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Bio-Fuels

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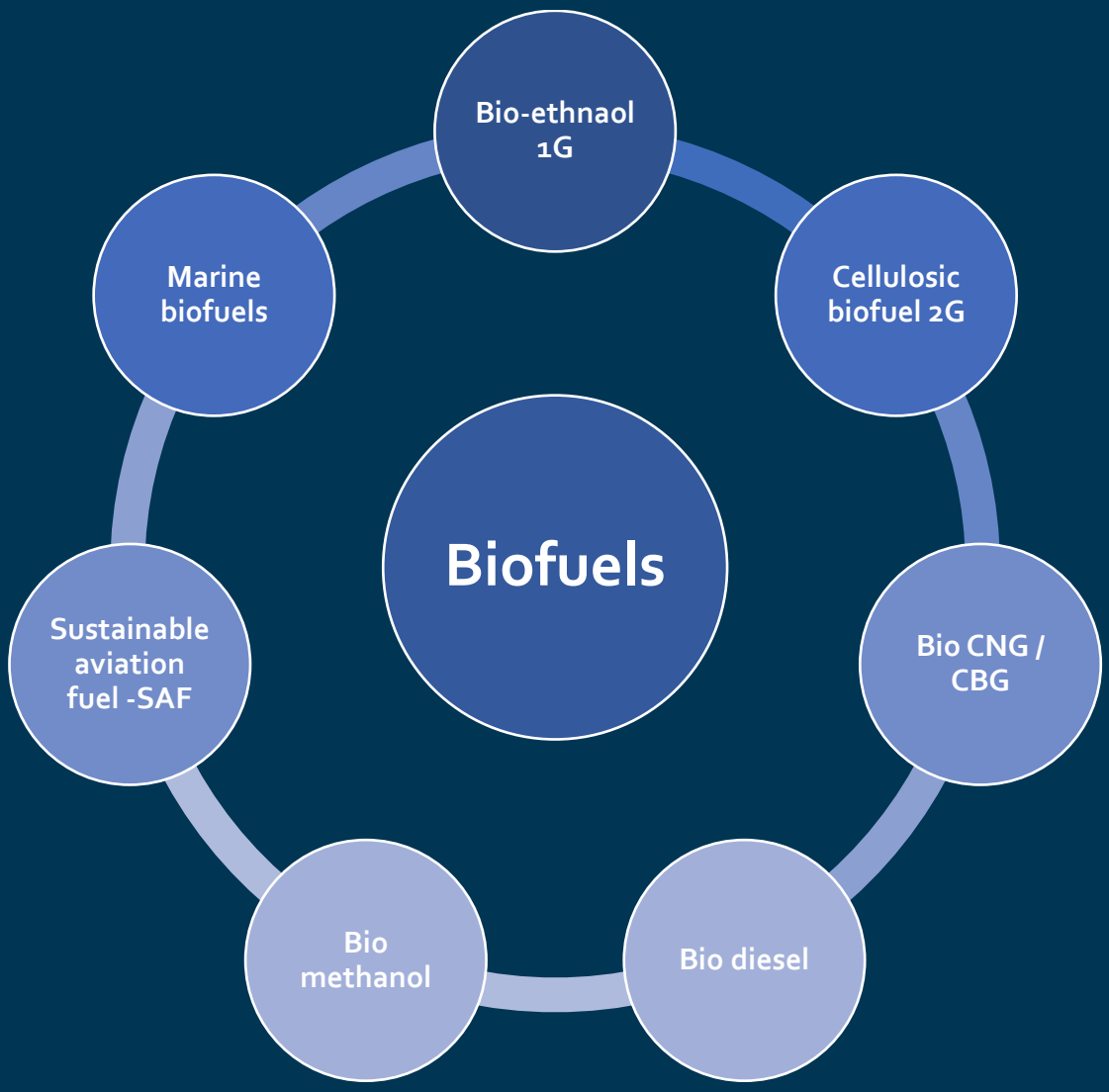

Clean and silent revolution

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Biofuels

A clean and silent revolution

INDIA | BIOFUELS | SECTOR UPDATE

24 July 2021

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Global awareness for environment and clean energy, along with the de-carbonization commitment, is attracting innovation and investment in biofuels. India has taken a realistic view on this sector, supporting changes under the National Policy on Biofuels – 2018, which promotes ethanol and bio-diesel blending, and increases the share of bio-gas in domestic consumption. The country's ethanol blending target of 20% is likely to create a c.Rs 840bn bio-ethanol market annually by 2025, while investment of Rs 1.75tn is planned in building a bio-CNG capacity of c.15mn tonnes per annum. These investments will not only benefit biofuel technology companies and storage and distribution players, but also help develop a sustainable agri and rural economy.

India to focus on cleaner and green fuel with timebound commitment: The government has recognized biofuels as an absolute necessity for the sustainable development of the country in an accelerated time-bound manner. The share of renewables/natural gas in India's energy basket is currently low at c.4%/6% (world average is 6%/24%) compared to oil/coal's higher share at 30%/55%. The promotion of biofuels has three broad aims: (1) To reduce GHG (Greenhouse gases) emission, pollution, (2) energy security and increasing domestic production under Atmanirbhar Bharat, and (3) value addition to agricultural products and rural development.

Gas-based economy: India has approved *Natural Gas Marketing Reforms*, taking a significant step to move towards becoming a gas-based economy to achieve the COP-21 Climate Change goals set for 2030. The government aims to increase the share of natural gas in the country's energy mix to 15-20% by 2030 from the current c.6%. India is promoting the use of bio-gas under the 'Sustainable Alternative towards Affordable Transportation (SATAT)' project launched on October 2018. Annual gas consumption in India is c.170mmscmd, set to rise to c.600mn by 2023. The import of LNG has increased consistently from 58mmsmd in FY16 to touch c.90 in FY21, as increasing demand is met through imports. CGD (City Gas Distribution) infrastructure will grow with an investment of Rs 1.2tn, serving more than 70% of the population by 2030 from c.20% at present. The proposed capacity addition should provide strong demand for gas meters, regulators, compressors, dispensers, CNG (Compressed natural gas) cascades, and CNG vehicles. India's network of CNG stations is set to triple to more than 11,200 by 2030.

Bio-ethanol's success after structural changes in 2018: The National Policy on Bio-fuels - 2018 addressed supply-side issues, including a wider range of feedstock for ethanol production (from the c-molasses to b-heavy and juice and other waste such as rural-urban garbage and cellulosic and lingo-cellulosic biomass) – in line with the *waste-to-wealth* concept. As a result, sugar mills are shifting to flexible business models with higher production of ethanol and are investing in the distillery segment as the 'need of the hour'. Attractive differentiated pricing should increase capacity in grain-based distilleries (using maize, broken rice, and damaged food grains) to c.7.5bn ltr per annum from c. 2.3bn ltr.

Bio-diesel and Sustainable Aviation Fuel (SAF) would be the next targets: Bio-mobility promotes the use of renewables to produce carbon-neutral transportation fuels across all modes of mobility, namely: (1) aviation with isobutanol, (2) shipping with methanol, and (3) road transport with ethanol (1G & 2G) and biodiesel.

Biofuels and electric vehicles: EVs are not an immediate solution, biofuel is. Ethanol is available here and now. EVs may not be as cheap and environment friendly, if we include the environmental cost of batteries and electricity (still mostly from coal!) and cost of charging infrastructure.

