosure by E&P companies of the quantum of associated gas extracted and the need for permission for flaring such gas, however, due to a

[8] Coal Bed Methane is natural gas that is recovered from coal beds, as opposed to conventional gas reservoirs. It is different from shale gas, which is found in shale rock formations that are far deeper than coal beds.

lack of adequate enforcement, infrastructure and clarity in pricing, associated gas has not been commercialised for usage to the extent possible.



	2008-09	2009-10	2010-11	2011-12	2012-13
Offshore	0.09	0.07	0.07	0.12	0.1
Onshore	0.71	0.57	0.56	0.69	0.53

Figure 17: Flaring (in BCM) by ONGC for 2008-09 to 2012-13

Source: MoPNG, 2013

Moving forward, the upstream regulator must create conditions that further foster the curbing of associated gas flaring in line with the recommendations of the World Bank Global Gas Flaring Reduction Partnership.

In order to tackle such wastage of associated natural gas, there have been several initiatives globally, most notably, the World Bank Global Gas Flaring Reduction Partnership. The World Bank (2011) recommends that in order to curb the practice of flaring; firstly, oil and gas legislation and licences should be clear about the treatment of associated gas. Secondly, fiscal terms should encourage investments that lead to the utilization of associated gas. Currently, there are high initial fixed costs to infrastructure that can utilize associated gas. Third, there should be market incentives to encourage the use and the commercialization of associated gas. This includes access to processing and transmission facilities and the presence of market based pricing. Fourthly, flaring should be regulated, accompanied by proper monitoring and regulation.

In Norway, for instance, a CO_2 tax of $120/1000m^3, which has been in place since 1991, has contributed to reduction in associated gas flaring. In the US, on the other hand, royalty payments are imposed on flared associated gas which the regulator deems could have been utilized (World Bank, 2011).

3.5.2 Energy efficiency measures in the midstream sector

In the transportation process, natural gas is used to fuel pumps and compressors while diesel oil and residual fuels are used to fuel large oil tanker ships. Road and rail transport of oil and gas is largely fuelled by diesel.

In India, crude oil pipelines had a capacity of 62.65 MTPA of crude oil in 2012. In that year, domestic production was 37.9 MT. Additionally, 184.17 MT of crude oil was imported in that year. Therefore while the pipeline capacity exceeds the domestic production, it is significantly short of the total crude supply in India. Similarly, in the case of petroleum products, the total domestic supply of petroleum products was 213.07 MTPA in 2012, while the pipeline capacity was 70.7 MTPA (MoPNG, n.d.). The balance crude oil and petroleum products were transported via rail and road, both of which are diesel intensive.

Pipelines not only shorten the time taken to transport crude oils and petroleum products, they lead to large reductions in CO_2 emissions when compared to other means of transport. The European Chemical Industries Council (CEFIC) lists out the emissions factors of several modes of transport[9], which are used by the European chemical industry there to estimate their carbon footprint. They estimate that road transport has an emission factor of 62 gCO_2/tonne-km while rail transport has an emission factor of 22 gCO_2/tonne-km (see Figure 18). Compared to this; pipeline transport has an emission factor of only 5 gCO_2/tonne-km (CEFIC, 2011). Therefore, there is a clear advantage in promoting the use of pipelines over rail and road. In addition to this, an indirect advantage of pipelines over road transport is the lowering of traffic congestion on highways, which would lead to improved average traffic speed and therefore efficiency of other vehicles.

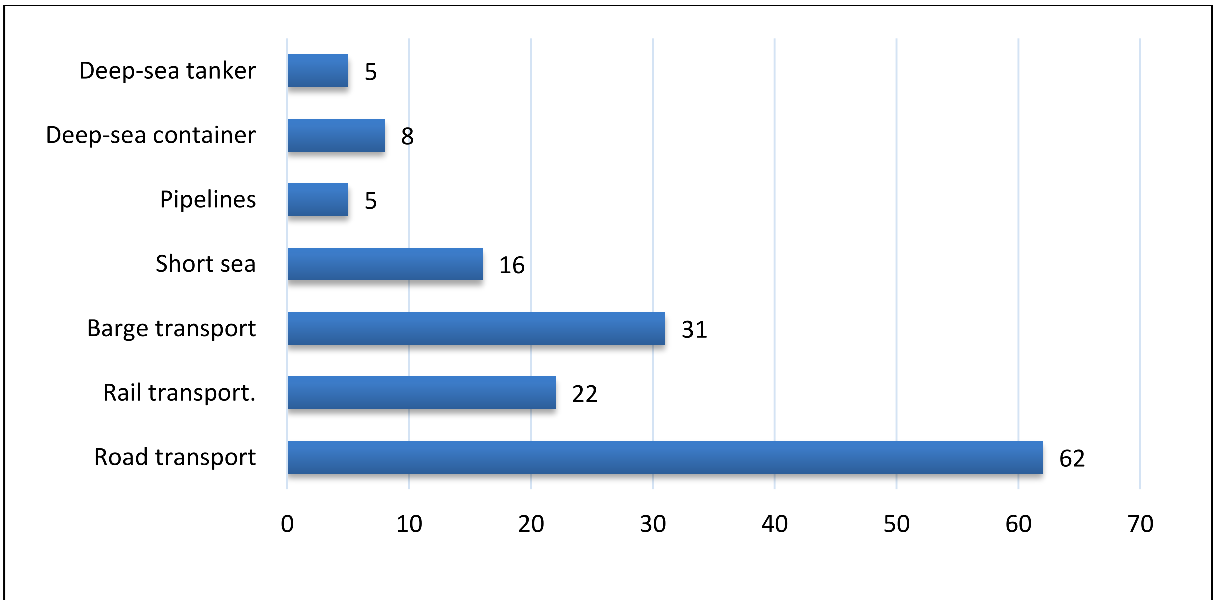


Figure 18: Emission factors for different modes of transport in the chemicals industry

