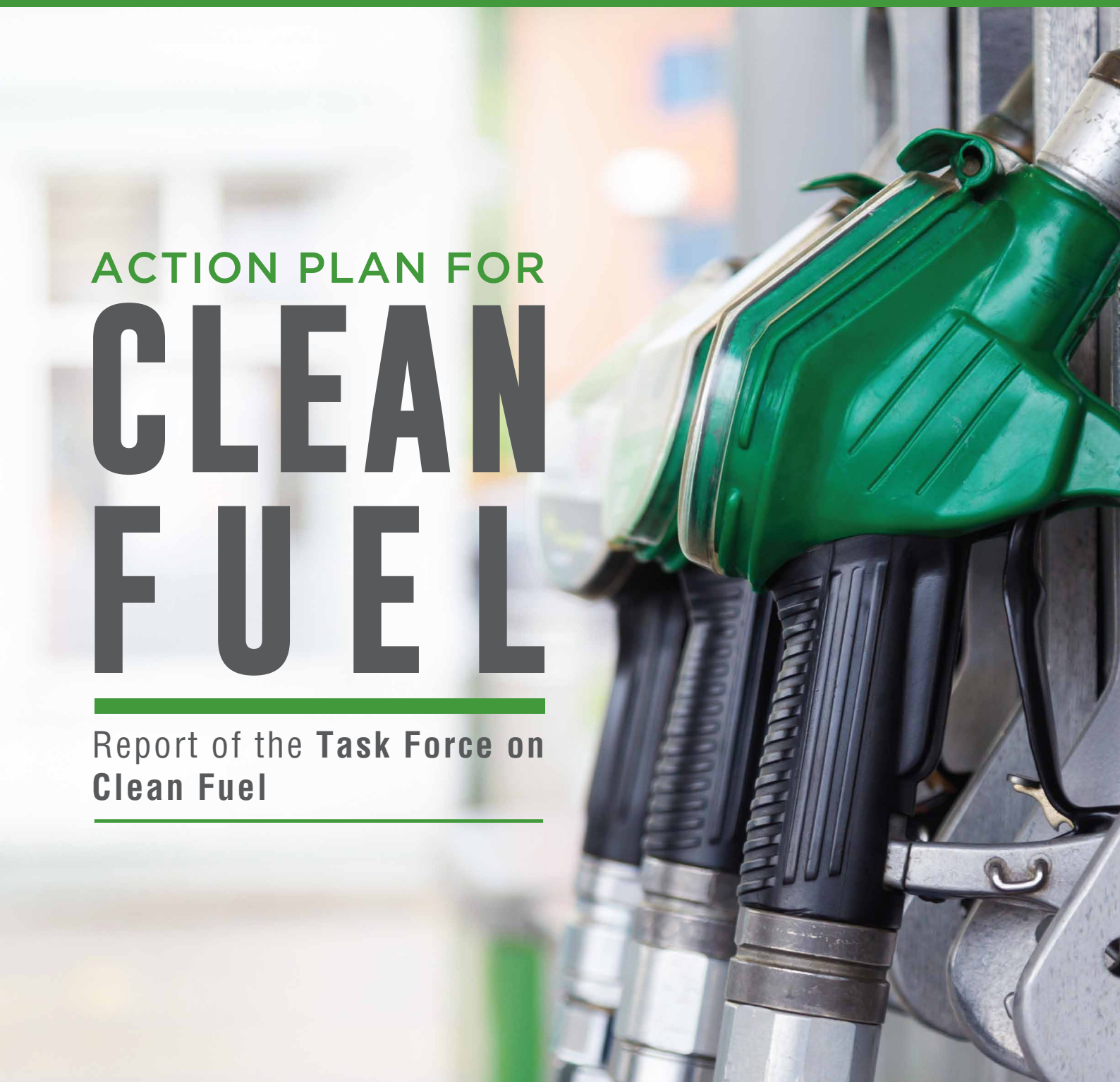
NITI Aayog

Confederation of Indian Industry

CII–NITI Aayog's **'Cleaner Air Better Life Initiative'**



ACTION PLAN FOR CLEAN FUEL

Report of the **Task Force on Clean Fuel**

Published by

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Message

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MESSAGE

Formulation of appropriate strategies for maintaining a clean, green and healthy environment is a priority in NITI Aayog. We are all aware that air pollution is a major threat to a healthy environment. For controlling air pollution, NITI Aayog has been working closely with Confederation of Indian Industry (CII) and other stakeholders. On the World Environment Day (5th June, 2017), NITI Aayog and CII organized the first meeting of their joint initiative "Cleaner Air Better Life" with an objective to address the issue of air pollution in the Country with active participation of the Government agencies, the industries and other stakeholders.

Subsequently, four Task Forces were constituted in NITI Aayog with experts as members to recommend suitable interventions for Clean Fuel, Clean Transport, Clean Industries and Biomass Management. The Task force on Clean Fuel has adopted a structured approach for identifying critical issues and possible solutions for addressing polluting fuel and emission from combustion sources. They have given valuable recommendations in their report which would be highly useful for moving towards the use of cleaner and more efficient fuel in industries, power generation, transportation, households and commercial sectors.

I congratulate the CII team for their excellent work on the "Cleaner Air Better Life" Initiative. I would also like to congratulate Mr. Sandeep Poundrik, Joint Secretary, MoPNG and Convener of the Task Force on Clean Fuel, for showing great leadership while undertaking extensive consultations with the stakeholders and coming up with specific recommendations. I would also like to place on record appreciation for Mr. Yaduvendra Mathur, Mr. Jitendra Kumar, Ms. Pratima Gupta and other officers of the NRE Vertical, NITI Aayog for providing necessary support and relevant inputs to the Task Force.

(Amitabh Kant)

Place- New Delhi

Message

Sandeep Poundrik, I.A.S.
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15th February, 2018

Message

India is one of the bright spots in global economic landscape and in fact has the potential to contribute towards sustainable development of globe. As we aim for inclusive social development, about 22% of India's population, which is still living under the poverty line need to be brought on development path. India's energy consumption is therefore bound to increase to suffice the needs of development. We are aware that fuel quality and access to cleaner fuels is imperative as we intend to reduce the environmental footprints of our nation's development.

We have experienced deteriorating air quality over last one decade with ambient air quality level in Delhi-NCR remaining severe most of the times. Ministry of Petroleum and Natural Gas is committed towards access to clean sources of energy in the country to reduce health impacts of indoor and ambient air pollution alike. Under CII-NITI Aayog cleaner air better life initiative, this report of task force on clean fuels presents the actionable recommendations for addressing the air pollution in Delhi-NCR. The suggested action agenda would require course correction by various actors along with prioritisation of fiscal policies for clean fuels in long-term. Providing cleaner fuel to end-users across NCR region such as industry, power plants, households, local businesses is priority of the Government.

In addition to recommending an overarching clean fuel taxation and pricing strategy, the report clearly articulates sector-specific measures, including low hanging fruits for immediate action. Task force recommendations have been prepared after due consultation with concerned stakeholders including assessment of technical and economic feasibility of proposed interventions. I hope that these actions would be considered immediately by concerned agencies. To that effect, some of these recommendations are already notified by the Union Government or are undergoing implementation.

I would like to thank CII and NITI Aayog for undertaking an initiative on this important issue concerning public health and giving me the opportunity to convene the consultations under the Task Force on Clean Fuel. I thank all task force members for their inputs and look forward to continued support of all stake holders in scaling up efforts to ensure clean fuels and cleaner air in Delhi NCR.

(Sandeep Poundrik)

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1. BACKGROUND

Air pollution is one of the major man–made environmental risks to the public health. The release of various gaseous emissions and particulate matter in the air has been on the rise due to various anthropogenic emissions. To address the rising concerns of deteriorating air quality, Confederation of Indian Industry (CII) in partnership with NITI Aayog launched the 'Cleaner Air Better Life Initiative' in November 2016. The first meeting of this initiative was held on 5 June 2017, on the World Environment Day and the initiative is now working towards engaging businesses, civil societies and government for actionable steps to improve the air pollution in Delhi and National Capital Region (NCR). Under the initiative, four task forces have been constituted by NITI Aayog for Clean Transportation, Clean Fuel, Clean Industry and Biomass Management.

There are several studies conducted by different institutions on deterioration of air quality in Delhi. A recent and most comprehensive source apportionment study was undertaken by IIT–Kanpur (IIT–K) on behalf of the Government of National Capital Territory (NCT) of Delhi. Findings from IIT–K study are being considered as the basis for designing the action plans for the initiative. The CII–NITI Aayog 'Cleaner Air Better Life Initiative' initiative aims at finding solutions to air pollution in a holistic manner by engaging with different stakeholders who are part of common air-shed in Delhi. Aforesaid task forces were mandated by NITI Aayog to find out actionable solutions for air pollution in their respective focus areas. First meeting of the task force on clean fuel was organised by the Convenor on 17 July 2017, which was attended by task force members including policymakers and representatives from industry, public sector undertakings (PSUs) and civil society organisations. Key focus areas were identified by the task force during the first meeting. This was followed by a second meeting on 2 August 2017, where the task force pursued on finding solutions to challenges specific to individual sectors outlined during first meeting of the task force (see Figures 1 and 2). Third meeting of the task force was held on 22 August 2017, where first draft of the report was discussed and specific inputs were sought from members. Drawing from the discussions during the task force meeting and inputs from its members, the report presents a recommended action plan including the short-term, medium-term and long-term actions. This report has been finalised during fourth meeting of the task force held on 29 November 2017, considering all the inputs received from the members.