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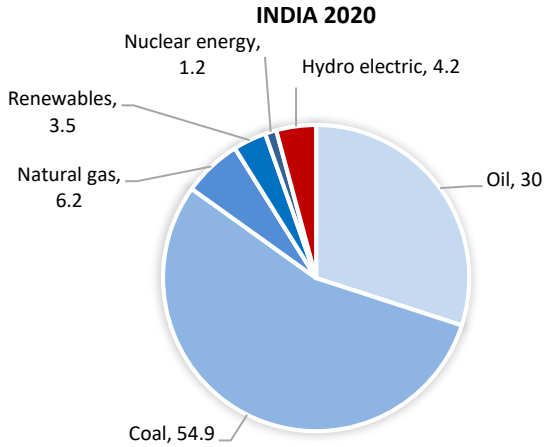
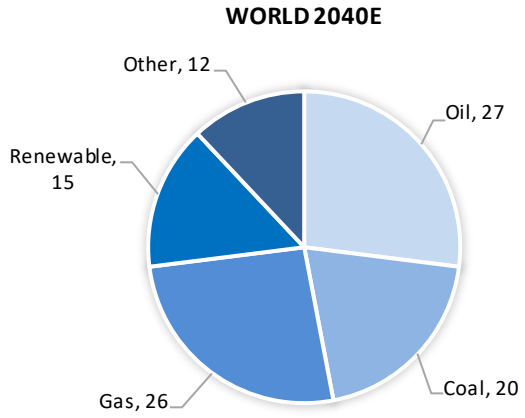
India energy mix: Focus on cleaner and green fuel

The energy demand in India is increasing with economic growth, rising population, and increasing urbanization. The share of renewables in India's energy basket is lower at c.4% and natural gas is 6% compared to the higher share of oil at 30% and coal at 55%. The use of renewables and gas in India is significantly lower than the world's average of 6% for renewable and 24% for gas. Considering the global trend for de-carbonization and cleaner energy sources, use of renewables and gas consumption are likely to grow as a faster pace in India ahead.

India's energy mix share is dominated by coal… (Unit in %)



…while the world moves towards a balanced energy mix

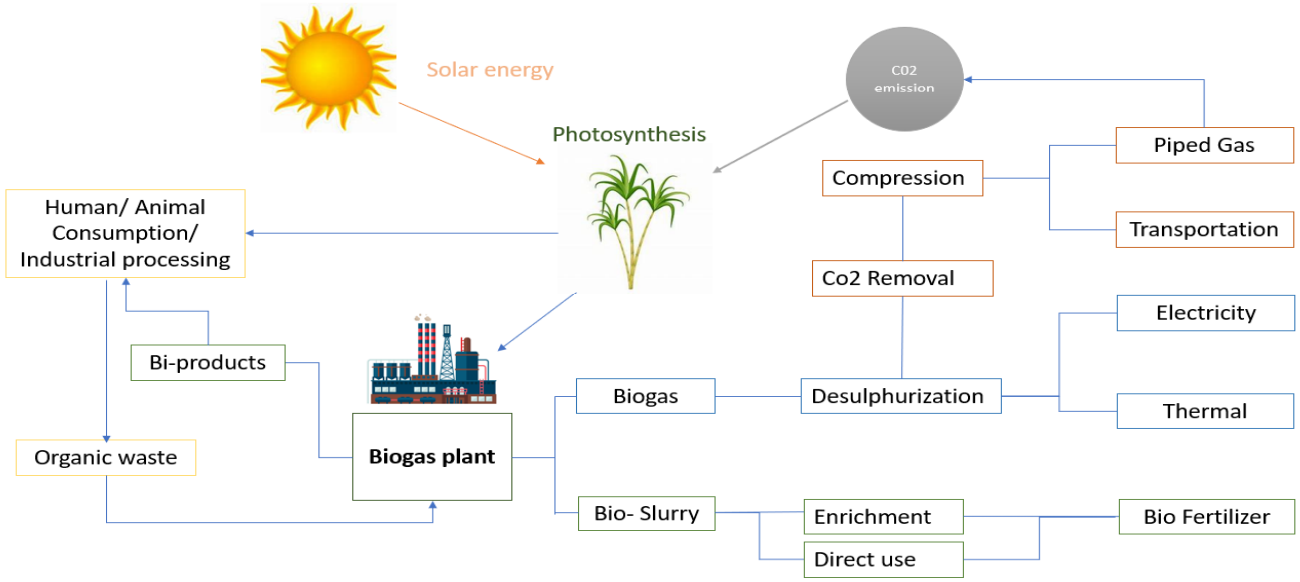


Source: PhillipCapital India Research, Industry Data

Sustainable cycle of biofuels

Biofuels are fuels produced from biomass and material waste. These are renewable fuels with a lower carbon cycle. The government has recognized biofuels as an absolute necessity for the sustainable development of the country in an accelerated time-bound manner. The learning curve in developing technologies for using abundant agri and other waste is becoming shorter – this should increase the use of bio fuels going ahead.

Biofuels – promoting a circular economy



Source: PhillipCapital India Research

India: Promoting green fuels in a time-bound manner

Achieving energy security and moving towards becoming a low-carbon economy is critical for developing nations such as India. India's government is promoting renewable fuels, enabling local enterprises and farmers' participation in the energy economy to reduce pollution.

The promotion of biofuels has three broad aims:

(1) Reduction in CGH imitation, pollution
(2) Energy security and increasing domestic production under Atmanirbhar Bharat
(3) Value addition to agricultural products and rural development

Biofuels for sustainable growth

Source: PhillipCapital India Research
Picture 1: Farmers burning agri residue after the harvest to prepare for their next crop, causing not only pollution but also losing the opportunity to earn additional income.
Picture 2: Energy crisis 1970; need for energy security and cleaner fuel.
Picture 3: Sugarcane promoted as energy crop. *To read our detailed report* Click here

Utilization of fossil fuels such as lignite, hard coal, crude oil, and natural gas converts carbon, stored for millions of years in the earth's crust, and releases it as carbon dioxide (CO_2) into the atmosphere. An increase in CO_2 concentration in the atmosphere is causing global warming, as carbon dioxide is a greenhouse gas (GHG). The combustion of biogas also releases CO_2, but the difference (vs. fossil fuels) is that since the carbon in biofuels is taken from the atmosphere by photosynthetic activity of the plants, the carbon cycle is closed quickly.

Air pollution and reduction in GHC

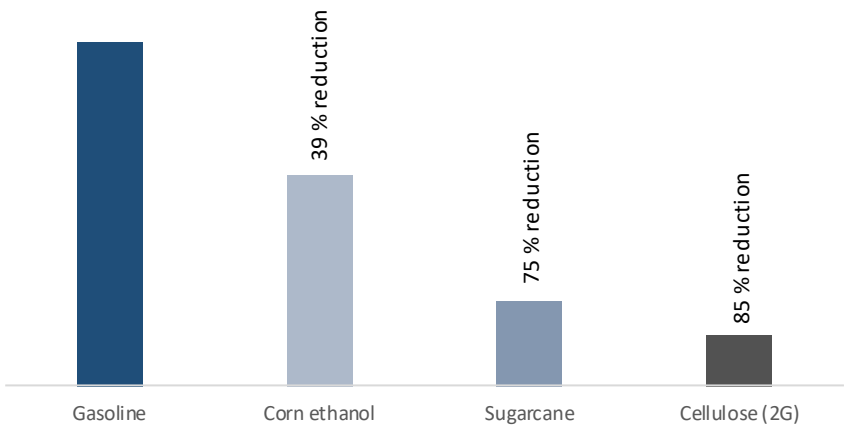
India consumes c.6% of the world's primary energy, but contributes to a proportionately higher c.7.5% of global carbon emissions, indicating a less cleaner energy mix. BP Statistical Review of World Energy 2020 data shows that while coal consumption has declined globally, it has marginally increased in India. Growth in coal and oil consumption has led to a high carbon emissions from the country (up 1.1%) compared to the world average of 0.5% in 2020. During 2008-2018, India registered a carbon emission growth of c.5%, much higher than the world average of just over 1%. With environmental issues and pollution becoming major concerns, the government is promoting cleaner fuel as a part of its de-carbonization and GHC reduction commitments. It aims to reduce the country's carbon footprint by 30-35% by 2030.

India is working towards reducing global warming as per the commitment made in COP-21 and the focus has been on greenhouse gas emissions and climate. The government will achieve de-carbonization targets in the following ways:

(1) Adopting biofuels and renewables
(2) Implementing energy efficiency norms
(3) Improving refinery processes
(4) Achieving demand substitution.

COP-21: The Paris Climate Conference is officially known as the 21st Conference of the Parties (or "COP") to the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations body that is responsible for climate and is based in Bonn, Germany

Cellulose ethanol – GHG emission reduction potential



Source: PhillipCapital India Research, Industry

The government of India has proposed a target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel by 2030, and introduced multiple initiatives to increase production of biofuels.