Source: Guidelines for Measuring and Managing CO2 Emissions from Freight Transport Operations, CEFIC

[9] Note that the emission factors are only indicative. They will vary with fuel, technologies being used, geography and other factors.

The government may thus pursue the implementation of pipelines over rail and road wherever the capacity permits. Tax collection from the oil and natural gas sector may be diverted for this purpose.

3.5.3 Energy efficiency measures in the downstream sector

Oil refining is the most energy intensive activity in the industry (followed by exploration and production of oil and gas). It accounts for nearly half of all the energy consumed by the oil and gas industry. The refining process largely uses refining gas, which is the by-product of the refining process, heavy fuel oil and natural gas as fuels in the refining process. The improvement of energy efficiency not only has environmental benefits by the way of reduction in emissions, it has significant implications on the finances of the refinery too. Energy costs accounted for 64 % of total pre-tax costs of refineries in Central and Southern Europe in 2010 (Solomon Associates, 2010).

Refineries in India have taken up measures to improve energy efficiency. For instance, IOCL, India's largest fuel transformation company, has a stated goal to reduce GHG emissions by developing a policy framework for energy management, conducting energy audits and achieving "better than industry benchmarks" in energy consumption efficiency.

IOCL's emissions since 2009-10 have been in the range of 0.25-0.26 tCO_2/MT. In 2012-13, 54.16 % of the emissions came from the generation of electricity, heat or steam. Another 32.12 % came from physical or chemical processing. IOCL implemented a total of 120 schemes with estimated savings of 1,20,000 Standard Refinery Fuels in Tonnes (SRFT) in 2012-13. The impact of additional savings with major energy conservation investments in 2013-14 is expected to be 83,000 SRFT.

Box 8: A few energy saving projects during 2012-13 by IOCL

- In order to enhance the gross refinery margins and to reduce GHG emissions, IOCL is increasingly using LNG as feed fuel in HGUs (Hydrogen Generation Unit) of the refineries.
- Optimisation of Hydrogen use and improved recovery through PSA (Pressure Swing Adsorption) systems
- Pre-heat improvements at Gujarat and Barauni refineries for savings in energy consumption
- Better process integration for improved heat recovery at Guwahati and Panipat refineries
- Savings in power consumption by installation of step-less controllers for compressors at Haldia refinery
- Optimisation in Gas/Oil ratios in DHDT at Barauni refinery and OHCU in Haldia refinery for lower power consumption of recycle gas compressors
- Full back pressure mode operation of TG1(Turbo-generator 1) at Barauni refinery, improvement in operating efficiency of GT (Gas Turbine)-2 at Gujarat refinery and STGs (Steam Turbo-generator) at Panipat and condenser cleaning for increased power generation efficiency at these refineries.
- The use of variable frequency drive for mainline pumping unit and use of Drag Reducer Agent (DRA) in mainline to increase the flow of the product in pipeline facilities.
- Other activities that are spread extensively across organisation such as solar powered equipment, energy efficient gadgets, use of light pipes for day-lighting etc.

Similarly, India's other major downstream company, BPCL, has taken measures towards energy efficiency and saving. The total GHG emissions per unit of throughput have shown a reduction of 3.23 % over 2012-13. The company reported emissions of 4.18 MT of CO_2. HPCL too made gains on energy savings and efficiency. In 2012-13, steps in this direction have resulted in savings of 42,157 SRFT/year. This translates to savings of INR 169 crores/year approximately.

Box 9: BPCL's energy savings through increased efficiency

- Production and supply of auto fuels (MS/HSD) meeting Bharat Stage IV specifications. Also in the process of developing plans for meeting the emerging Euro-V specifications.
- Transportation of 85% of the petroleum products through pipelines resulting in lower GHG emissions in the life cycle of our products.
- Replacing liquid fuels with Re-gasified Liquefied Natural Gas (R-LNG) has immensely helped in reducing CO_2 and sulphur dioxide (SO_2) emissions from the refineries.
- Installation of a new state of art energy efficient Crude & Vacuum distillation unit is under implementation. This will produce higher yield of products as compared to the old units

Internationally too, energy efficiency measures have been pursued. For instance, Petrobras, the semi-public Brazilian energy corporation, after the 1973 oil crisis, adopted several energy efficiency measures in the downstream sector. These included the installation of air pre-heaters in all distillation furnaces, the enhancement of steam condensate collection, the installation of vacuum pumps in distillation towers and other such measures.