2. INCLUSIVE APPROACH OF THE INITIATIVE

Air-shed management is a much more complex issue compared to water-shed management because of the various environmental and climatic factors. An integrated approach is required, involving all concerned stakeholders, through intense engagement with an objective to design market-oriented solutions. This would ensure long term sustainability of actions. Various institutions have designed different actionable plans, however, this initiative aims to create required synergy and build a consensus among the stakeholders to drive actions on ground.

The initiative aims towards:

- Developing an integrated approach that brings together policy makers, industry, academia, community and civil society
- Building consensus and get buy–in from stakeholders on actions for improving air quality
- Delivering voluntary commitments from stakeholders towards reducing air pollution
- Influencing adherence to existing policies and advocacy towards newer policies

The task force on Clean Fuel has adopted the structured approach in identifying key issues and possible solutions to address the polluting fuels and combustion sources of emissions. The consultative and multi-sectoral approach is outlined below in Figures 1 and 2. The full list of stakeholders consulted by the task force can be found in Annexure 6 of the report.

Figure 1. Consultative process followed by the Task Force on Clean Fuel

Stakeholders consulted:

Government: NITI Aayog, Ministry of Petroleum and Natural Gas (MoPNG); Ministry of New and Renewable Energy (MNRE); and Central Pollution Control Board (CPCB).

Industry: Confederation of Indian Industry (CII); and Society for Indian Automobile Manufacturers (SIAM)

Oil and Gas Marketing Companies: GAIL India Limited; Indraprastha Gas Limited (IGL); Indian Oil Corporation Limited (IOCL), Reliance India Limited (RIL).

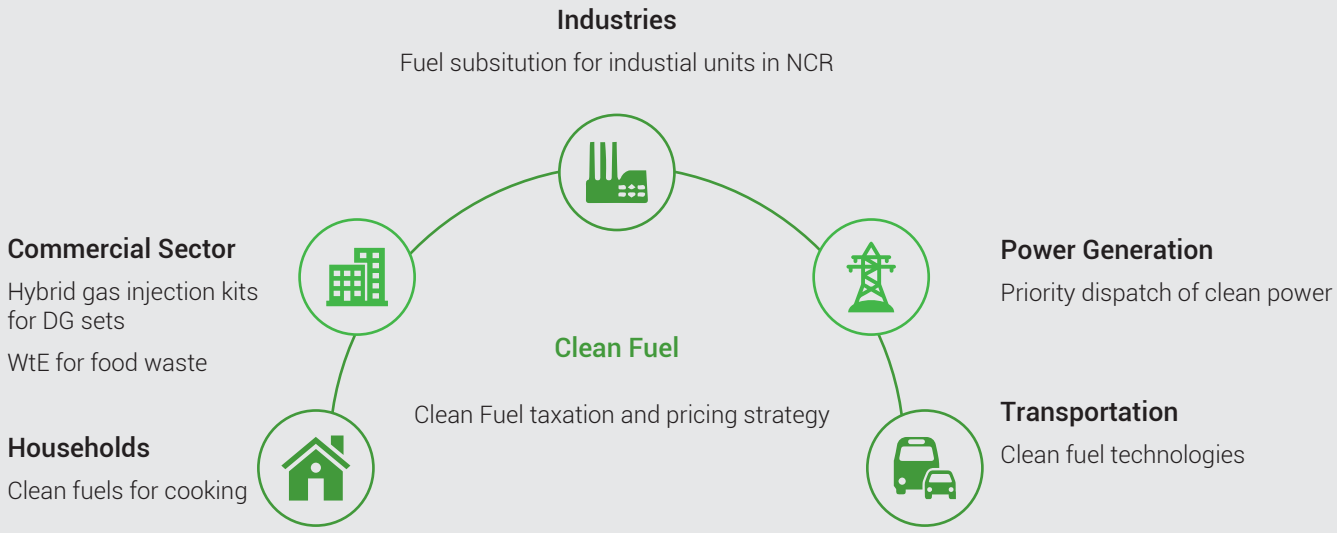
Civil Society: Centre for Science and Environment (CSE).

3. RECOMMENDED ACTION PLAN FOR CLEAN FUELS

Combustion sources contribute most to the air quality in Delhi's air-shed. Source apportionment study reveals that 54% contributions to particulate matter (PM) 2.5 arise from combustion sources, including 100% contribution to NOx emissions from the combustion sources (Sharma & Dikshit, 2016). Health impacts and exposure to air pollution are important criteria for designing control strategies especially in case of vehicular emissions. Characteristics of PM from different sources are also important, for instance, coal and diesel are major contributors of toxic PM. It is estimated that the annual average PM10 reduction of 74% will be required to meet the air quality standards in Delhi. As a result, incremental actions would not have any impact on air-pollution and comprehensive set of actions are urgently required.

The key sub-sectors for the task force on clean fuel and proposed solutions for them are elaborated under the subsequent sub sections. These sub-sectors and key recommendation under them are highlighted in Figure 2.

Figure 2. Multi–sectoral approach of the task force on Clean Fuel



Imports of PC have reached
14 million
tonne in 2016–17

3.1 Clean Fuels for Industry

Highly polluting fuels[1] such as petroleum coke (PC) and furnace oil (FO) are used by industrial units, especially the small and medium-sized enterprises (SMEs) in the country. Even some categories of waste such as tyre oils and used lubricants, that don't fall under the approved list of fuels (for their use) by regulatory authorities, are used as source of energy in some industrial units. Imports of PC have reached 14 million tonne in 2016–17 (Department of Commerce, GoI, 2017) which is a matter of concern. Countries like USA and China have banned the import of PC. As per the DPCC notification under the Air Prevention & Control of Pollution Act, use of PC is banned in Delhi (DPCC 1996). The ban on these fuels has been further extended by Supreme Court of India, to the neighbouring states of NCR, and the sale, distribution and use of pet coke and furnace oil is prohibited in NCR from 1 November 2017.

It has been assessed by IOCL and was noted by the task force that removal of sulphur from PC/FO[1] is not cost-effective. The estimated cost for production of 5,000 ppm FO is around INR 40 per litre whereas the cost of production for BS-IV Diesel (50 ppm) is around INR 30 per litre (IOCL 2017). In addition, it was reported that no commercially viable technology is available for desulfurization of FO from current sulphur levels of 3% (by weight) to 500 ppm (See Annexure 1).

[1] These are refinery by–products; with high sulphur content ranging 25,000 ppm.

> Taxation and pricing strategy for clean fuels is needed to provide impetus to cleaner fuels and discouraging the use of polluting fuels.

As the use of PC and FO is already prohibited in Delhi NCR, it is recommended that fuel substitution is facilitated by making sure that alternate fuel is available and fiscal instruments are utilised to provide a policy push towards cleaner fuels.

Liquid Natural Gas (LNG) is the cleanest and economic fuel available, as during the process of liquefaction of natural gases all the impurities especially sulphur gets removed completely and the product is directly imported as finished product. Due to the prevailing tax structure, the current delivery prices of LNG are higher than polluting fuels like furnace oil and pet coke even though the imported price of LNG is 8–10% cheaper than crude oil (GAIL 2017a). Government's import bill can hence be reduced by promoting LNG.

Further, for geographical regions of the country, where natural gas pipeline or City Gas Distribution (CGD) network availability is an issue, LNG supply through cryogenic road tankers should be incentivized to make it competitive compared to furnace oil and pet coke, through cess on polluting fuels, lower differential taxes on cleaner fuels and inclusion of LNG in GST.

Following actions are recommended for enabling the fuel switch in industrial units in NCR-

a) Ensure liquid petroleum gas and piped natural gas supply to all designated industrial areas in Delhi NCR on an urgent basis

Gas Authority of India Limited (GAIL) maintains that assessment for gas supply in Delhi NCR has been carried out (GAIL, 2017b). Gas can readily be supplied to industrial clusters, except very thinly spread industry share of which is relatively small and supplying gas would not be economically viable. Therefore, the task force recommends that LPG and Piped Natural Gas (PNG) supply is ensured in all designated industrial clusters located in Delhi–NCR. Whenever PNG infrastructure is available in an industrial area, polluting fuels may be removed from the list of approved fuel list for that area.

b) Better taxation strategy for cleaner fuels is required

Taxation and pricing strategy is needed to provide impetus to cleaner fuels and discouraging the use of polluting ones. Lower taxes on the cleaner fuels are sought and for the purpose, GST can create a level playing field in the country. It is recommended that MoPNG may undertake formulation of taxation strategy along with the Ministry of Finance (MoF).

c) Notify the list of approved fuels in NCR region

It is recommended that the list of approved fuels is notified by concerned State Pollution Control Boards (SPCBs) in the NCR region to curb the use of other dirty fuels which might be in use. CPCB should ensure that concerned SPCBs issue notification similar to the DPCC notification[2] under the Air (Prevention & Control of Pollution) Act.

[2] As per the latest information available at the time of writing this report, a new list of acceptable fuels is currently in its draft stage and DPCC will soon be notifying the new list for Delhi NCT.

d) Facilitate City Gas Distribution projects in adjoining NCR towns

Government should facilitate city gas distribution operations in all towns/areas falling under NCR, wherever PNG supplies are currently not available. Few such cities or towns in NCR which do not have natural gas distribution infrastructure include Hapur, Bulandshahar, Baghpat, Mewat, Jhajjar, Bhiwani, Mahendragarh, Jind, Muzaffarnagar and Palwal.