Biofuel compliance in the European Union

Country	Penalty for non-compliance with mandate
Belgium	Euro 0.90/ltr of mossing biofuel
Finland	Euro 0.84/ltr of mossing biofuel
Italy	Euro 0.75/ltr of mossing biofuel

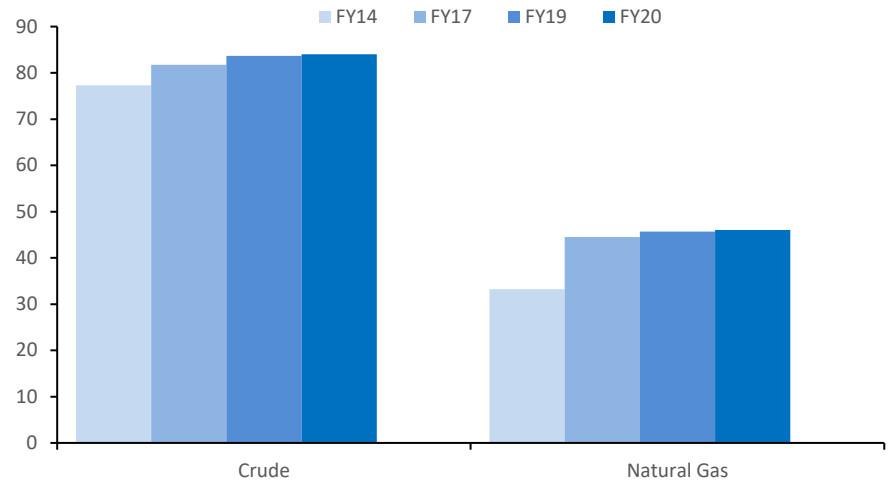
Source: PhillipCapital India Research, Industry

Energy security – India imports 85% of oil demand

India imports c.85% of its oil and c.50% of gas requirements. Without intervention, India's import dependency in crude and natural gas consumption is projected to increase to 92% by 2040. As a result, the Government of India is focused on achieving energy security; its target is to cut import dependence (i.e., usage of fossil fuels) by 10% from current levels by 2025.

The Indian economy should grow steadily, despite temporary setbacks due to the Covid-19 pandemic.

India's import of primary energy (crude at c.84%, gas at c.50%)



Source: PhillipCapital India Research

The Indian economy should grow steadily, despite temporary setbacks due to the Covid-19 pandemic. India has 85% import dependency in crude oil.

About 98% of the fuel requirements of India's road transportation sector is currently met by fossil fuels and the remaining 2% by biofuels. India's net import of petroleum was 185mt at a cost of c.US$ 551bn in FY21; most products were used for transportation. A successful E20 program (20% ethanol blending with petrol) can save the country c.US$ 4bn per annum, i.e., Rs 300bn.

The government aims to triple India's natural gas consumption over the next decade to 600mmscmd by 2030 from c.170mmscmd at present. Its target is to increase the share of natural gas in the country's energy basket to 15-20% from 6% at present, by replacing coal and liquid fuels. The country has committed investments worth US$ 60bn to expand gas infrastructure. This would include LNG import terminals, laying pipelines, and expanding city gas distribution networks across the country.

The National Policy on Biofuels (2018) aimed to accelerate the promotion of biofuels

Automobile manufacturers are likely to scale down the production of diesel vehicles due to the additional cost of production associated with stricter emission norms and rising diesel prices for consumers. The share of diesel vehicles has already reduced dramatically to 29% in FY20 from 58% in FY13, which could reduce further to 15-18% over the next three years.

Participation of farmers and agri economy

Though biofuels are gaining importance due to growing energy-security and environmental concerns, they are also a very effective tool for rural development and additional income for farmers. The government is promoting biofuels from foodgrains such as maize, rice, and damaged food grains, which provide an opportunity for bio-energy, help create additional income for farmers, and reduces pollution (due to crop burning). In case of food grains such as maize, which contains starch, protein, oil, and fibre, the starch content is mainly used for producing ethanol, while the remaining valuables such as protein and fibre are used for animal feed or producing value-added products.

Sugarcane biofuel economics

- One hectare (Ha) of sugarcane cultivation can produce c.75 tonnes of sugarcane.
- c.75 ltr of ethanol can be produced from one tonne of cane.
- So, 5,500 ltr of ethanol can be generated from one hectare of sugarcane cultivation. This is equivalent to 4,000 ltr of renewable oil per ha of land.
- India cultivates sugarcane on c.5.5mn Ha land – this is worth c.20bn ltr of oil or c.30bn ltr of ethanol.

The government is promoting procurement of ethanol produced from other non-food feedstock like cellulosic and lignocelluloses which is available in agri-waste. (See our report for technology on 2G for ethanol. **For detailed report Click here**

Agri waste burned in fields causing GHG and loss of income

Waste is collected in bale form as energy source

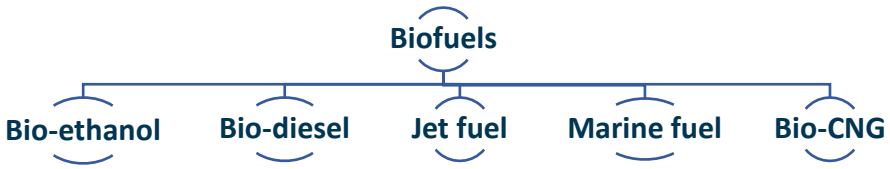
Source: PhillipCapital India Research

Renewable fuels: Biofuels

Biofuels are carbon neutral

Several processes and technologies for converting biomass into heat, electricity, fuels, and other products are under development globally. However, ethanol has been the most successful biofuel used so far for blending with gasoline (petrol); the use of biofuels in replacing diesel and gas is also increasing. A combination of new policies and favourable economics has driven the momentum for biofuels. Biofuels can reduce the consumption of fossil fuels and reduce carbon dioxide emissions. For biofuels, the carbon cycle is much shorter, as the carbon dioxide that is emitted when a biofuel is burned merely returns to the atmosphere the carbon dioxide that was taken into plants from the atmosphere by photosynthesis. Natural gas and renewables have contributed to c.75% of the overall energy consumption growth in 2019 in USA.

Fossil fuel consumption is a major cause of climate change. When biofuels replace fossil fuels, the net CO2 emission decreases



The Indian government is promoting 20% ethanol blending by 2025 from current c.8% and started working towards flexi fuel vehicles than can run on 100% ethanol. Promotion of bio-ethanol, LPG, and electric vehicles (EVs) replaces and reduces petrol consumption. Bio-diesel and promotion of gas (including bio-gas) replaces diesel consumption. Biofuel trails for aviation and marine applications have been successful.

Natural gas and renewables have contributed to c.75% of the overall energy consumption growth in 2019 in USA

Substitutes for fossil fuels

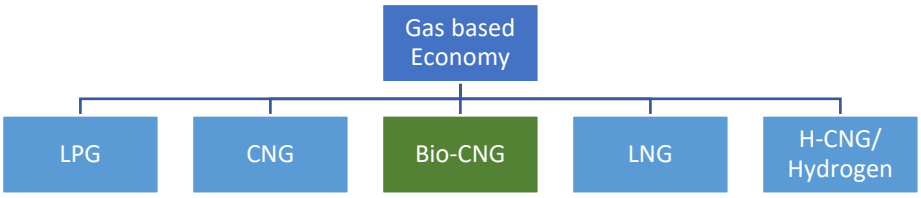
Current Fuel	Substitute
Petrol	Bio-Ethanol, LPG, EV
Diesel	Bio-Diesel, Bio CNG, CNG, H-CNG, LNG, EV
ATF -Aviation Turbine Fuel	SAF – sustainable aviation fuel, Butanol
Shipping Bunker, Marine Fuel	Methanol, Biomass derived oils, LNG

Source: PhillipCapital India Research

Promoting a gas-based economy in India

Thee fourth of global energy growth in 2020 came from natural gas and renewables
Globally, both forms of energy have started to displace coal gradually in the power sector as a sustainable choice. India is promoting use of bio-gas under 'Sustainable Alternative towards Affordable Transportation (SATAT)' project launched on October 2018. It has approved 'Natural Gas Marketing Reforms' taking a significant step to move towards a gas-based economy to achieve the COP-21 Climate Change goals set for 2030. It aims to increase the share of natural gas in the country's energy mix to 15-20% by 2030 form current 6.2%.

In clean energy, renewables and natural gas have emerged as more feasible options.