Therefore overall in Brazil, several projects that were already in progress across the oil and gas chain as of 2007 (the year when Petrobras; 2020 Strategic Plan was developed) were expected to have led to energy savings of 884 thousand BOE/day and emissions of 5,83,000 tCO_2/annum were avoided, all for investments of $273 million. In the refining sector specifically, further projects planned were estimated to lead to the avoidance of emissions by 2,21,740 tCO_2/annum (Marinho, 2007). The company has a goal to cut energy intensity between 9-10 % between 2009 and 2015 through the product chain, along with an 8-15 % reduction in the intensity of greenhouse gas emissions (Petrobras, 2010).

In OECD countries, the energy intensity of oil refineries – as measured by the energy used per barrel of output – has fallen by as much as 13 % since 1980 (IPIERCA, 2013). These gains were made in part due to voluntary commitments to improve their energy efficiency. For instance, members of the American Petroleum Institute (API) and the National Petroleum and Refiners Association (NPRA) in the United States undertook a mission called the Climate Action Challenge to reduce their greenhouse gas emissions by increasing their energy efficiency by at least 10 % between 2002 and 2012. The Solomon Energy Intensity Index (EII) was adopted to track gains made by each refinery (IPIERCA, 2007).

The EII is the percentage of the actual energy use of a particular refinery to standard energy usage, which is the "expected" use of energy by an average global refinery of similar configuration. Solomon Associates, the company which tracks EII, also calculates the "World's Best" among energy efficient refineries. The World's Best is defined as the "weighted average data of six of the best individual refineries with excellent EII performance" from three regions: two from North and South America, two from Europe and the Middle East, and two from the Asia Pacific region. The World's Best EII was 73.5 in 2008. Individual refineries can use this index to see how they are doing and can identify the avenues of improvement. Figure 19 is an example of the comparison of the EII of a refinery with the World's Best, detailing the energy intensity in those processes which lead to the most gains for the World's Best[10]. Individual refineries can then work on those processes for to make efficiency gains (Solomon Associates, 2010). Globally, EII ranges as much as +/- 40 % (Solomon Associates, 2012).

The EII is used around the world, including by the US EPA, the Netherlands Government (which has a "Dutch Covenant" goal of being among the world's top 10 per cent in energy efficiency), the Japan Ministry of Economy, Trade and Industry and the New Zealand Ministry for the Environment.

Moving forward, the government of India must also adopt such a standard efficiency indicator which would bring greater transparency in efficiency of refineries and foster a competitive spirit in pursuing efficiency improvement measures. Targets on efficiency may also be mandated with favourable credit lines to fund infrastructure overhauls. It would not only lead to reductions in emissions and the saving of fuel, it will also lead to cost cutting, which could help foster growth in the sector.

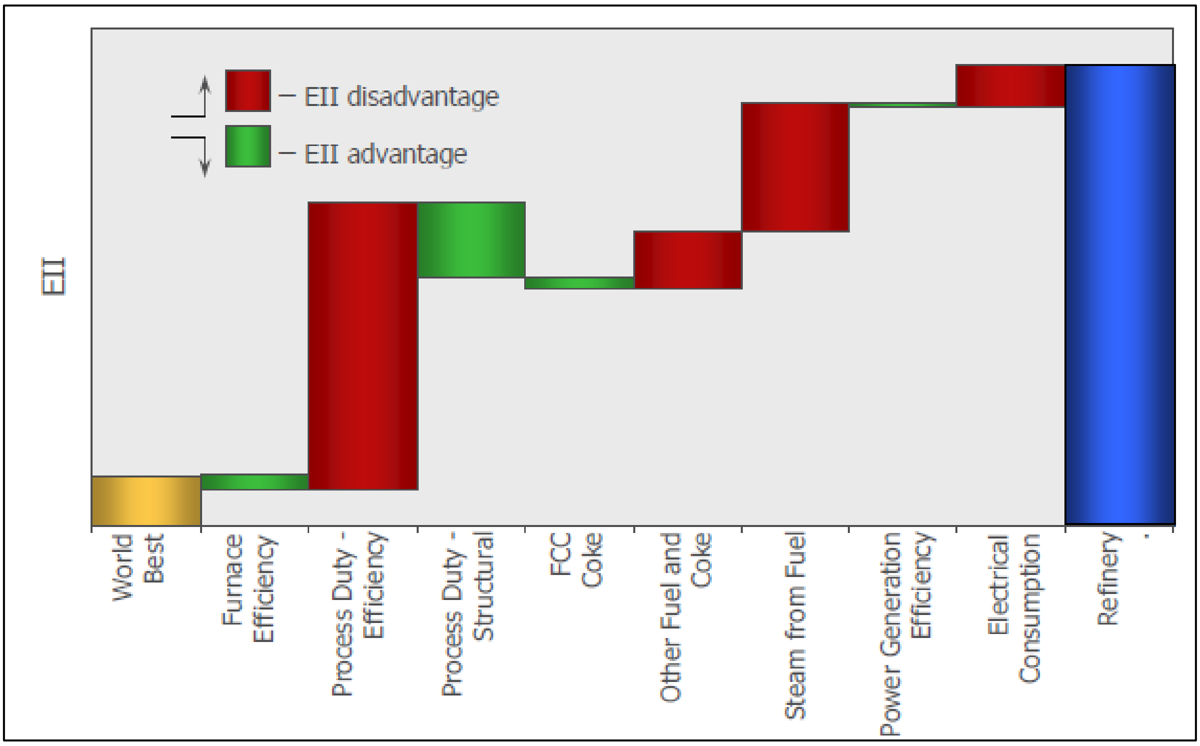


Figure 19: EII Index

Source: EII Analysis Methodology - Gap Analysis Versus World's Best EII, Solomon Associates

[10] Note that the quantum of emissions from refineries primarily depend on the technology and type. Refineries are classified into Topping refineries, cracking refineries and coking refineries. Topping refineries deal with light crude and have low energy intensity and therefore low CO_2 emissions. Cracking refineries refine average crude and are fairly energy and carbon intensive. Coking refineries use the most energy and therefore emit the most amount of CO2. They deal with heavy crudes (Solomon Associates, 2012).