> Priority ranking of power plants needs to be revised so that gas-based generation enjoys the same status as renewables for its ability to provide clean power

3.2 Clean Fuels for Power

Although, there are no coal based thermal power plants (TPPs) operational in Delhi, except one plant in Badarpur, there are 13 TPPs with the capacity over 11000 MW in a radius of 300 km from Delhi (Sharma & Dikshit, 2016). Additionally, the gas-based plants in the region are highly underutilised. This is due to the regulatory procedures for power dispatch and fluctuation in gas prices which render plant operation economically unviable. Currently, all renewable based power plants, except the biomass power plants and cogeneration plants, are treated as 'must–run' power plants which means that they are not subjected to the merit dispatch order (owing to their infirm nature) (CERC 2010). On account of Merit Dispatch Order principle, the coal based power plants with cheapest variable cost per unit of electricity gets advantage over Natural gas based power plants. As a result, natural gas power plants in Delhi are not able to run at full capacity. Gas-based power can meet 50% of Delhi's demand whereas it is only catering upto 20% of this demand presently (CSE 2017). Hence the priority ranking of power plants needs to be revised so that gas-based generation enjoys the same status as renewables for their ability to provide clean power.

The gas-based generation has several benefits over other conventional thermal power generation plants including:

- Low emissions (0.30 tCO_2/MWh) to atmosphere compared to coal (0.98 tCO_2/MWh) or diesel (0.59 tCO_2/MWh) and ability to provide clean electricity as a result.
- Fast ramping capabilities of gas-based generation (open–cycle gas power plants) for large-scale integration of renewables into the grid.
- Gas-based power plants act as peaking plants in the electricity system. Additionally, the Diesel generators used during peak hour power shortages are not only more expensive, they are environmentally more polluting (CEA 2016).
- Higher efficiency (55%), in general, compared to coal-based TPPs (38–40%) and lower auxiliary power consumption (3% compared 8.5% in coal-based TPPs).
- Significantly lesser land and water requirements compared to coal based TPPs, which is very relevant for densely packed urban areas.

Nationally, gas-based generation suffers huge economic loss due to inadequate supply and very low plant load factor (PLF) of about 23% (2015—16) due to unavailability of natural gas (CEA 2016). As per the World Bank's world development indicators, the gas-based power share in India is 7.7% compared to global average of 22% (CEA, 2016).

It is also important to understand what percentage of renewable electricity could be a realistic target to meet Delhi's electricity demand. Currently, under smart city mission, the New Delhi Municipal Council (NDMC) is proposed to lease rooftops for setting up rooftop solar. Public participation is an important enabler for adoption of rooftop solar at a substantial scale.

Following actions are required for prioritising clean fuel for power generation-

a) Provide a push to cleaner power generation in NCR by notifying priority status for gas–based power generation (short–term)

Notification to Northern Region Load Dispatch Centre (NRLDC) to provide the priority status to natural gas based generation in Delhi NCR, by making sure that gas based generation is granted a must-run status and is not subjected to merit order dispatch.

b) Amend the Indian Grid Electricity Code (2010) giving priority to cleaner sources of power generation (long–term)

Amend the Indian Grid Electricity Code (2010) by mandating the natural gas-based plants as 'must–run' in dense urban agglomeration (not subjected to the merit order dispatch), based on their environmental advantage over other fossil fuel based power plants to provide cleaner power.

c) Provide priority support to stranded gas based generation in NCR and other dense urban agglomerations in line with the national schemes

The Ministry of Power launched the 'Scheme for utilisation of gas-based generation capacity' in 2015 which provides financial support to gas–based stranded power. This financial support is in the form of waiver on custom duty for imported LNG, reduction in pipeline tariff charges, exemption of transmission charges and support from Power System Development Fund (PSDF). Outlay of this support was fixed at INR 3500 Crores and INR 4000 Crores for the year 2015–16 and 2016–17, respectively. In line with this scheme following recommendations are made–

It is recommended that, in line with the scheme for financial support to gas based generation (in FY 2015–16 and 2016–17), a long term scheme is formulated (as recommended in the draft National Electricity Plan of CEA in 2016) to support the stranded capacities in coming years and priority is given to the stranded gas-based power plants located in and around dense urban agglomerations.

d) Increase uptake of solar rooftop in Delhi by scaling up existing schemes

The target share of renewable electricity in Delhi is 19.75% (with 8.75% solar) for 2019–20, as per the latest DERC regulation (draft order in Aug 2017), with immediate target for 2017–18 as 14.25% (with 4.75% solar). These targets seem to be ambitious as total renewable electricity procured by power distribution companies (DISCOMs) in 2016–17 was 9%. Foreseeable challenges to mass uptake of rooftop (RT) solar need to be addressed by adequate stakeholders consultation and inclusive approach. Broad estimates suggest that uptake from the existing groundwork could result in addition of 3000 MW solar roof top capacity in Delhi by the year 2022 (MNRE 2017).

The New Delhi Municipal Council (NDMC) has jurisdiction over central Delhi where all major office establishments of central government are located along with the key central business district of the city. It aspires to source 70% of its total energy from renewables by 2025 as part of the smart cities initiative (MoUD 2017). NDMC area spreads across 43.7 km^2 area which is merely 3% of the National Capital Territory (1483 km^2) and is very miniscule as compared to NCR (53,817 km^2) (NCRPB 2017).

The present demand for transport fuels in Delhi NCR is found to be **6.2 million** tonne diesel and **1.98 million** tonne motor spirit (IOCL 2017)

It is recommended that learnings from initiative are replicated in the colonies of three municipal corporations of Delhi (MCDs) and other major urban local bodies within NCR, in order to promote clean energy across NCR and have a wider impact.

3.3 Clean Fuels for Transportation

Fuel quality has direct link to the emissions from vehicles. During the discussion in task force meeting, it was agreed that if NCT of Delhi can move to BS–VI compliant fuels without any change in current vehicle technology, it would be beneficial to improving air quality of Delhi. The BS–VI fuel offers significant advantages compared to BS–IV fuel being used today including reduced sulphur (80% reduction) content and reduced polycyclic aromatic hydrocarbon (PAH) (27% reduction) content (See Annexure 2 for more details) (ACEA; Alliance; EMA; JAMA 2013; IOCL 2017).

The present demand for transport fuels in Delhi NCR is 6.2 million tonne diesel and 1.98 million tonne Motor Spirit (MS) (IOCL 2017). The BS–VI fuel can alleviate the vehicular pollution and should immediately be made available in Delhi. Task force recommended that the technical feasibility for sourcing the required fuel should be explored and the cost of sourcing BS–VI fuels for Delhi can be absorbed in national market. Capacities of two major Oil Marketing Companies (OMCs) have therefore been assessed with this purpose–

- The IOCL's combined annual capacity in the region (Panipat and Mathura refineries) for BS–VI compliant fuel is presently found to be only a fraction of this demand (0.22 million tonne diesel and 0.39 million tonne MS). As per IOCL, BS–VI projects for both the refineries will be complete by the end of 2019 and hence, in view of this timeline, it will be difficult for IOCL alone to cater to the fuel demands of Delhi.
- Reliance India Limited (RIL) has capacity in excess to Delhi's demand for transport fuels. It is found that RIL's combined capacity to provide BS–VI fuels, at two of its refineries, is 24 million tonne high speed diesel (HSD) and 10.8 million tonne MS. But, it would need an assurance for logistic support from the government for supplying fuel in Delhi.

The feasibility for supplying BS–VI fuels to meet Delhi's demand has been assessed by the Centre of High Technology (CHT) in consultation with OMCs and accordingly, the task force makes following recommendation.

a) Prepone the introduction of BS-VI compliant fuels in Delhi and NCR

It has been assessed by IOCL that if BS–VI fuels are made available in Delhi and NCR before the expected date (1 April 2020), the emissions from all the in–use vehicles would reduce thereby lowering the emission load of all existing vehicles in the NCR. Task force agrees that BS–VI compliant fuels can lead to improvements in air quality and should be adopted at an earlier date. The logistic arrangements for supply of BS–VI fuels have been assessed by CHT in consultation with OMCs and task force recommends supplying BS–VI compliant fuels to Delhi by 1 April 2018 and to entire NCR by 1 April 2019.

b) Set up an HCNG demonstration project at one DTC depot

Emerging alternate fuel, especially those which can utilise existing piped gas infrastructure are important for promotion of clean fuels in the city. Compressed Natural Gas (CNG) as an auto fuel was introduced in

HCNG can be used as a fuel for heavy duty engines after minor engine optimisation.

Delhi due to its advantage of lower emissions and better fuel economy. Delhi may go ahead with CNG buses in future till the BS–VI is fully implemented. Therefore, opportunities for utilising existing gas piping infrastructure for Bio–CNG can be explored in Delhi. In order to find cleaner alternative for transportation and reduce dependence on petroleum imports, the Indian Oil Corporation limited (IOCL) and Society of Indian Automobile Manufacturer (SIAM) have collaboratively undertaken a pilot project (sponsored by MNRE) on compact reforming process for Hydrogen and Compressed Natural Gas (HCNG) blend.

It envisages lowering of the exhaust emissions from CNG vehicles due to improved combustion characteristics of resultant fuel blend (18 v/v % hydrogen in CNG, See Annexure 3 for more details). HCNG can be used as a fuel for heavy duty engines after minor engine optimisation. The test results with buses on a pilot scale indicates on average,[3]

29% reduction in CO emissions and 13% reduction in methane and total hydrocarbon (THC) emissions whereas the specific fuel consumption is 2-3% lower than CNG. The NOx emissions during the pilot tests with buses, however, increased by 40% on average. Comprehensive testing with various vehicles indicate no clear trend in NOx reduction (increase in NOx levels in most of the cases except very few cases where NOx levels decrease) but consistent reduction in CO emissions across vehicles (SIAM 2017). The Indian Oil Corporation limited maintains that these emissions can be brought under control by tuning the engine and optimising air–fuel ratio, ignition timings etc. These adjustments will reduce NOx emissions to at least neat CNG levels if not lesser (IOCL 2017). The technology is ready for demonstration and is recommended by the task force for implementation at one of the Delhi Transport Corporation (DCT) depots. However, there are several challenges related to the implementation of new technology that need to be addressed, as outlined in the subsequent recommendations.