Natural gas consumption in India has increased consistently over the last five years
India is now the 13th largest consumer of natural gas globally and 3rd in Asia Pacific, only behind China and Japan. Overall gas consumption increased significantly primarily driven by higher LNG imports and cheaper LNG prices. Natural gas prices have come down to c.US$ 2.5 (per mmbtu) from US$ 5 in FY15. The gas consumption is mainly from power (18%), fertilizer (30%) and City Gas Distribution (CGD) (15%). Domestic gas production has been declining since FY11, with the lowest recorded output in FY20.

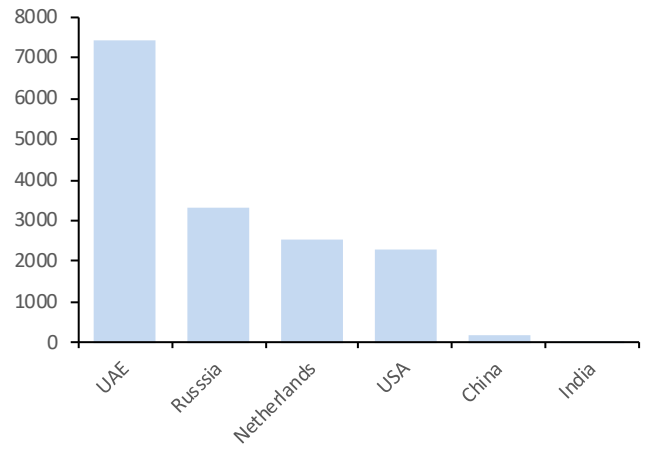
Structural reforms for a gas-based economy

Increasing domestic production	Developing gas infrastructure	Improving market access
•Pricing guidelines for domestic gas •Discovered small fields •Coal Bed Methane •Bio-gas production	•National gas grid •North East Gas Grid through SPV •New LNG import facilities •Developing CGD Network •Network of CNG and LNG fuel stations •Promotion of Bio-CNG (SATAT policy)	•Gas trading exchange (GTE) •E-bidding platform •Rationalization of tariff to benefit consumers and operators •Tax related aspects

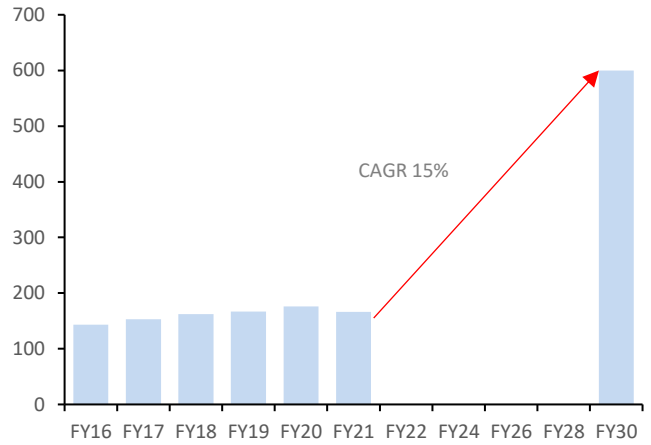
Source: PhillipCapital India Research

India's annual gas consumption is c.170 (in mmscmd), which is expected to increase to c.600mmscmd by 2030. Import of LNG has increased consistently to c.90 mmscmd in FY21 from c.58 mmscmd in FY16, as increasing demand is met through imports.

M^3 per capita of natural gas consumption 2019



Annual gas consumption in India (mmscmd)



Source: PhillipCapital India Research, Company Data

City Gas Distribution (CGD) with success of 9th and 10th round

India's city gas distribution infrastructure has been rising. Its number of CNG stations increased to 3,101 in FY21 from 938 CNG FY14 and is set to exceed 11,200, a growth 3x by 2030. Proposed capacity additions should provide strong demand for PNG meters, PNG regulators, CNG compressors, CNG dispensers, CNG cascades, and CNG vehicles.

India will have operational CGD infrastructure across 407 districts of the country with the potential of covering more than 50% of the country's area and serving more than 70% of the population by 2030 from current c.20%. The 9th / 10th CGD bidding round covers 174 / 124 districts for development of a CNG network and pipelines, and will cumulatively attract an investment of c.Rs 1.2tn. Automobile companies have started increasing the CNG models in their fleet portfolio, particularly Maruti, while reducing it for diesel.

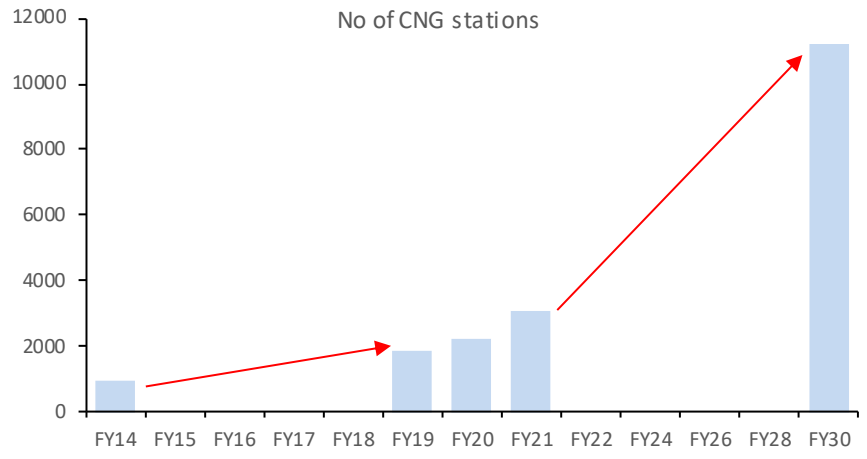
Automobile companies have started increasing the CNG models in their fleet portfolio, particularly Maruti, while reducing it for diesel

Development of city gas distribution network in India

CGD Authorisation	Geographical areas (GA)	Population covered %
Existing infrastructure	92	19.9
Round 9 expansion	178	46.2
Round 10 expansion	228	70.5

Source: Source: EKC, PNGRB

No of CNG stations will cross 11,000 in 2030 with a time-bound commitment



Source: PhillipCapital India Research

LNG – developments

- LNG gives a better mileage as well as better range (up to 900 kms between refills). It is also cheaper than diesel, but requires specialized cryogenic storage tanks, making it cost-effective for only medium and heavy commercial vehicles. As such, the government is promoting LNG as fuel for heavy commercial vehicles and shipping.
- PNGRB announced in June 2020 that any entity can set up an LNG filling station in any Geographical Area (GA) or anywhere else, even if it is not the authorized entity for that GA.
- Petronet LNG has announced plans to set up 1350 LNG dispensing stations across major national highways.

HCNG – developments

- H-CNG is a blend of hydrogen and CNG with hydrogen concentration at c.18%. H-CNG is better than CNG and it has 70% lesser Co2 emissions.
- Delhi has started HCNG trials in buses.
- IOCL, in collaboration with the transport department of Delhi, has a production plant of 4 tonnes per day at Rajghat, Delhi.

Compressed biogas (CBG)

A solution for stubble burning – waste to wealth

Taking advantage of the agriculture base in the country, India is promoting biogas as an important option for sustainable energy. Indian farmers burn agri residue in their field because it is easy, and there is a short window available for land preparation for the next crop. CBG can be produced from by-products generated by sugar mills such as distillery waste, press mud and bagasse. Animal waste releases GHG (Greenhouse gases-mainly methane) in air causing pollution, which can be effectively captured as CBG and used for industrial and transportation requirements. Apart from agri waste, India can use cattle manure (i.e., cow dung from the gaushalas - cowsheds), poultry droppings, slaughterhouse waste, waste from dairies, etc. for CBG generation.

Indian farmers burn agri residue in their field because it is easy, and there is a short window available for land preparation for the next crop

The Ministry of New and Renewable Energy has notified a Central Financial Assistance (CFA) of Rs 40mn per 4,800 kg of CBG per day generated from 12,000m^3 of biogas per day, with a maximum limit of Rs 100mn per project. The capital investment in a typical 10-tonne-per-day biogas unit is around Rs 400-500mn, and it is suitable for local demand for transportation and industrial use. The government is promoting local production and consumption of bio-CNG – the most efficient way.