3.6 Focus on renewables in the oil and gas sector

Since electricity forms approximately 10% of the energy used in the oil and gas sector (IPIERCA, 2007) – most of which is sourced from fossil fuel sources – there is scope for sourcing electricity generated from low-emission or renewable sources. In this regard, extraction companies are already taking steps to increase the adoption of such electricity sources.

India is in a position to play a major role in large-scale commercialisation of renewable energy technologies, and can offer technology transfer to other developing countries and support them in building capacity. The country has already achieved installation of over 10,000 MW of renewable energy-based capacity, and stands fourth worldwide in terms of wind power installed capacity. Suzlon, an Indian-owned company, has managed to blend strategies creatively to leapfrog innovation to enter new technology markets. Operating in 20 countries, Suzlon is ranked as the third leading wind turbine maker in the world.

Diversification into renewable energy is one of the key opportunities that the oil and gas sector can enter into to battle climate change. Renewable energy can really make a substantial contribution to meet the ever rising energy demand and it is no longer an "alternate energy", but is increasingly becoming a vital part of the solution to the nation's energy needs.

There are certain notable trends in renewable energy investments made by Indian oil and gas companies. Companies with upstream oil exploration and production operations like ONGC and OIL have made significant investments in wind, solar and nuclear energy. In fact, ONGC's sustainability targets include 30 % revenue generation from non-exploration and production operations, through investments in alternate technologies. It plans to generate 6.5 GW of renewable energy from wind, solar and nuclear by 2030. Downstream marketing companies, on the other hand, invest mostly in renewable energy options to reduce the cost of operating pipelines and development of biofuels.

Though the sector holds enormous potential, it is imperative that the government further incentivizes the use of renewable energy, promotes technological advancements as well as global best practices, and eliminates barriers that hinder the import of tools and technical know-how. A slew of such measures would give a fresh impetus to the sector that can contribute immensely in reaching the goal of national energy security in a clean, cost-effective manner. According to a study conducted by WWF-India in 2009, responses from the Indian companies belonging to both the energy intensive and non-energy intensive sectors convey a common understanding that efficient regulations in renewable energy in India, if imposed, will prove to be an opportunity rather than a risk.

The remaining sub-section reviews various renewable energy initiatives by Indian oil and gas companies.

3.6.1 Solar energy initiatives

ONGC aims to generate 1.5 GW of solar power by 2030. The company has taken up a project to convert solar energy directly into grid quality electricity. It has also acquired equity stake in promising solar photo voltaic technology for further development. OIL also has significant investments in solar energy. Three out of four solar projects are already up and running – 100 KW in Jaipur, 100 KW in Tanot, and 30 KW in Noida. A larger 5 MW project at Ramgarh is in pipeline.

Similarly, GAIL commissioned its first PV based solar power plant with a 5 MW capacity at Raghwa village in Jaisalmer district. The power generated through this plant is exported to NTPC Vidyut Vyapar Nigam Limited (NVVN) as per a long term power purchase agreement (PPA) signed with the company. The plant was built at a cost of INR 51 crores. The total power generated and exported to NVVN during the year 2012-13 was 8,38,581 units with a corresponding revenue generation of INR 78 lakhs. The total solar energy generated in 2012-13 resulted in savings of 654 tonnes of CO_2. GAIL has plans to set-up additional capacities over the coming years.

BPCL's initiative to provide solar power for its pipeline is a commendable strategy in the midstream sector. The 259-kilometre long pipeline from BPCL's refinery in Bina to Kota, Rajasthan is used for transportation of processed petrol, diesel and kerosene. Due to power failures in Madhya Pradesh and Rajasthan, DC sets had to be used to power the valve stations in the pipeline. The cost of this project is INR 92.32 lakhs for installing solar power systems of 6.4 KW capacity at each of the seven valve stations. The company reports that the resultant savings are to the tune of INR 18 lakhs annually. However, they have not reported the emission-reduction it offers. HPCL has undertaken a similar initiative for their Rewari-Kanpur pipeline, for solar powered lighting and water heating at all the valve stations.

3.6.2 Wind energy initiatives

ONGC's target is to have 2 GW of wind power generation capacity (onshore and offshore) by 2030. A 51 MW wind power project in Jhakau, Gujarat has been operational since 2009. A 102 MW wind power project in Rajasthan, with an investment of INR 6,780 million, is scheduled to be commissioned by mid-2014. In addition, a hybrid power system (solar panel and micro wind turbine) on 16 unmanned platforms in western offshore is also under implementation.