[3] Pilot level testing with the Ashok Leyland and Tata buses.

> Existing vehicles can handle up to 10% blending and flex–fuel vehicle roadmap is required in order to move to higher blending targets.

A single stage compact reformer plant with 4 tonnes HCNG per day capacity is recommended to be set up by IOCL at one of the DTC bus depots. This plant can fulfil the fuel requirements of nearly half of the average bus fleet at such depot.[4] The CAPEX of the plant is estimated to be 11.56 Crores (IOCL 2017). The OPEX is estimated at INR 6.8/ kg HCNG.[5] Following actions are required for the proposed demonstration project at DTC by IOCL-

i. Set up compact reformer plant at one DTC depot

The capacity of the unit would be 4 tonne HCNG/day (CAPEX: INR 11.56 Crores) which can cater to the fuel demand of nearly half of the buses at the respective depots. Time required for setting up compact reformer is 18 months.

ii. Notify HCNG as an automotive fuel

The Ministry of Road Transport and Highways (MoRTH) will need to issue a notification for usage of HCNG as an automotive fuel.

iii. Notify standards for use of HCNG as a fuel

The Bureau of Indian Standards (BIS) will need to notify the HCNG fuel specifications.

iv. Safety clearance for HCNG storage cylinder on vehicles

IOCL will need approval from Petroleum and Explosives Safety Organisation (PESO, formerly the Department of Explosives) for using type–1 cylinders to store HCNG in vehicles. Test results for type–1 fuel cylinder have already been submitted by IOCL to PESO (See Annexures II and III, A3).

While discussing other clean fuel options for vehicles, it is highlighted that existing vehicles can comfortably handle up to 10% blending beyond which flex–fuel vehicles will be required. Currently, the supply of molasses based ethanol in the country is limited for achieving higher blending targets. Flex–fuel vehicle roadmap is required in order to move to higher blending targets. Also, biofuel blending would need to be harmonised and standardised across the states. A shift to bio–fuels is a long–term goal and will require at least 3–5 years. Subsequent recommendation is made in this regard.

c) Achieve 10% ethanol blending in transport fuels, nationally, by 2022

The options to achieve a realistic target of 10% ethanol blending, harmoniously across the nation, should be explored. Strong policy convergence is required between waste to energy (from agricultural waste) and fuel blending.

[4] DTC owns 43 bus depots with 7200 CNG buses.

[5] Expected to come down to INR 2-3/ kg with economy of scale in the future (IOCL 2017).

> Vapour emissions during fuel loading and dispensing are major concerns for secondary organic particles which eventually contribute to PM pollution. It was highlighted during task force meetings that vapour recovery systems (VRS) can be implemented easily in a cost effective manner.

d) Formulate strategy for promoting LNG as transportation fuel

LNG is the cleanest and economical transportation fuel being widely used in countries like China and USA. Long–haul road transportation, inland waterways and railways are the important areas where LNG can be used as transportation fuel. One single LNG retail outlet station can serve the purpose of providing LNG as well as LCNG to the range of automobiles and provide substantial reduction in pollution arising out of vehicular transportation. As compared to diesel, LNG can provide cost savings of at least 20% (GAIL 2017a). However, requisite infrastructure in terms of LNG/LCNG stations and supply chain logistics is required to be developed and strategy for promoting LNG as transportation fuel may be formulated by the government.

e) Prioritise Implementation of Vapour Recovery Systems in Delhi:

Vapour emissions during fuel loading and dispensing are major concerns for secondary organic particles which eventually contribute to PM pollution. It was highlighted during the meeting that Vapour Recovery Systems (VRS) can be implemented easily in a cost effective manner and recommendations for action have already been passed by MoPNG to concerned OMCs (Letter dated 2 August 2017). VRS not only ensures emission reduction but reduces the product losses and is important for efficient operations by OMCs. Following are the recommendations based on the implementation status as per the CHT (2017) and CSIR–IIP's consultation with public sector OMCs including IOCL, BPCL and HPCL on 8 August 2017:

i. Expedite the VRS stage I[6] implementation in Delhi:

VRS stage I implementation needs to be expedited for Delhi and NCR. Two out of three supply locations in Delhi have implememted vapour recovery system. (CHT 2017) (See Table 1 for more details). The infrastructure at supply locations need to be converted from top loading to bottom loading which would require major changes in piping, pumping and tankers.

Table 1. Status of VRS stage I for supply locations in Delhi

Supply location	OMC	Status
Bijwasan	BPCL	In planning stage, completion expected by March 2019
Tikrikalan	HPCL	Commissioned
Tikrikalan	IOCL	In operation

Source: CHT (2017)

[6] Stage one covers the fuel loading, and unloading via tankers at supply locations and retail outlets, respectively.

The role of new and emerging **technologies** would be very important in future as they could disrupt the business as usual, paving a way for cleaner fuels

ii. Notify the Department of Legal Metrology for immediate clearance for implementation of VRS stage two[7] at retail outlets in Delhi

Currently VRS stage two in Delhi exists at 55% of the Retail Outlets (ROs) above dispensing capacity of 300 kilo litres per month and at 20% ROs of smaller size (See Table 2 for more details). VRS stage 2 implementation in Delhi may be expedited notifying the urgency of action to the Department of Legal Metrology under the Department of Consumer Affairs; Ministry of Consumer Affairs, Food and Public Distribution. There is no evidence suggesting that VRS system affects consumers in any way (CHT 2017). With the clearance for the Department of Legal Metrology, implementation of VRS stage II in Delhi can be completed by OMCs in 2018.

Table 2. Status of VRS stage two for retail outlets in Delhi

Retail outlet (RO) size	Number of total ROs in Delhi	Number of total ROs with VRS stage two	Remaining ROs
>300 kilo litre- MS/ month	155	85	70
<300 kilo litre- MS/ month	232	47	185

Source: CHT (2017)

iii. Install the leak detectors at ROs in Delhi

OMCs will need to install leak detectors at all ROs using submersible turbine pump (STP) for dispensing fuel. Leak detectors are not required for ROs using suction type dispensation.

Bureau of Energy Efficiency (BEE) is currently implementing first phase of fuel–efficiency norms which cover the light vehicles below 3.5 tonne. Additionally, for heavy duty vehicles, the norms have been notified by BEE. Although these are not addressed in detail under the task force, it is speculated that improved fuel efficiency norms can have a positive impact on air quality. Additionally, the role of new and emerging technologies would be very important in future as they could disrupt the business as usual, paving a way for cleaner fuels. For instance, the Shell is piloting a 5 tonne per day (TPD) plant in Bangalore for liquefaction of municipal waste to transport fuels which could pave a way for converting waste into transport fuels in future. Role of electricity is crucial for clean transportation and electric vehicle are being addressed by task force on clean transportation under this initiative.

[7] Stage two covers dispensing of fuels at retail outlets

Commercial buildings such as hotels and restaurants, institutional areas, and residential societies can benefit from processing their own waste for energy. Waste-to-energy can partly fulfil the energy demand of waste generators for street lighting and cooking fuel.

3.4 Clean Fuels for Households

Ensuring 100% access to clean energy, PNG for urban households and LPG to rural households, is priority for the Government of India. The task force members differ on LPG/ PNG penetration in households in Delhi NCR and it is speculated to be anywhere around 90%. It is speculated that 100% or more penetration, on papers, (See Annexure 5 for more details) could imply that some of the LPG is being diverted for commercial use. Delhi and Haryana have banned use of kerosene but Uttar Pradesh (UP) is required to ban it. Use of polluting fuels such as wood and kerosene is especially common with households below poverty line (BPL) who cannot afford clean fuels despite availability and access. BPL households in NCR would therefore require targeted subsidies for switching to cleaner cooking fuels. Following recommendations are made for the domestic sector.

a) Ban kerosene for domestic use in the state of UP in NCR area

It is recommended that following the similar suite as Government of Delhi and Haryana, Government of UP may consider banning kerosene for domestic use in the NCR region.

b) Targeted smart subsidies for BPL households in Delhi NCR

It is recommended that targeted smart subsidies are devised for Below Poverty Line (BPL) households in Delhi NCR with 100% tax exemption for LPG and PNG.

3.5 Clean Fuels for Commercial Sector

Delhi has a huge potential to convert organic waste into energy products. Biogas generated from bio–digestion or bio–methanation of organic waste fractions can be directly used as fuel or can further be converted into CNG (bio–CNG) or electricity. Organic waste content of municipal solid waste (MSW) generated within the jurisdiction of five local bodies of Delhi is estimated[8] to be 4000–5000 tonnes per day (Talyan et al 2007; DPCC 2014; MCD 2015; Mohit Sharma 2016). It is further estimated that 54% of total MSW in Delhi originates from the residential areas (which has 58–78% organic content), 18% from main shopping centres (~16% organic content), and 10% from vegetable markets (~ 97% organic content).[9] Total potential for biomass generation from organic waste originated from all these source is therefore estimated to be 320,000–400,000 m^3 (74–91 MW) biogas[10] (Hulgaard 2015; PC, 2014). Assuming 35% efficiency in biogas to electricity conversion, potential for electricity generation would be 26–32 MW which is 0.5% of Delhi's peak demand (6,526 MW).