Smaller economic size and value addition from agri and other solid waste makes CBG projects attractive for India

Agri residue raw materials suitable for commercial CBG generation

Seasonal dry biomass	Rice straw, wheat straw, corn stover and cobs, soybean straw, pigeon pea straw
Surplus green biomass	Napier grass, green corn biomass

Overall, India has around 350mn tonnes of surplus biomass residue and can generate 45mn tonne of CBG

Biogas generation from distillery waste

Sugar companies are actively taking part in the government's energy sustainability commitment. Apart from increasing integration to produce bio-ethanol, sugar companies can produce CBG from by-products generated by sugar mills such as distillery waste (spent wash, press mud and bagasse). A 30 KLPD distillery can produce 12,000 m3/day biogas with a capital expenditure of c.Rs 45m and a payback period of 3-4 years.

The first biogas plant from press mud has started production in FY21 in Uttar Pradesh with indigenous technology developed by Praj Industries, Pune.

Source: PhillipCapital India Research

Biogas production from distillery waste.

Do you know?

August 10th is celebrated as World Biofuels Day – for increasing environmental awareness. In fact, India is the first country to give bio-gas technology to the world and the first biogas plant was set up in 1897 in Matunga in Mumbai.

The decomposition of organic waste releases methane into the atmosphere, causing GHG emissions, which are likely to trap 20-30x more atmospheric heat as carbon dioxide emissions. Reducing the release of methane into the air is crucial to limit global warming. Renewable fuel technology captures methane and uses it as an energy source while it uses the remaining components as fertilizer or for other industrial uses.

Biogas production is carbon-neutral and does not add to greenhouse gas emissions. The by-product is bio-fertilizer, which retains nitrogen required for plant growth. Use of bio-fertilizers reduces the need for chemical fertilizers, which release extremely powerful greenhouse gases.

The government started promoting biogas actively since the 1970s after the oil and gas crises, with the development of the *Janta Model of Biogas* and promoted biogas under the *National Project for Biogas Development (NPBD)* in 1981 with limited success. A more rational view came about in the *Sustainable Alternative Towards Affordable Transportation (SATAT)* scheme, announced in October 2018 whose aim was exponential growth and not incremental growth. Its aim is to set up CBG plants, produce and supply CBG to oil marketing companies (OMCs) for sale as automotive and industrial fuels.

SATAT Policy 2018

The Government of India has envisaged 5,000 bio-CNG plants (minimum capacity of > 2.0 tonnes per day of CBG) which will commission in a phased manner across India under the SATAT scheme over the next five years. There is no restriction on the technology choice for developers. The government has categorized CBG plants under the 'white category', so they will not require any consent from pollution control boards for operations.

Bio-manure is an important by-product of CBG plants and the government has included it in the Fertilizer Control Order 1985 under *fermented bio-manure* to provide an opportunity for organic farming across the country. The government is providing financial assistance to promote this sector – it has included CBG projects under priority-sector lending and eased funding norms. It has given ten-year visibility for CBG projects under the SATAT policy.

CBG plants will provide an investment of Rs 1.75 tn (average project cost of Rs 350mn), generate an additional revenue source for farmers, and create 75,000 direct job opportunities in India. It has the potential to boost availability of more affordable transport fuels, better use of agricultural residue, cattle dung, and municipal solid waste. India has potential for 60mn mt of CBG from biomass while SATAT's target of 5,000 plants will produce c.15mn tonnes CBG by 2025.

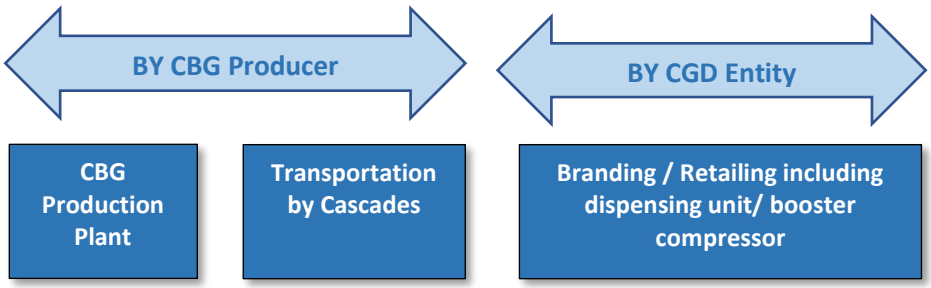
Capital subsidy support up to Rs 100mn from MNRE (Ministry of New and Renewable Energy) – banks are giving 25bps concession over their usual card rates, as projects are classified under priority sector lending and term loan is payable in 10-12 years. There is an escrow account for routing sale proceeds from OMCs for term-loan payments.

Praj Industries has demonstrated CBG technology, with a demo plant in its R&D facility at Pune, three operational commercial plants (one each in UP, Ludhiana, and Hyderabad) in FY21, and five CBG projects being set up across Gujarat (2), Uttar Pradesh (2) and Punjab (1). There are 12 commercial projects so for while it has signed LOIs for 1,550 projects under SATAT.

The government is in discussions with the fertilizer department for marketing manure produced in these plants and recently inaugurated the first injection of CBG into the CGD pipeline network of Gujarat Gas at NadiadKheda, Gujarat.

CBG projects

- **There is an MOU between five companies** – IOCL, HPCL, BPCL and Gail and IGL – taking marketing responsibility for city gas distribution, retail distribution, fertilizer marketing, and financing of CBG projects. The agreement among government PSUs will inspire confidence among entrepreneurs that are putting up CBG plants, and eliminate qualms about the marketing responsibility of gas from these plants.
- **Indian oil is a nodal agency for CBG plant development in India**. The government, via state-controlled refiner IOC, has signed initial agreements with companies including JBM, Adani Gas, Torrent Gas, and Petronet LNG for c.1,550 CBG plants.
- **IOCL has begun the sale of CBG in select cities** under the brand name IndiGreen, and has issued LOIs for setting up 325 plants for supplying 0.78mmtpa of CBG.
- **The government is working with** state agricultural departments, renewable departments, and water-management departments to ensure that these projects become viable from day one.
- **CGD (city gas distribution) companies will also invest** in the biomass-based plants.



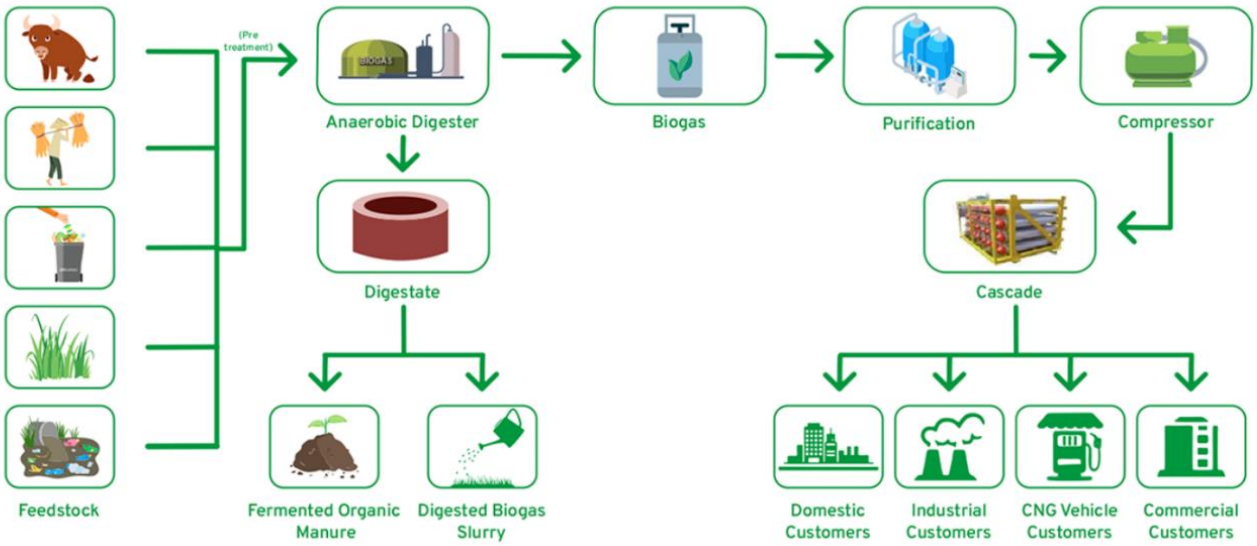
High pressure cylinder cascade used for transportation of CNG

Biogas: Production and distribution

Biogas is the production of gaseous fuel (mainly methane) by fermentation of organic material and the process takes place in the absence of oxygen. The living bacteria converts raw material into biogas, mainly in three stages.