OIL firmed up its strategy to selectively diversify into the field of renewable energy and presently has an installed capacity of 67.6 MW of wind power. OIL first established its footprint in renewable energy on 31 March 2012 by successfully commissioning its 13.6 MW Wind Energy Project in Rajasthan, connecting it to the state power grid at Amar Sagar, Jaisalmer. The 13.6 MW capacity turnkey projects, executed by Gamesa Wind Turbines Private Limited, comprise of 16 wind turbine generator units, each having an installed capacity of 850 KW. OIL has also commissioned its 54 MW wind turbine plant at Dangri, Jaisalmer district, Rajasthan in March 2013. The project, executed by Inox Wind Limited, comprises of 27 wind turbine generator units, each with an installed capacity of 2,000 KW.

Wind power generated by OIL is being sold to local state utility under long term Power purchase agreement (PPA) at fixed preferential tariff.

Box 10: OIL's wind energy investment snapshot

Parameters	Project 1	Project 2
Wind farm capacity	13.6 MW	54 MW
Commissioned on	31 March 2012	30 March 2013
Location	Ludurva, Jaisalmer	Dangri, Jaisalmer
Developer	Gamesa Wind	Inox Wind
Power evacuation grid	Amarsagar – 10 km	Akal – 47 km
Feed in tariff	INR 4.46/kWh	INR 5.18/kWh
Project cost (including 10 years of O&M cost)	INR 102 crores	INR 360 crores
Payback period	6 years	6.4 years
Units generated so far (as on 31 March 2013)	18.2 million	3.21 million

GAIL commenced wind power generation in 2010 through a wind power project setup in Gujarat. Over a period of three years, it has increased its wind energy portfolio to 118 MW comprising 14.7 MW in Gujarat and 98.75 MW together in Karnataka and Tamil Nadu, with a total investment in excess of INR 700 crores. Till date, these projects have generated around 34 million KWh of wind energy which is equivalent to a savings of around 26,520 tonnes of CO_2. GAIL has plans to set up a total of 500 MW wind power capacity in the next 5 years.

Wind energy investments depend on stable policies, attractive tariffs and "business case certainty". Accurate wind resource estimates, reliable and efficient technology, sufficient grid capacity and power system integration remain the key fundamentals for attracting investments.

3.6.3 Biofuels and other eco-friendly products

IOCL invests extensively in the development of biofuels and end-use fuel's (diesel, gas and petrol) quality improvement. 17 additional cities were covered in 2012-13 by the company where Bharat Stage grade 4 fuel will be available. This comes under the government's plan to extend the availability of high quality fuel in 50 cities by 2015. IOCL also invests in other quality improvement and eco-friendly initiatives like Ultra Low Sulphur Diesel and various biodegradable lubricants used in the textile and hydraulics industries. The company has also started selling LPG (or auto-gas fuel) at their outlets. And CNG is marketed from selected outlets as a franchise of Mahanagar Gas in Mumbai and Indraprastha Gas in Delhi. IOCL has examined and optimised the synthetic processes for the preparation of biodiesel from various vegetable oils; which includes oil from rice bran, Jatropha, Curcas, palm and sunflower. This process has been patented and scaled up to pilot plant level.

BPCL has similar initiatives in biofuel production. Bharat Renewable Energy Limited (BREL) was incorporated in 2008 as a joint collaboration between BPCL and Nandan Biomatrix Limited, Hyderabad and Shapoorji Pallonji. This entity undertakes the production, procurement, cultivation and plantation of horticulture crops such as Karanj, Jatropha and

Pongamia in Uttar Pradesh. It also takes care of trading, research & development (R&D) and management of all crops and plantation including bio-fuels. Similarly, HPCL has also formed a joint venture company for developing bio-diesel through Jatropha cultivation at Raipur and a 100% subsidiary company – HP Biofuels – for manufacturing ethanol in Bihar.

The government has an ethanol policy mandating up to 5 % blending of ethanol with petrol. However, this policy has not been successful due to several bottlenecks on the supply side which led to only 45% of the requirement of ethanol being met in 2013. These bottlenecks included procurement issues that arose due to the taxation structure. Firstly, state governments regulate transportation of ethanol, while the refining industry, which procures ethanol, is governed by the central government. Secondly, the pricing of ethanol lacked clarity until December 2014, when new ethanol prices were declared. However, moving forward, the government must formulate a new dynamic pricing structure instead of the current fixed pricing system that is in place. Thirdly, sugarcane production is cyclical in nature and this leads to variability in supply. In order to tackle this, the government must provide impetus to the sugarcane industry in order to ensure regular availability of ethanol. Further, the country's agricultural policy must reflect the demands of the ethanol blending policy.

3.7 Sustainable water management strategies

3.7.1 Upstream water management strategies

The requirement of freshwater at all exploration and production sites presents unique water challenges for upstream oil and gas companies. For example, the North Eastern oil and gas assets have an abundance of water, whereas assets in Gujarat or Rajasthan face shortage of fresh water. On the other hand, offshore installations face entirely different water challenges, where desalination plants have to be used to meet total freshwater demand.

The upstream companies have their sustainable water management strategy aimed to reduce freshwater consumption and develop action plans for baseline assessment of current water consumption, location specific water recycling and reuse targets as appropriate in the medium to long term. Based on various upstream companies' sustainability reports, approximately 13 to 25 billion litres of freshwater is required in oil and gas production activities. Out of this requirement, approximately 1 to 2 billion litres of water is recycled.