Commercial buildings such as hotels and restaurants, institutional areas, and residential societies can benefit from processing their own waste for energy. Biogas generated from such bio–methanation plants can be utilised for following purposes–

- It can partly fulfil the energy demand of waste generators for street lighting and cooking fuel for kitchens at the hotels/restaurants or community kitchens
- It can be upgraded to bio–CNG (by purifying and compressing it) and can be used as a transportation fuel utilising the already existing CNG infrastructure in Delhi.

[8] CII–ITC CESD, 2017 estimation based on cited references.

[9] Rest is composed of construction and demolition waste, hospital waste and industrial waste.

[10] In an optimised system, methane content of biogas could be as high as 50% and biogas generation varies from 70-90 m3 per tonne of organic waste.

CPCB may issue a directive for mandating use of PNG for power backup in cellular network towers, wherever PNG supply is available.

- It can be further converted into clean electricity using gas-based electric generator and fed into the electricity grid (although the net efficiency of operation is much lower when compared to the options above).

Organic fractions of waste are not segregated at the moment, due to lack of proper waste management in the city. For any such intervention, segregation would be a prerequisite as contamination with other types of waste can significantly undermine the efficiency of energy recovery process (Kumar & Sil 2015). IOCL has piloted the small scale bio–CNG plant (250 kg food waste per day) with higher methane content (>80%) compared to conventional biogas plants (60–70%) in operation (IOCL 2017). Details of the plants are attached in the Annexure 4. Following recommendation is made for waste–to–energy (WtE) from food waste in Delhi.

a) Set up WtE facilities for large generators of food waste

It is recommended that commercial premises and residential societies may set up WtE plants to treat organic waste and convert it into useful energy products. To begin with, large commercial areas and residential societies can be identified by IOCL for setting up bio–CNG facilities on demonstration basis. Time required for setting up WtE plants is 9 months.

In addition, following recommendations are made for the commercial sector to promote the use of cleaner fuel in hotels, restaurant and mobile towers.

b) Ensure supply of PNG to commercial sector

The PNG supply should be ensured to commercial buildings such as hotels, restaurants to reduce their dependence on polluting fuels such as coal.

c) Mandate use of PNG for power backup in mobile network towers

For all mobile towers and similar activities in Delhi NCR, where use of diesel-generator (DG) set is required for backup power, option of hybrid technology (gas injection kits for DG sets) could be utilised. Concerned agency such as CPCB may issue a directive for mandating use of PNG in mobile network towers, wherever PNG infrastructure is available and utilization of gas as a backup fuel is feasible.

Table 3. Execution details for respective sectors with agencies involved in implementation

	Recommended action	Steps required	Implementation	Status
Industry	Fuel switch in NCR industry	Ensure gas supply to Industry clusters in Delhi NCR	MoPNG; IGL; GAIL	PNG supply to industrial clusters is feasible as per GAIL
		Taxation strategy for cleaner fuels under GST	MoPNG; MoF	
		Notify the list of approved fuels in NCR regions in a phased manner	CPCB, SPCBs for Haryana, U.P. and Rajasthan	
		Facilitate City Gas Distribution (CGD) projects in adjoining NCR towns	MoPNG	
Power	Priority status for cleaner generation	Provide a push towards cleaner power generation by notifying priority status to gas based generation in Delhi NCR (short-term)	MoP; CERC; SERCs; NRLDC	
		Amend the Indian Grid Electricity Code (2010) giving priority to cleaner sources of power generation in dense urban agglomerations (long-term)	MoP; CERC; SERCs	
		Extend the scheme for utilisation of the stranded gas based capacities and provide priority support to stranded capacities based in dense urban agglomerations	MoP, MoPNG	

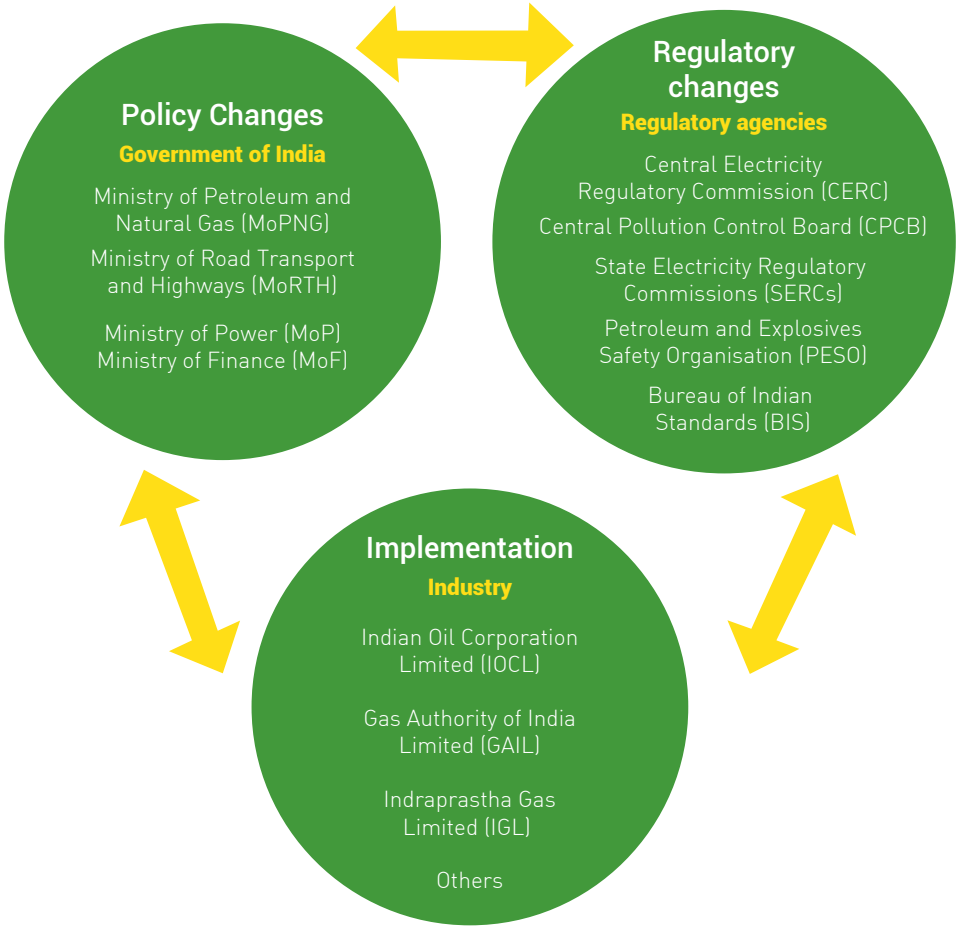
	Recommended action	Steps required	Implementation agencies	Status
	Increase share of RT solar in electricity-mix of Delhi	Scale up the NDMC scheme to rest of Delhi	MNRE	
Transportation	Introduce BS-VI compliant fuel in Delhi and NCR	Introduce BS–VI compliant fuels in Delhi NCT by pooling national capacities	MoPNG, OMCs	Already notified by the Ministry http://pib.nic.in/newsite/PrintRelease.aspx?relid=173517
		Introduce BS–VI compliant fuels in Delhi NCR by pooling national capacities	MoPNG, OMCs	
	Introduce HCNG demonstration plant at DTC bus depots in Delhi	Set up a compact reformer plant at one DTC depot (4 t HCNG/day)	IOCL	
		Notify HCNG use as an automotive fuel	MoRTH, GoI	
		Notify standards for HCNG as Fuel	BIS	
		Safety Clearance for HCNG on-vehicle storage cylinders	PESO	Application submitted to PESO in 2012 by IOCL
	Achieve 10% biofuel blending	Achieve 10% blending in transport fuels nationally by 2022	OMCs	
	Promote LNG as transportation fuel	Formulate a strategy for promoting LNG as transportation fuel	MoPNG, MoRTH	

	Recommended action	Steps required	Implementation agencies	Status
Transportation	Prioritise on–going implementation of vapour recovery systems for Delhi	Prioritise and expedite the VRS stage I at supply location in Bijwasan, Delhi	BPCL	
		Notify the urgency of action to the Department of Legal Metrology for VRS stage II clearance at all ROs in Delhi	Ministry of Consumer Affairs, Food and Public Distribution	
		Complete VRS stage II in remaining 255 retail outlets in Delhi	OMCs	
		Install leak detectors at STP type ROs in Delhi	OMCs	
Households	Ban kerosene for household use in Delhi NCR	Notification by Government of UP for banning kerosene use by households in NCR area	UP Government	Kerosene banned in Delhi and Haryana
	Smart subsidies are Below Poverty Line (BPL) Households	Devise targeted smart subsidies for Below Poverty Line (BPL) Households with 100% tax exemption for LPG and PNG	MoPNG, PSUs	
Commercial	Set up waste–to–energy from food/ organic waste at commercial buildings and residential societies	Identify areas for setting up waste to bio–CNG demonstration plants	IOCL, Hotels/ restaurants, RWAs	
	Promote cleaner fuels in Hotels/ restaurants	Ensure supply of gas to commercial premises within NCR	GAIL/ IGL	
	Promote cleaner fuels in mobile towers	Mandate use of gas in telecom towers in Delhi NCR	CPCB and concerned SPCBs	

4. IMPLEMENTATION PLAN

Actions recommended by task force are captured in Table 3 with the key execution details (such as steps required, implementation agencies involved and action status) required for their implementation. Also, the short–term actions which deserve immediate attention of policymakers and implementation agencies, are highlighted in the table. Figure 3 outlines the implementation plan of the Clean Fuel Task Force and highlights various actors who are responsible for policy/regulatory changes and implementation required to bring the recommended actions to fruition.