Cellulolytic bacteria	**Convert polymers to sugar**
Acetogenic bacteria	**Convert sugar to acetic acid**
Methanogenic bacteria	**Convert acetic acid to methane**

Flowchart of Bio-CNG production and distribution



The composition of biogas as produced from organic materials contains 50-60% methane, 40-45% carbon dioxide, and 0.1-4% hydrogen sulphide (H2S). The bio-gas is purified to remove hydrogen sulphide (H2S), carbon dioxide (CO2), water vapor and then it is compressed, which is known as Compressed Bio Gas (CBG), which has methane (CH4) content of more than 90%.

Technical paraments of bio-gas

Parameters	Biogas	Bio-CNG
Methane (v/V)	55-65%	92-98%
Co2 (v/V)	35-45%	2-8%
H2S (ppm)	500-30,000	<20 ppm
Other impurities	Present	Not present
Calorific value (LCV)	19,500 KJ/Kg	52,000KJ/Kg

Source: PhillipCapital India Research

Biogas upgradation for wider use and reducing CHG

Biogas needs to be processed before it can be injecting into the CGD network and used as transportation fuel.

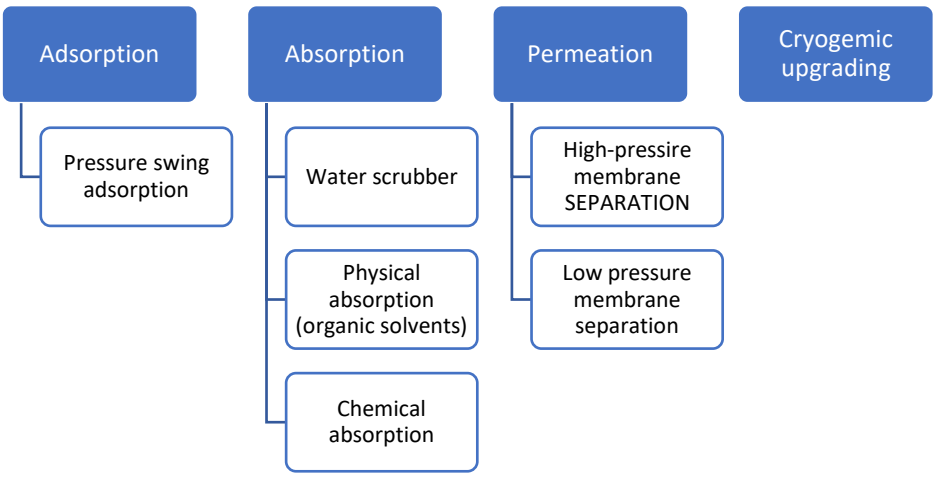
- CBG has to be free from liquids over the entire range of temperature and pressure encountered in the storage and dispensing system.
- It needs to be free from particulate matter such as dirt, dust, and odorized to a level found in the local distribution.
- This upgraded biogas is often named biomethane.

Sweetening of gas

- Hydrogen sulphide is toxic and corrosive and the removal of H2S is called sweetening of gas.
- Removal of carbon dioxide is done to reach the required Wobbe Index.
- When removing carbon dioxide from biogas, small amounts of methane CH4 are also removed.
- Methane has a 23-fold stronger greenhouse gas effect than CO2, and it is important to keep methane losses low, for both economic and environmental reasons.
- Two common methods of removing carbon dioxide from biogas are absorption (water scrubbing, organic solvent scrubbing) and adsorption (pressure swing adsorption, PSA) while less frequently used are membrane separation and cryogenic separation, which is a relatively new method currently under development.

The Wobbe Index is a measure of the interchangeability of fuel gases and their relative ability to deliver energy. It gives an indication of whether a turbine or burner will be able to run on an alternative fuel source without tuning or physical modifications.

Gas upgradation is important for wider use



Pure CO2 is generated in gas cleaning and used for production of polycarbonates, dry ice, or for surface treatment (sandblasting with CO2). CO2 from biogas can also be used in agriculture, as fertilizer in greenhouses. The CBG produced is compressed at high pressure of 250 Bar and supplied through cascades to the retail outlets or through pipelines to OMCs' fuel-station networks. Biogas can be used for cooking, lighting, heating, power generation and transportation fuel. One kg of bio-gas gives a mileage of c. 20km+ and it is cleaner than diesel.

Stable pricing framework of CBG

The government has announced long-term procurement price (for 10 years) of CBG as per IS 16087: 2016 standards delivered to CGD retail outlets in cascades. The procurement price of CBG from 1 October 2018 to 31 March 2024 is Rs 46/kg + applicable taxes. There will be periodic revision in procurement price with effect from April 2024, but the minimum procurement price will not be lower than Rs 46/kg + applicable taxes for the period from 1 April 2024 to 31 March 2029.

Success stories

India has seen a successful transition towards cleaner energy at the industrial cluster at Morbi in Gujarat, which can be the benchmark model for the rest of India. Morbi houses more than 950 ceramic units, c.70% of India's ceramic industry, c.5% of the world's. Nearly 50% of the ceramic companies relied on coal gasifiers at the start of 2019, and gas consumption was around 2.5mmscmd.

In view of the local pollution from this cluster, the National Green Tribunal (NGT) restricted the use of the polluting fuel and passed orders to switch to cleaner alternatives such as natural gas. This move has resulted in the additional LNG consumption of c.5mmscmd within a span of 8 months, with significant improvement in the air quality levels in the Morbi region.

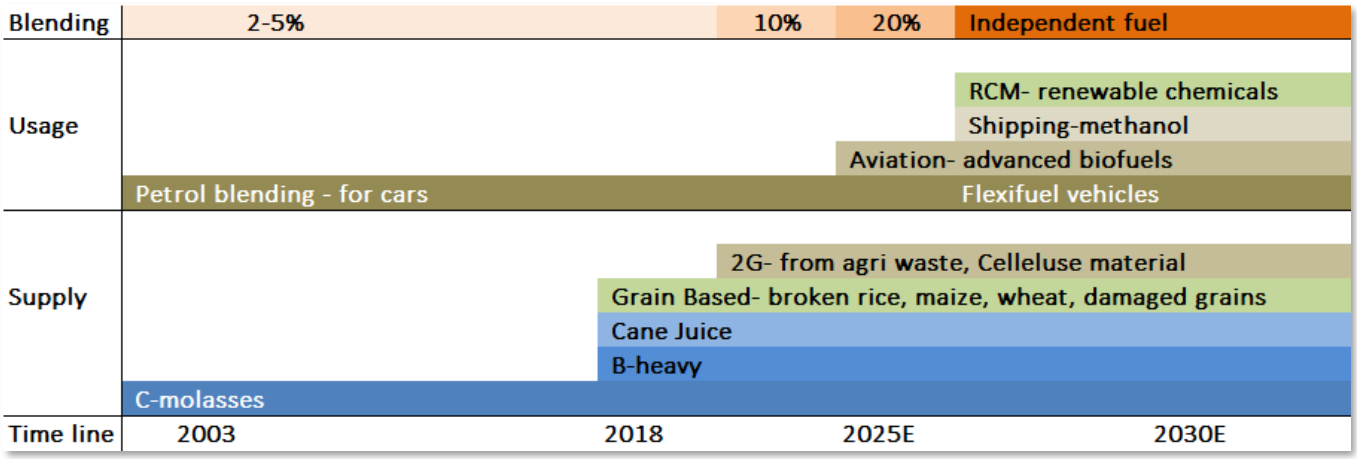
Delhi has shifted all polluting industries (c.1,650 out of c.1,800) to CNG to reduce pollution, while public bus transport uses CNG. Delhi now has more CNG stations than petrol pumps.

Bio ethanol

The Ethanol Blended Petrol Programme (EBPP) in India started in 2003, mandating 5% blending of ethanol in 9 major sugarcane-growing states and 4 union territories. The EBPP programme had limited success due to structural supply-side issues. Blending was 2-5%, even though target was set at 10%. Major ethanol supply was from sugar mills, but they were restricted to use only C-molasses. Ethanol production was dependent on sugar production, whose by-product was 2.5-3bn ltr annually, out of which the liquor industry's demand was 1.3bn ltr, and the chemicals industry's was 0.6-0.9bn ltr, leaving availability at 1-1.2bn ltr for ethanol, against a demand of c.2bn for 5% blending.