In 2012-13, ONGC managed a 15% reduction in fresh water consumption. This has been possible due to increased awareness towards use of fresh water achieved due to a number of initiatives such as closed water monitoring at Mehsana asset. In order to conserve the natural resources by reducing the fresh water consumption, the treated effluent (produced water) is injected to the extent possible for the purpose of maintaining the reservoir pressure and during the drilling operations. As a policy decision, it has been made mandatory to implement rain water harvesting in all future projects including the residential complexes across the country. Water foot printing and rain water harvesting were taken up as Sustainable Water Management initiatives under MoU targets for the financial year 2013.

Apart from putting in place an integrated water management system at various locations, upstream companies try to negate their water consumption by recycling and reusing. The corporate policy of ONGC promotes 4R philosophy – Reduce, Reuse, Recycle and Replenish. Under this policy, rain water harvesting system is used as a mechanism for replenishment. The company has taken a long term project on rainwater harvesting across its work centre. 2012-13 was the first year of the project and focused on creating suitable facilities and infrastructure across four of its work centres (Vadodara, Tripura, Rajahmundry and Ahmedabad). Similarly, OIL has constructed a water harvesting unit at OIL's Store Complex located at Hamira, Jaisalmer, and Rajasthan. Roofs of the warehouses have been utilised for rooftop rainwater harvesting.

3.7.2 Downstream water management strategies

Water requirement for refining is comparatively lesser than the requirement for extraction. Also, 80 % of the water is recycled and reused. Therefore, water management strategies in the transformation sector of the oil and gas industry involve investments in technologies to recycle and process waste water and make it reusable. Refinery water is sourced mainly from surface water such as canals, lakes, rivers and ponds. 21.84% of water is sourced from ground and 71.84% of water is sourced from surface water at refineries. Pipeline and marketing divisions mainly rely on the ground water and municipality supplies.

Refining and oil marketing companies comply with the MINAS (Minimal National Standard) set by the Ministry of Environment & Forests, Government of India, and Pollution Control Board with regard to the use of water resources and the quality of effluents discharged. The refineries are equipped with elaborate, well-designed effluent treatment plants (ETPs). Liquid effluent is collected through underground network of oily water sewer (OWS), contaminated rain water sewer (CRWS) and sanitary sewer. The treatment comprises of physical, chemical, biological and tertiary treatment sections. The treated effluent is reused for various purposes within the unit such as firewater & cooling towers make-up, coke cutting and developing and maintaining green belts, eco-parks and eco-ponds in the premises. These initiatives have helped reduce discharge outside the unit and fresh water consumption for normal operations.

4 Policy roadmap

Due to the physical attributes of oil and natural gas, growing usage of these fuels will lead to greater greenhouse gas emissions, ceteris paribus. Therefore the curbing greenhouse gas emissions would require a reduction in the use of fossil-fuel based energy and promotion of renewable sources. While energy systems slowly transition, conventional sources of energy such as oil and gas will remain the mainstay in the short and medium-terms due to the carbon-lock in caused by the techno-institutional complex. This is acutely so in activities involving cooking and transport. As the oil and gas sector will continue to remain relevant, a sustainable growth strategy for the sector would be based on increasing energy efficiency of the sector as the economy at large transitions towards renewable energy.

The proposed policy roadmap in this paper does not include the imposition of carbon taxes as a means towards creating an energy efficient oil and gas sector. A tax on carbon is a form of a Pigouvian tax[11], which in theory would rationalise the use of fossil fuels, potentially leading to reduced greenhouse gas emissions. However, as such a tax would be incident on all sectors of the economy – in particular on the consumption side – it is out of the scope of this paper.

Further, while a tax on resource extraction can in theory reduce the supply of fossil fuels apart from rationalising inter-temporal extraction, it may have undesired consequences. In India, the government already imposes taxes on the production process with the intention of accruing revenues. These taxes include royalties paid on crude oil and natural gas, custom and excise duties on crude oil and refined petroleum products, and other forms of taxes. Imposing further taxes on extraction can have perverse outcomes in India's case. This is because the country is import dependent in the case of oil, and increasingly so in the case of natural gas as well. Such a tax may therefore increase import dependence, which would raise the fuel import bill.

Therefore, instead of carbon and extraction taxes, this paper will focus on measures that directly aim to reduce emissions and lead to better resource management in the oil and gas sector. Further, there are measures proposed to ensure rational fossil fuel use and greater uptake of natural gas. These measures have been divided into the short run, which is defined to extend to 2020, the medium run, which extends to 2030, and the long run, which extends to 2047.

In the short run, firstly, the disclosure of energy usage and carbon emissions should be made mandatory across the sector. This would lead to greater clarity and public awareness of the issue, which can further facilitate policy action in the future. Secondly, E&P contracts should include incentives for energy saving in operations. In particular, there ought to be fiscal arrangements in the form of tax incentives to encourage the reduction of associated gas flaring. Thirdly, in the midstream segment, a roadmap which plans an integrated fuel transport policy must be created. This document should in particular focus on a pipeline network where viable, and lay out a roadmap for the implementation of such a network in the medium run. Fourthly, natural gas imports should be streamlined to ensure affordable and consistent LNG supplies to the industry and power gas based power plants. Fifthly, in the refining segment, this paper has already discussed the role that the Solomon Energy Efficiency Index in helping the industry grow more energy efficient. India too must adopt such a standard that would help policymakers set reasonable energy use reduction goals in the medium and long run. To begin with, reporting efficiency according to the guidelines of such an index may be promoted. Finally, in order to promote biofuel usage, pricing and taxation related bottlenecks must be addressed.