Figure 3. Implementation plan for the Task Force on Clean Fuel with MoPNG as the central monitoring agencies for all the actions



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ANNEXURES

Annexure 1
Sulphur reduction in furnace oil

Annexure 2
Impact of using BS–VI fuel in BS–IV engine vehicles

Annexure 3.
Hydrogen blended CNG (HCNG for buses)

Annexure 4
Bio–CNG for Delhi NCR

Annexure 5
LPG footprint in Delhi NCR

Annexure 6
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ANNEXURE 1

Sulphur Reduction in Furnace Oil

Technology for Sulphur reduction in Furnace Oil (FO)

Indian Oil Corporation Limited (IOCL)
4 August 2017, New Delhi

Presently, the fuel oil (FO) of different grades (Sulphur: 3–3.5 wt %) is prepared by blending of following streams to meet viscosity and sulphur:

- Lighter stream (light cycle oils/ other cracked gas oils)
- Heavy stream (vacuum/ visbreaker residues, cat cracker slurry oils)

Fuel oil desulfurization economics

Currently, petroleum streams (gasoline and diesel) are desulfurized in a fixed bed reactor system, which are not suitable for processing FO. In refineries with existing process units, FO desulfurization even to 5000 ppmw sulphur level is not possible.

FO desulfurization to 5000 ppmw sulphur, requires heavy oil hydro–desulfurization facility, which includes ebullated and slurry based technologies. However, due to requirement of significant amount of hydrogen and high-pressure operation (more than 120 bar g H2 partial pressure), the process is cost intensive.

Typical ballpark cost estimate for a 1 MMTPA FO desulfurization unit (from feed sulphur of 3 wt % to 0.5 wt %) is around Rs. 2000 Cr. However, this unit also requires other accessories, viz. hydrogen generation unit, sulphur recovery unit, off–site plants, etc. Hence, the estimated cost for a FO desulfurization complex is around Rs. 3000 Cr., the typical operating cost for a 1 MMTPA unit is around Rs. 4500 per Metric Ton. The estimated cost for production of 5000 ppmw FO is around Rs. 40 per liter. However, the cost of production for BS–IV Diesel (50 ppm) is around Rs 30 per liter.

In view of the above it is better to use BS–IV Diesel (50 ppm) instead of 500 ppmw sulfur containing FO.

To the best of our knowledge, currently no commercial technology is available for desulfurization of FO from current sulphur levels of 3 wt% to 500 ppmw (i.e. industrial FO).

ANNEXURE 2

Impact of using BS–VI fuel in BS–IV engine vehicles

Impact of using BS–VI fuel in BS–IV and pre-BS-IV vehicles

Indian Oil Corporation Limited (IOCL)
03 August 2017, New Delhi

BS–VI fuels offer significant improvements in terms of performance, emissions and durability of BS–IV and Pre–BS–IV vehicles.

DIESEL: The comparison between the BS–IV and BS–VI diesel fuel is given in Table A2.1. Few fuel specifications have been revised in BS–VI as compared to BS–IV. The effect of these changes on BS–IV & older vehicles are as follows:

1) **Sulphur:** In BS–VI, the sulphur content of diesel is reduced to 10 ppm from 50 ppm in BS–IV. Decrease in sulphur level will reduce corrosion and engine wear related issues; this would essentially increase the life of the engine. The sulphur reduction will also reduce the sulphate formation and related exhaust particulate matter (PM) emissions. Low sulphur fuel allows the use of advanced exhaust catalysts for emission control and enhances their durability.

2) **PAH:** Reduction of PAH content of diesel fuel offers the benefit of significant decrease in both oxides of nitrogen (NOx) and PM emissions. Further, the carcinogenic PAH emissions in the exhaust will also be reduced.

3) **FAME (Biodiesel) Content:** BS–VI specification allows blending of up to 7% biodiesel in diesel. The addition of biodiesel would reduce the CO, HC and PM emissions significantly. In general, biodiesel has superior lubricity characteristics compared to normal diesel, which would improve the life of the fuel system components and engine.

GASOLINE: The comparison between the BS–IV and BS–VI motor gasoline is given in Table A2.2. There are certain parameters namely distillation (E70), sulphur, Reid Vapour Pressure (RVP), Vapour Lock Index (VLI), gum, oxygen content and ethanol content were revised in BS VI compared to BS IV. The effect of these changes on BS–IV and older vehicles are as follows;

1) **Sulphur:** Studies indicate strong correlation between fuel sulphur with HC and PM emissions. It enables the use of more advanced technologies for emissions reduction and fuel efficiency. Further, like diesel, low sulphur gasoline improves the performance of engine and efficacy & durability of after-treatment devices.

2) **Gum:** The gum content is reduced to 4 mg in BS–VI compared to 5 mg in BS–IV. The reduced gum level decreases the formation of engine combustion chamber deposits leading to higher fuel economy.

3) **E70, RVP, VLI, Oxygen content and Ethanol content:** The fuel parameters such as E70, RVP, VLI, oxygen content were revised in BS–VI gasoline specification to allow ethanol blending up to 10%. The blending of ethanol offers significant benefit in terms of HC and CO emissions. However, E10 blend results in average fuel economy penalty of ~2% on account of lower calorific value (~3.5%). Internationally, to begin with, a practice of differential taxation was followed wherein an appropriate tax credit used to be given to the customer opting for environment friendly fuels Such initiatives may enhance the use of bio-ethanol for blending thereby; decreasing the dependence on fossil fuel imports leading to significant savings in foreign exchange.

Possibility of advancing the availability BS VI fuels in Delhi and NCR region and the cost implications thereof:

The present annual Diesel and MS demand in Delhi and NCR region is as 6200 TMT and 1980 TMT respectively, while at present the annual capability of both PR and MR to produce BS–VI compliant Diesel and MS is only 220TMT and 385TMT respectively. It is pertinent to note that the BS–VI projects for both the refineries are getting completed by the end of 2019 and hence, in the view of this timeline it will be difficult to cater to the demands of Delhi NCR region by BS–VI compliant fuels prior to April 2020 deadline.

However, already IOC has commenced supplies to auto majors for engine testing purposes BS–VI compliant fuels from Matura Refinery. Moreover, supply of limited volumes of BS–VI gasoline and diesel are already being explored at select RO's in major metros on the request of the Automobile manufacturers.

Table A2.1 Specification of Commercial Diesel Fuel

Property	Unit	BS-IV (IS 1460:2005)	BS-VI
Density @15°C	kg/m^3, max	820-845	845
Distillation T95	°C max	360	360
Sulphur	ppm max	50	10
Cetane No	Min	51	51
Cetane Index	Min	46	46
Flash Point	°C min	35	35
Viscosity @40°C	cSt	2.0-4.5	2.0-4.5
PAH	% wt max	11	8
Total Contaminants	mg/kg max	24	24
Carbon Residue (Ramsbottom) on 10% residue	% wt max	0.3	0.3
Water Content	mg/kg max	200	200
Lubricity, Corrected Wear Scar Diameter (VVSD) @60°C	Microns, max	460	460
Ash	% wt max	0.01	0.01
Cold Filter Plugging Point			
a) summer, max	°C	18	18
b) winter, max	°C	6	6
Oxidation stability	g/m^3, max	25	25
Copper strip corrosion for 3 hrs @ 50°C, max	Rating	Class 1	Class 1
FAME Content	% v/v max	---	7.0

Table A2.2 Specification of Commercial Gasoline Fuel

Property	Unit	BS-IV (IS 2796:2008)	BS-VI
Density @15 °C	kg / m^3	720-775	720-775
E-70	% vol	10-45	10-55 (Summer)/10-58
E-100	% vol	40-70	40-70
E-150	% vol, min	75	75
FBP	°C, max	210	210
Residue	% vol, max	2	2
Sulphur	ppm, max	50	10
RON	Min	91	91
MON	Min	81	81
RVP@38°C	Max	60	67
VLI			
Summer (May-July)	Max	750	1050
Other months	Max	950	1100
Benzene	% vol, max	1	1
Aromatics	% vol, max	35	35
Olefin	% vol, max	21	21
Gum	mg/100ml, max	5	4
Oxidation stability	Minutes, min	360	360
Lead as Pb	g/ litre, max	0.005	0.005
Oxygen content	% wt, max	2.7	3.7
Oxygenates	% vol, max		
Methanol		nil	3 (nil*)
Ethanol		5	10
Iso-propyl alcohol		10	10
Iso-butyl alcohol		10	10
Tertiary-butyl alcohol		7	7
Ethers containing 5 or more C atoms per molecule		15	15
Other oxygenates		8	8
Copper strip corrosion for 3 hrs @50°C, max	Rating	Class 1	Class 1

* Methanol is not permitted as per draft BIS specification for BS-VI motor gasoline

ANNEXURE 3

Hydrogen blended CNG (HCNG for buses)

Use of hydrogen–blended CNG (HCNG) in commercial buses in Delhi NCR

Indian Oil Corporation Limited (IOCL)
03 August 2017, New Delhi

CNG as an auto fuel originally was introduced in Delhi NCR as a legislative direction. Subsequently, it has registered significant growth owing to its advantages in terms of lower emissions and better fuel economy. However, cities like Delhi need further cleaner alternatives in order to reduce the vehicular emission inventories for improving the ambient air quality. Blending of hydrogen in CNG (known as HCNG) can result in further lowering of exhaust emissions from CNG vehicles due to improved combustion characteristics of the resultant blend.