Structural changes post 2018: The National Policy on Bio-fuels - 2018 (NPB -2018) released in June 2018 took a more realistic approach, allowing a wider range of feedstock for ethanol production (from c-molasses to b-heavy and juice and other waste such as rural-urban garbage and cellulosic and lingo-cellulosic biomass) in line with the "waste-to-wealth" concept. The feedstock that is permitted as of today includes sorghum, sugar-beet, cassava, decaying potatoes, damaged grain including maize, wheat, rice, and most importantly, crop residue such as wheat and rice stubble.

Evolution of ethanol blending in India



Source: PhillipCapital India Research

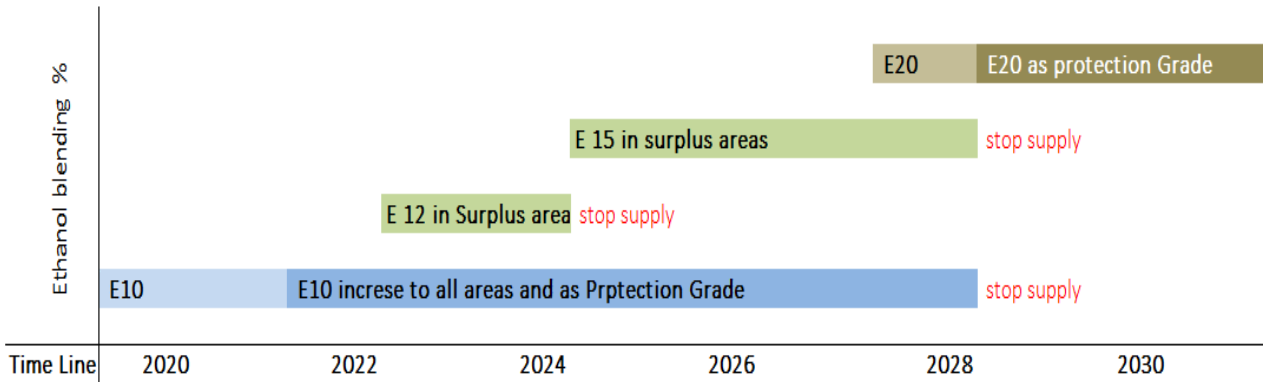
Policies for promotion of ethanol blending with petrol

- Differentiated and attractive pricing for bio-ethanol produced from different raw material sources.
- Interest subvention scheme of up to 6% for molasses and grain-based distilleries (DFPD).
- Setting of standards for E5 (Ethanol 5%, Petrol 95%), E10 and E20 blends of ethanol blended petrol (Bureau of India Standards, BIS).
- MoRT&H has notified GSR 156(E) on 8th March 2021 for adoption of E20 fuel as automotive fuel and issued mass emission standards for it.
- MoRT&H has also notified safety standards for ethanol blended fuels [vide GSR 343(E) dated 25th May, 2021] based on Automotive Industry Standard (AIS 171). It lays down safety requirements for type approval of pure ethanol, flex-fuel, and ethanol-gasoline blended vehicles in India. BS-VI Emission norms in effect since 1st April 2020 are applicable for E-20 vehicles.

Rollout plan over 2026

- The Indian government has created a roll out plan for ethanol, with inputs from relevant ministries and associations, considering challenges in manufacturing flexi-fuel vehicles and the infrastructure required for its storage and distribution.
- It has planned availability of E10 across the country from April 2022, for existing vehicles, until till April 2028.
- The Ministry of Petroleum and Natural Gas (MoP&NG) will initiate a phased roll-out of 20% blending from April 2023 with the launch of educational campaigns for customers.
- In 2023, the government will launch E20 in select cities of 11 states and union territories, viz. Himachal Pradesh, Uttarakhand, Uttar Pradesh, Haryana, Delhi, Goa, Daman Diu & Nagar Haveli, Karnataka, Bihar, Maharashtra, and Punjab. Based on the learning from these states, the government will roll-out ethanol blending across India.

Ethanol blending (E20) roadmap



Source: PhillipCapital India Research, NITI Aayog

Vehicle modification and launch of flexi fuel vehicles

Currently, gasoline vehicles (2W / 4W) in the country are designed for running on pure gasoline and can be tuned to suit ethanol blended fuels ranging from E0 to E5 depending on the vehicle type. On the material compatibility front, the rubber and plastic components are compatible up to E10. Considering this, E10 fuel availability as protection-grade fuel for existing vehicles is a must and OMC's needs to continue dispensing E10 fuel up to almost 2028-30.

When using E20, there is an estimated loss of 6-7% fuel efficiency for 4 wheelers that are originally designed for E0 and calibrated for E10 and 1-2% for 4 wheelers designed for E10 and calibrated for E20. According to Society of Indian Automobile Manufacturers (SIAM), modifications in engines (hardware and tuning), can reduce the loss in efficiency due to blended fuel. To compensate the consumers for this decline in efficiency, tax incentives on E10 and E20 fuel may be considered.

E20-material compliant and E10-engine tuned vehicles may be rolled out all across the country from April 2023. These vehicles can tolerate 10-20% ethanol blended gasoline and give optimal performance with E10 fuel. Vehicles with E20-tuned engines can be rolled out all across the country from April 2025. The cost of E20 compatible vehicles should be higher – in the range of Rs 3,000-5,000 for four-wheelers and Rs 1,000-2,000 for two-wheelers, over and above the cost of ordinary vehicles tailored to run on 100% gasoline.

To use higher ethanol blends, vehicles designs in the future will consider material compatibility, engine tuning (spark timing) and optimization (compression technology) – to benefit from higher-octane ethanol blends.

FLEX FUEL VEHICLES (FFVs) – vehicles which can run on 100% biofuel

Flex Fuel Engine technology (FFE) is a well-accepted concept in Brazil, representing over 80% of the total number of new vehicles sold in the country (2019). Flex-fuel vehicles used in Brazil operate with E27 or E100 ethanol, or any blend between these two.

The cost of flex fuel vehicles in India (four-wheelers) would be higher, in the range of Rs 17-25,000 and two-wheeled vehicles would be costlier in the range of Rs 5-12,000 compared to normal petrol vehicles, as per SIAM. Running costs (due to lower fuel efficiency) would be 30% higher when run on E100 fuel. So, unless E100 fuel cost at retail outlets is 30% cheaper than petrol, customers will not turn to it. The government may announce tax benefit to make E100 fuel an attractive option.

Dynamics of ethanol blending in India

The prices of ethanol produced in India are higher in comparison to global players, since the cost of raw materials viz. sugarcane and food grains are fixed by the government to support farmers. While petrol is subject to excise duty, GST of 5% is levied on ethanol, which is in the range of Rs 2.28/ltr to Rs 3.13/ltr of ethanol, based on an ex-mill price in the range of Rs 45.69/ltr to Rs 62.65/ltr; excise duty on petrol is c.Rs 33/ltr. Considering total national ethanol blending volumes of 3.3bn ltr, revenue loss to the central government due to replacement of petrol by ethanol amounts to Rs 109bn per annum. The excise duty on landed costs of petrol at oil depots is higher than GST on the landed cost of ethanol, and the benefit is passed on to retail consumers.

Petrol and bio-ethanol pricing in India

Cost of 100% petrol	1-Nov-20	16-Jul-21	Ethanol		
Element	Rs/ ltr	Rs/ltr	Juice	B-Heavy	C Molasses
Price to dealers (Excluding excise, VAT)	25.8	41.4	62.7	57.6	45.7
Excise duty	33	32.9	0	0	0
Dealer Commission	3.6	3.9	3.6	3.6	3.6
VAT (including VAT on commission @30%)	18.7	23.4	19.9	18.4	14.8
Retail selling price	81.1	101.5	86.2	79.6	64.1
Equivalent cost of E100 at 30% lower	56.8	71.1			

Source: PhillipCapital India Research

The government estimates the demand for 20% at 10.16bn ltr, based on ongoing vehicle growth, but factoring for the success of electric vehicles the demand may be in range of 7.2 to 9.2bn ltr annually in 2025. Considering the demand for non-blending use at c. 3-3.5bn ltr per annum, the total demand for ethanol should increase to 10-13bn ltr by 2026.