In the medium run, firstly, when it comes to associated gas flaring, the government can go one step further, by mandating mandatory cuts in associated gas flaring, in line with the World Bank Global Gas Flaring Partnership recommendations. Secondly, oil and gas

[11] Pigouvian taxes get their name from economist Arthur Pigou, who proposed taxes to internalise negative externalities. In the case of fossil fuel use, externalities take the form of the social cost of use, such as health issues caused by air pollution or the impact of climate change.

companies may be encouraged to invest in the renewables sector through CDM projects. The goal could be to ensure at least as much renewable energy production as the sector consumes itself in the extraction and processing of hydrocarbons. Thirdly, to facilitate energy efficient fuel transport, the railway freight corridor network currently being constructed between the metro cities may be expanded as and where capacity permits. Fourthly, in the downstream segment, refineries must be mandated to cut emissions, as measured by the efficiency indicators. Fifthly, on the consumption side, a Green Gas Quadrilateral must be created by setting up natural gas pumps along the Golden Quadrilateral highways in order to promote the use of gas as a transport fuel. Sixthly, universal rural electrification must be pursued to reduce kerosene use for lighting purposes. Finally, necessary infrastructure to ensure the uptake of electric vehicles must be pursued.

In the long run, firstly, in line with the World Bank recommendations, necessary physical and technical infrastructure should be created to commercialise associated natural gas that would otherwise be flared. Secondly, as and where viable, secure transnational pipelines may be pursued to ensure energy efficient import of natural gas. Thirdly, the Green Gas highway network should be expanded to inter-state highways, where capacity permits. Finally, LPG subsidies may be reduced and rationalised, and electricity as a cooking fuel may be promoted.

Such policies measures could create a framework that would lead to greater energy efficiency within the oil and gas sector. Table 6 provides the summary of these recommendations.

Table 6: Policy Roadmap for the Oil and Gas Sector

	Upstream	Midstream	Downstream
Short term (2020)	▪ Mandatory disclosure of energy usage and carbon emissions in the exploration and production processes ▪ E&P contracts should include incentives for energy saving in operations ▪ Fiscal arrangements in the form of tax incentives to encourage reduction of flared gas ▪ Securing LNG imports for power generation	▪ Mandatory disclosure of energy usage and carbon emissions in transportation segment ▪ The creation of a national roadmap of pipeline based fuel transport that could be implemented in the medium and long term	▪ Mandatory disclosure of energy usage and carbon emissions in the transformation and distribution segment ▪ Adoption of a standard efficiency indicator, such as the Solomon Index, to promote competition in transformation efficiency ▪ Streamlining pricing and taxation related bottlenecks to improve ethanol supply to refineries ▪ Reducing and rationalising kerosene subsidies
Medium term (2030)	▪ Gas flaring reduction targets for the E&P industry ▪ Encouraging E&P companies to invest in the renewable sector through CDM projects	▪ Expanding the freight corridor network of the country for efficient transport of crude and processed products	▪ Mandatory efficiency improvement targets, as measured by the standard efficiency indicator ▪ Creation of a Green Gas Quadrilateral by setting up gas retail outlets to promote use of natural gas as a transport fuel ▪ Universal rural electrification to reduce kerosene use for lighting ▪ Creating necessary infrastructure to encourage usage of electric vehicles
Long term (2047)	▪ Creation of required technical and physical infrastructure to commercialise associated natural gas that would otherwise be flared	▪ Pursue viable and secure transnational pipelines to promote energy efficient import of oil and gas	▪ Expanding the Green Gas network on targeted inter-state highways of the country, where capacity permits ▪ Rationalising LPG subsidies and the promotion of electricity as a cooking fuel

5 Conclusion

This chapter set out to identify the avenues of green growth in the oil and gas sector. After presenting an overview of the oil and gas industry in India, it assessed the value chain where interventions have been made. Further, it identified further interventions that can be made by creating a policy framework to foster sustainability. The chapter stated that due to the energy intense nature of the processes of extraction, transport and transformation of hydrocarbons, significant efficiency gains can be made. Finally, it produced a public policy framework to foster such sustainability initiatives within the oil and gas sector, learning from domestic as well as global best practices.

6 Bibliography

BP. (2014). *Statistical Review of the World Energy 2014.* BP.

CEFIC. (2011). *Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations.* Brussels: Cefic European Chemical Industry Council (CEFIC).

Center for Climate and Energy Solutions. (2008, September). *Climate Change Mitigation Measures in India.* Retrieved August 27, 2014, from Center for Climate and Energy Solutions: http://www.c2es.org/docUploads/India-FactSheet-09-08.pdf

Clearstone Engineering. (2008, September 18). Guidelines on Flare and Vent Measurement. Calgary, Alberta, Canada.

Elvidge, C. D., Baugh, K. E., Tuttle, B. T., Howard, A. T., Pack, D. W., Milesi, C., et al. (2007). *A Twelve Year Record of National and Global Gas Flaring Volumes Estimated Using Satellite Data - Final Report to the World Bank.*

GE Energy. (2010). Flare Gas Reduction: Recent global trends and policy considerations.