Benefits of using 18% HCNG blends:

1. Light duty vehicles

Under a project funded by MNRE on 'Use of HCNG blends for Light duty vehicles', Indian Oil R&D conducted joint studies with SIAM on a fleet of vehicles including 3–wheelers, passengers' cars and LCVs [Table A3.1]. The studies established the following:

- 18 v/v% (or ~2.7% by mass) of hydrogen in CNG is the most optimal blend ratio for Indian vehicles
- Reduction of 45% in CO and 35% in HC emissions could be achieved with 18% HCNG
- NOx emissions may increase or decrease depending upon the engine design and tuning

Table A3.1 SIAM - MNRE - IOC joint studies on HCNG blends

	Ashok Leyland	Bajaj 3-Wheeler	Mahindra Bolero	Tata Indica	Average	Percentage reduction with HCNG
0 Km Base CNG						
CO	0.34	0.8	0.88	0.25	0.57	45.4
THC	0.5	0.59	0.41	0.06	0.39	35.9
NOX	0.35	0.59	0.07	0.02	0.26	11.7
0 KM 18% HCNG						
CO	0.18	0.57	0.3	0.19	0.31	
TI-IC	0.39	0.32	0.23	0.06	0.25	
NOX	0.37	0.44	0.06	0.04	0.23	

Notes:
1. Emission data expressed in g/km on a chassis dynamometer
2. Wide variations in results of other three vehicles were observed

2. Heavy duty engines

Indian Oil R&D embarked upon another collaborative programme with Ashok Leyland and Tata Motors to validate the use of HCNG in heavy duty engines / vehicles [Table A3.2]. The studies indicated that;

- HCNG can be used as a fuel for heavy duty CNG engine after minor engine optimization.
- The Specific Fuel Consumption of HCNG engine is lower than CNG by 2 to 3%.
- In Ashok Leyland HD engine, CO, CH_4 and THC emissions got reduced by 28%, 20% & 20%, respectively while NOx emissions increased by 48% respectively.
- Studies conducted on Tata Motors HD engine indicated a reduction of CO, CH_4 & THC, emissions by 31%, 6.7% and 6.5% respectively while an increase in NOx emissions by 32.5% was observed.
- The NOx emission with HCNG fuel can be reduced through optimization of engine which may result in the penalty on engine power output.
- No adverse impact of HCNG on vehicle components and engine performance was observed.


Table A3.2 Heavy duty engine testing with 18% HCNG blends

TATA Motors						
Fuel used	Work, kWh	CO, g/kWh	TUC, g/kWh	CH_4, g/kWh	NOx, g/kWh	CO_2, g/kWh
CNG	12.8010	2.26	0.46	0.45	1.63	678.01
18% HCNG	12.7635	1.56	0.43	0.42	2.16	647.70
Improvement		31%	6.50%	6.70%	-32.50%	4.50%
Ashok Leyland						
Fuel used	Work, kWh	CO, g/kWh	THC, g/kWh	CH_4, g/kWh	NOx, g/kWh	CO_2, g/kWh
CNG @ 0 hrs	13.431	0.64	0.15	0.15	0.23	729.25
HCNG @ 0 hrs	13.203	0.46	0.12	0.12	0.34	716.64
Improvement		28%	20%	20%	-48%	2%

Production of HCNG through IOC R&D's patented Compact Reformer technology

Conventionally, HCNG is produced by physical blending of CNG and Hydrogen. However, this approach involves onsite production of neat hydrogen through electrolysis of water, followed by its compression, storage and blending with CNG at high pressures using complicated mass flow control technology. The resultant blend is much more expensive than CNG due to presence of multiple energy intensive steps.

In order to overcome this challenge, Indian Oil R&D developed a low severity single step compact Steam Methane Reforming process for HCNG production from natural gas. A demonstration unit of 2.5 Nm^3/h (~1.6 kg/h) HCNG capacity has been installed at Indian Oil R&D and the performance of the process has been successfully validated by dispensing 18% HCNG in the demonstration vehicles. The cost of production of HCNG by above process is significantly lower as compared to physical blending.

Proposal

At 43 bus depots of Delhi Transport Corporation (DTC), 7200 commercial CNG buses are running in Delhi NCR. Hence, on an average 180 buses are present in a bus depot. Assuming one bus runs 200 km/day, amount of CNG requirement of a bus depot to fill the buses is 9 TPD. Therefore, a single stage compact reformer plant of capacity ~4TPD would be sufficient to supply H-CNG to the 50% bus fleet of a depot.

As a part of 'Cleaner Air Better Life' initiative, it is proposed to set–up a 4 TPD single stage compact reformer plant in a commercial bus depot of DTC to significantly reduce the emission inventory from CNG buses by using 18% HCNG. Based upon the success of this demonstration, same process can be replicated for other bus depots also.

Cost Estimates

A typical heavy duty CNG bus with 6 cylinders of 74 L capacity each can accommodate a total of ~52 kg HCNG at 200 bar while delivering an average fuel economy of 4 km/kg. Therefore, a 250 Nm^3/hr capacity HCNG plant can fill up 3 buses per hour i.e. 72 buses per day considering single filling in a depot operational on 24-hour basis.

Indian Oil R&D has prepared a Basic Design Engineering package (BDEP) of single stage compact reformer suitable for bus depot with following specifications:

- Capacity: 250 Nm^3/hr i.e., ~165 kg/h (4TPD)
- Skid dimension: 4 m (L)X10 m(W) X 9 m (H)
- CAPEX of compact reformer = INR 11.56 Crores
- Estimated OPEX is INR 6.8/kg of product

Issues related to Commercialization of HCNG:

i. HCNG as an automotive fuel needs to be notified by Ministry of Road Transport & Highways (MoRTH).

ii. HCNG Fuel specifications need to be notified by Bureau of Indian Standards (BIS).

iii. Approval by Petroleum & Explosives Safety Organization (PESO) for using Type 1 cylinder to store 18% HCNG in vehicles.

- It is pertinent to mention that Indian Oil R&D submitted a report to PESO highlighting the findings of the health assessment study undertaken on Type 1 cylinder used for filling 18% HCNG fuel after covering 20,000 km. The tests based on chemical analysis of used cylinder, corrosion, tensile strength, impact, hardness and micro-structural analysis established that 18% HCNG can be used in existing CNG storage cylinder [Box A3.1].
- Further, a BIS sponsored study conducted by ARAI [Dekate et al, 2013] had established the compatibility of 18% HCNG with fuel supply system components of the vehicle (except cylinder).

Box A3.1 Indian Oil Corporation Limited's letter to PESO for safety clearance to HCNG demonstration plant (Dated 12.07.2012)

This is in reference to the letter no. G3(4) 40/ Hythane/ 2011 dated 7th May 2012 on the above subject.

The pointwise response to your various queries is as under-

1. We want to submit the following facts regarding commissioning of our HCNG dispensing stations:

a) HCNG dispensing station at IOC R&D Centre, Faridabad was commissioned in October 2005 and,

b) Dwarka HCNG station in New Delhi was commissioned in January 2009.

Further, we have recently completed the demonstration trial of 20,000 km with 18% HCNG blended fuel in 5 nos. of 3-wheelers with refuelling from both the dispensing stations. In these 3-wheelers, CNG cylinders conforming to IS 15490 have been used. After completing 20.000 km of field trial, the cylinder from one of the 3-wheeler was removed and sample specimen of the same was investigated and compared against new CNG cylinder for the following characteristics in our laboratories:

• Chemical analysis • Tensile tests • Impact tests

• Hardness tests • Micro structural analysis

The detailed test report on the above aspects is attached (Annexure-I). On comparing the results of tensile test and impact test of used HCNG cylinder and new CNG cylinder as well as reference data, it is evident that the tensile properties (UTS & YS), % elongation and impact energy of used HCNG cylinder are on lower side as compared to those of new cylinder as well as reference data. HCNG cylinder's mechanical properties show factor of safety of the order of 2.0.

The used cylinder has still good mechanical strength and its DBTT (ductile brittle transition temperature) is still around -50 oC. The cylinder's application temperature will be much higher than DBTT obtained (except Himalayan region where temperature is sub-zero). Based on the above in-depth study, it may be concluded that the HCNG cylinder is fit for use for another 20000 km. After that, further studies may be carried out on the metallurgy and mechanical properties of the cylinder material. This study would provide further insight into the effect of HCNG usage on the cylinder material.

2. Noted, we will ensure the compliance to gas cylinder rules for valves

3. The dispenser at IOC R&D comprises of two nozzles. One nozzle is for dispensing HCNG @ 250 bar and another one is for dispensing hydrogen @ 350 bar. HCNG dispenser is already approved by PESO and approval is being sought for dispensing neat hydrogen. A photo of the dispenser is attached indicating the hydrogen and H-CNG dispensers separately. Further technical details of the hydrogen nozzle are also attached (Annexure-II).

4. The P&ID of the dispenser is enclosed (Annexure-III) highlighting the hydrogen line for dispensing.

5. The hydrogen is produced from electrolyser and it conforms to ISO 14687-2.

6. The refuelling connection devices will conform to ISO 17268-2.

Further, Sh. P. C. Srivastava, Joint CCOE, Nagpur also visited our HCNG dispensing station on 18 June 2012 and technical features of the station and future plans have been discussed in detail. Further, as desired by Sh. Srivastava, third party certificates and documents for the dispensing station are also enclosed (Annexure IV).