IEA. (2012). *Energy Balances of Non-OECD Countries - 2012 Edition.* Paris: International Energy Agency (IEA).

IEA. (2013). *Key World Energy Statistics.* Paris: International Energy Agency (IEA).

IEA. (2014). *World Energy Outlook 2014.* Paris: International Energy Agency (IEA).

IPIERCA. (2007). *Saving Energy in the Oil and Gas Industry.* London: International Petroleum Industry Environmental Conservation Association (IPIERCA).

IPIERCA. (2013). *Saving Energy in the Oil and Gas Industry.*

Kahn, J., & Yardley, J. (2007, August 26). As China Roars, Pollution Reaches Deadly Extremes. *New York Times*.

Marciano, M. (n.d.). *What is Clean Development Mechanism?* Retrieved June 24, 2015, from Global Alliance for Incinerator Alternatives (GAIA): http:// www.no-burn.org

Marinho, F. (2007). PETROBRAS' Experience in Energy Efficiency Projects. *XXV Brazil - Germany Business Meeting (XXV Encontro Empresarial Brasil - Alemanha).* Blumenau.

McKinsey. (2007). *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity.* McKinsey.

MOPNG. (2013). *Indian Petroleum and Natural Gas Statistics 2012-13.* New Delhi: Ministry of Petroleum and Natural Gas (MoPNG).

MoPNG. (n.d.). *Refining Capacity and Pipelines in India.* Retrieved August 20, 2014, from Ministry of Petroleum and Natural Gas: http://petroleum.nic.in/refinery.pdf

OIL. (2013). *Sustainability Report 2012-13.* Noida: Oil India Limited (OIL).

ONGC. (2013). *Sustainability Report 2012-13.* Dehradun: Oil and Natural Gas Corporation Limited (ONGC).

Petrobras. (2010). Energy Performance Management in PETROBRAS Refineries. *V Latin American Carbon Forum.* Santo Dominigo.

PPAC. (2014). *City Gas Distribution (CGD) Network in India.*

Sandbag. (2011, July 26). *What is the Clean Development Mechanism (CDM)?* Retrieved August 1, 2014, from The Guardian: http://www.theguardian.com/environment/2011/jul/26/clean-development-mechanism

Solomon Associates. (2010). *EII Analysis Methodology - Gap Analysis Versus World's Best EII.*

Solomon Associates. (2010). Solomon Associates' Benchmarking - An Insight into Energy Performance and Gaps. *CEE Refining and Petrochemical Meeting.* Gdansk.

Solomon Associates. (2012). Solomon Petroleum Refinery Efficiency Metrics - Creating a Level Playing Field. *Chevron Modernization.*

Stephan, D. (2013, 5 16). *ONGC Registers One of the World's Biggest Clean Development Mechanism Projects*. Retrieved August 1, 2014, from Process Worldwide: http://www.process-worldwide.com/india/articles/405250/

Stern, D. I. (2003). *The Environmental Kuznets Curve.* Rensselaer Polytechnic Institute, Department of Economics. Troy, NY 12180: Internet Encyclopaedia of Ecological Economics.

TERI. (2014). *Energy Security Outlook.* New Delhi: TERI.

TERI. (2014). *The Energy & Environment Data Directory Yearbook 2013/14.* New Delhi: The Energy and Resources Institute (TERI).

UNESCAP. (2012). *Low Carbon Green Growth Roadmap for Asia and the Pacific: Turning Resource Constraints and the Climate Crisis into Economic Growth Opportunities.* Bangkok: United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP).

Unruh, G. C. (2000, October). Understanding carbon lock-in. *Energy Policy, 28*(12), 817–830.

Uppal, J., & Raje, N. (2007, Februrary). Challenges in Utilizing Challenges in Utilizing Flared/ Vented Gas & Opportunities for Carbon Emissions Opportunities for Carbon Emissions Reduction in Assam. New Delhi.

World Bank. (2011). *Global Gas Flaring Reduction Partnership*. Retrieved June 24, 2015, from Global Gas Flaring Reduction Partnership: http://go.worldbank.org/NEBP6PEHS0

About TERI

A unique developing country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across many continents to enhancing forest conservation efforts among local communities; from advancing solutions to growing urban transport and air pollution problems to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. However, while TERI's vision is global, its roots are firmly entrenched in Indian soil. All activities in TERI move from formulating local- and national-level strategies to suggesting global solutions to critical energy and environment-related issues. TERI has grown to establish a presence in not only different corners and regions of India, but is perhaps the only developing country institution to have established a presence in North America and Europe and on the Asian continent in Japan, Malaysia, and the Gulf.

TERI possesses rich and varied experience in the electricity/energy sector in India and abroad, and has been providing assistance on a range of activities to public, private, and international clients. It offers invaluable expertise in the fields of power, coal and hydrocarbons and has extensive experience on regulatory and tariff issues, policy and institutional issues. TERI has been at the forefront in providing expertise and professional services to national and international clients. TERI has been closely working with utilities, regulatory commissions, government, bilateral and multilateral organizations (The World Bank, ADB, JBIC, DFID, and USAID, among many others) in the past. This has been possible since TERI has multidisciplinary expertise comprising of economist, technical, social, environmental, and management.

teri
The Energy and Resources Institute
www. teriin.org