In view of the above, it is requested to grant approval for dispensing neat hydrogen for our demonstration protects as mentioned earlier.

ANNEXURE 4

Bio–CNG for Delhi NCR

Indian Oil R&D's Bio—CNG Technology for Delhi NCR

Indian Oil Corporation Limited (IOCL)
3 August 2017, New Delhi

Introduction

Bio–methanation is a process of converting organic wastes into biogas and digestate by anaerobic microorganisms in the absence of air. Products of bio–methanation are biogas and digestate. Biogas is a mixture of methane, carbon dioxide and traces of other contaminant gases. Biogas can be used for various applications such as power generation, heating, cooking and transport applications. Digestate contains valuable plant nutrients such as nitrogen and potassium to be used as a fertilizer and soil conditioner.

Indian Oil R&D Technology

Indian Oil R&D has developed in–house bio–methanation technology for conversion of kitchen waste into biogas that can be used as bio–CNG. The technology deploys high performing bacterial inoculum which is responsible for conversion of organic waste into biogas with high methane (>80%) content (as indicated in Table A4.1) vis–a–vis 60-70% reported in conventional biogas plant technologies.

Table A4.1 Typical composition of biogas generated through IndianOil R&D bio–methanation process

Component	Methane	Carbon Dioxide	Nitrogen
Composition (vol %)	80-85%	11-13%	3-5%

Current Status

Performance of 50 kg/day bio–methanation plant was validated at Indian Oil R&D. Based on the encouraging results; the microbial inoculums were successfully evaluated in an existing 250 kg/day bio–methanation plant at Panipat Refinery. Efforts are underway to setup plants in other IOC refineries.

Cost Estimates

The Table A4.2 shows details of cost estimates for installing a 250 kg/day bio–methanation plant with expected biogas yield and composition.

Table A4.2 Cost estimates for installing a 250 kg/day bio–methanation plant

Food waste loading kg/day	250
Expected biogas/ bio–CNG production Nm3/day	5-6
Dry solid manure kg/day	20-25
Capex	
Estimated plant cost without CO_2 removal	12.6 Lakhs
Estimated plant cost estimate with CO_2 removal	15.6 Lakhs
Opex*	
Cost of inoculum (one time)	INR 60,000
Cost of Chemicals per annum	INR 50,000

Note: *Cost of manpower (2 nos.) will be extra

Way forward

In Delhi NCR, IOC's technology can be deployed at integrated townships, colleges, hotels and Municipal Corporation identified locations to utilize this gas for captive cooking purpose. Further, IOC is in the process of marketing the CNG source from biogas plants in few states of the country. The potential of bio–CNG as automotive fuel may also be explored in Delhi NCR to improve the ambient air quality. Use of fuel cells can also be explored using bio–CNG both for stationary and mobility applications.

ANNEXURE 5

LPG Footprint in Delhi NCR

LPG Footprint in Delhi NCR Region for cooking purposes and transportation

Indian Oil Corporation Limited (IOCL)
3 August 2017, New Delhi

In Delhi NCR, 664 TMT of domestic LPG was supplied by IOC during the FY 2016–17 which constituted 59% of the entire market. Auto LPG sales during the same period were 1.18 TMT in Delhi NCR which was entirely met by IOCL. Apart from domestic and auto LPG, the OMCs also supplied 121 TMT non–domestic packed LPG and 5.1 TMT bulk LPG, for which IOC's contributed 50% and 30% respectively. The LPG penetration levels in Delhi–NCR region are more than 100% as per the available data [See Table A5.1].

Table A5.1 LPG Detail for Delhi and its adjoining Districts

State	District	As on 01.07.2017						No. of ALDS as on 01.07.17				Product-wise LPG sale during FY 2016-17 (in TMT)				Product-wise LPG sale during FY 2016-17 (in TMT)											
		Active Domestic Consumers (in Lakh)				Estimated number of households (in lakh)	LPG coverage by OMCs					Domestic LPG				Non-Domestic Packed LPG				Bulk LPG				Auto LPG			
		BPC	HPC	IOC	OMC			BPC	HPC	IOC	OMC	BPC	HPC	IOC	OMC	BPC	HPC	IOC	OMC	BPC	HPC	IOC	OMC	BPC	HPC	IOC	OMC
DELHI					A	B	C = A/B																				
HARYANA		11.6	7.2	29.3	48.1	37.9	127%	0	5	13	18	164.2	106.9	443.9	715.1	24.0	14.0	43.7	81.7	0.00	0.00	0.03	0.03	0.00	0.00	0.93	0.93
	FARIDABAD	2.4	0.7	2.2	5.4	4	135%					30.8	8.9	30.4	70.2	3.7	0.9	2.8	7.3	0.14	0.24	0.00	0.38	0.00	0.00	0.00	0.00
	GURGAON	1.7	1.0	3.1	5.8	3.6	161%					20.2	12.5	38.8	69.6	4.6	3.3	6.0	13.9	1.64	0.71	0.30	2.65	0.00	0.00	0.00	0.00
	JHAJJAR	0.3	0.8	1.1	2.1	2.1	104%					2.7	8.3	12.0	23.0	0.2	1.4	0.6	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SONIPAT	1.4	0.4	1.3	3.0	3	100%					14.8	5.0	14.1	34.0	1.3	0.7	1.3	3.3	0.78	0.00	0.00	0.78	0.00	0.00	0.00	0.00
UTTAR PRADESH	BAGHPAT	0.0	0.3	1.6	2.0	2.3	85%					0.3	3.1	17.4	20.8	0	0.0	0.1	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	GAUTAM BUDH NAGAR	2.7	1.3	2.3	6.3	3.6	176%			2	2	33.5	15.8	26.3	75.6	3.5	2.0	2.0	7.4	0.00	0.00	0.51	0.51	0.00	0.00	0.13	0.13
	GHAZIABAD	2.0	0.6	6.4	9.0	9.4	96%			1	1	24.6	7.2	83.8	115.6	1.6	0.6	3.0	5.1	0.00	0.00	0.74	0.74	0.00	0.00	0.13	0.13
Total		22.1	12.3	47.2	81.7	65.8	124%	0	5	16	21	291.3	167.8	664.7	1123.8	38.8	22.9	59.3	121.0	2.56	0.95	1.57	5.08	0.00	0.00	1.18	1.18

ANNEXURE 6

List of stakeholders consulted

Stakeholder category	Stakeholder's name	Organisation
Government	Sandeep Poundrik	Ministry of Petroleum and Natural Gas
	Dr Vinod Kumar	Ministry of Petroleum and Natural Gas
	G. L. Meena	Ministry of New and Renewable Energy
	Rajnath Ram	NITI Aayog
	S. K. Paliwal	Central Pollution Control Board
	Garima Sharma	Central Pollution Control Board
Industry	Ashish Aggarwal	Cummins
	P. K. Banerjee	Society of Indian Automobile Manufacturers
	K. K. Gandhi	Society of Indian Automobile Manufacturers
	S. Bairagi	GAIL India Ltd
	Raj Kumar Chakraborty	GAIL India Ltd
	Vishal Bhatia	Indraprastha Gas Limited
	P. K. Pandey	Indraprastha Gas Limited
	Dr Reji Mathai	IndianOil
	Sanjeev Singh	IndianOil
	Dr SSV Ramakumar	IndianOil
	S M Vaidya	IndianOil
Civil Society	Anumita Roy Choudhury	Centre for Science and Environment
Scientific bodies	Prakash D Chavan	Central Institute of Mining and Fuel research
	Rajendra Singh	Central Institute of Mining and Fuel research
Confederation of Indian Industry (CII)	Seema Arora	CII ITC Centre of Excellence for Sustainable Development
	Kamal Sharma	CII ITC Centre of Excellence for Sustainable Development
	Mohit Sharma	CII ITC Centre of Excellence for Sustainable Development

Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has over 8,500 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 200,000 enterprises from around 265 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

As a developmental institution working towards India's overall growth with a special focus on India@75 in 2022, the CII theme for 2017-18, **India@75: Inclusive. Ahead. Responsible** emphasizes Industry's role in partnering Government to accelerate India's growth and development. The focus will be on key enablers such as job creation; skill development and training; affirmative action; women parity; new models of development; sustainability; corporate social responsibility, governance and transparency.

With 67 offices, including 9 Centres of Excellence, in India, and 11 overseas offices in Australia, Bahrain, China, Egypt, France, Germany, Iran, Singapore, South Africa, UK, and USA, as well as institutional partnerships with 355 counterpart organizations in 126 countries, CII serves as a reference point for Indian industry and the international business community.

CII-ITC Centre of Excellence for Sustainable Development

CII-ITC Centre of Excellence for Sustainable Development is a not-for-profit, industry-led institution that helps business become sustainable organisations. It is on a mission to catalyse innovative ideas and solutions, in India, and globally, to enable business, and its stakeholders, in sustainable value creation. It's knowledge, action and recognition activities enable companies to be future ready, improve footprints profiles, and advocate policymakers and legislators to improve standards of sustainable business through domestic and global policy interventions.

CESD leverages its role of all-inclusive ecosystem player, partnering industry, government, and civil society. It has been a pioneer of environment management systems, biodiversity mapping, sustainability reporting, integrated reporting, and social & natural capital valuation in India, thus upgrading business in India to sustainable competitiveness.

With three locations in India, CESD operates across the country and has also been active in parts of South and South East Asia, Middle East, and Africa. It has held institutional partnerships and memberships of the United Nations Global Compact, Global Reporting Initiative, International Integrated Reporting Council, Carbon Disclosure Project, development agencies of Canada, the USA, the UK, and Germany.

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