Ethanol supply: The existing distillation capacity is c. 6.84bn ltr (4.3bn ltr from sugar /molasses and 2.6bn ltr from grains). The government aims to increase production capacity to c.15bn ltr per annum with 7.6bn ltr from sugar-based raw material and 7.4bn ltr from grain-based ones. To produce c.7bn ltr of ethanol by sugar mills, equivalent of 6mn tonne surplus sugar would have to be diverted to ethanol, compared to current diversion of c.2mn tonne per annum. The 60% incremental capacity should come from gain-based raw materials using c.18mn tonnes of food grains annually. The country is producing sufficient food grains and sugar to meet the requirement for ethanol for 20% blending.

Raw material availability for ethanol production (mn tonnes)

mn tonne	Annual production	Consumption	Surplus
Sugar	32.0	26.0	6.0
FCI Rice	52.0	35.0	30.9
Maize	28.5	16.5	10.3

Source: PhillipCapital India Research. # Stock in Central pool

OMCs will now develop infrastructure for E10 and E100 fuel from which E20 can be dispensed through mixing or separately. OMCs are increasing the tankage capacity at supply locations, replacing plastic equipment of dispensers, and building more dispensing stations for E20 and E10 petrol. OMCs' current storage capacity is c.178mn ltr, sufficient for 4.30bn ltr of ethanol handling annually, considering 15 days of coverage period. With a total tankage capacity of 446.4bn ltr by 2025, they can handle about 10.60bn ltr of ethanol annually, considering 15 days of coverage period.

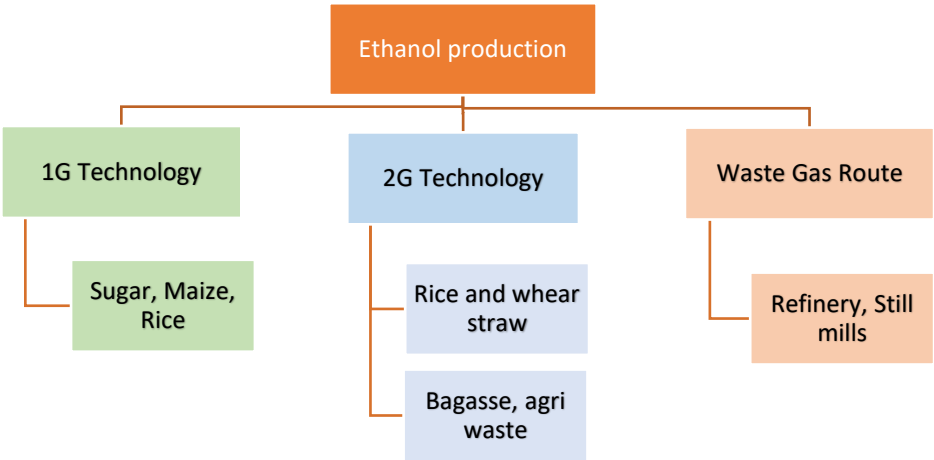
Storage capacity needed for 20% ethanol blending

Company	Tankage (Current)	WIP/Additional	Total
IOC	65	125	190
BPCL	45	74	119
HPCL	68	69.4	137.4
OMC Total	178	268.4	446.4

Source: PhillipCapital India Research

The need for feed-stock improvement and diversification

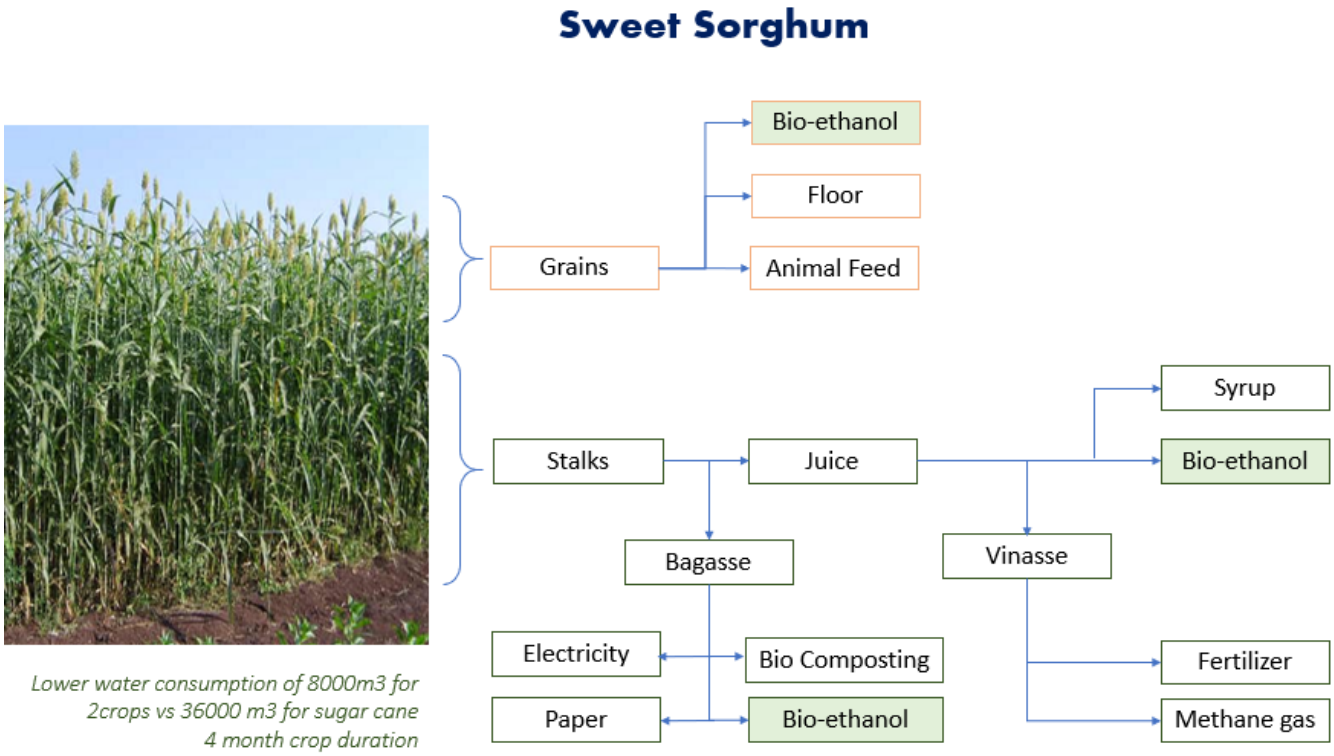
The government is encouraging lower water-consuming food-grain crops such as maize (for 1G technology) and sweet sorghum (for 2G technology) as feedstock for production of ethanol. Sugarcane is a water-intensive crop. Cultivation of each kg of sugar requires 1,600-2,000 ltr of water. However, the net returns from sugarcane are also much higher than those from food crops; for example, in Karnataka it was about Rs 113,590 per ha as compared to Rs 33,877 per ha from paddy and Rs 22,931 per ha from maize during FY19. Because of sugarcane's higher price, sugar prices rise and also prices of its by-products such as molasses and eventually, ethanol. NITI Aayog estimated that sugarcane and paddy combined, are using 70% of the country's irrigation water, depleting water availability for other crops.



To combat this, the government is promoting ethanol from agricultural residues and by-products such as organic waste, most preferably woody, grassy, and waste materials as feedstock, and biodegradable fractions of municipal and industrial waste. Studies indicate that lignocellulosic surplus biomass availability in India is around 120-160bn tonnes per annum and 2G technology has the potential to produce 25-30bn ltr of ethanol per annum.

Thailand is using sugarcane for ethanol production and has seen a shift toward cassava-based ethanol, whose production is likely to increase by 26% to 698mn ltr in 2021, using 4.4mn metric tonnes of cassava root, contributing to c.45% of total ethanol production.

Indian has done trials with sweet sorghum for ethanol production as an alternative crop to sugar cane. The promotion of ethanol form grains such as maize and rice is diversifying the raw-material base, bringing sustainability to ethanol blending.



Biofuels from waste Gases route: The mixtures of carbon mono-oxide and hydrogen from industrial waste gases (refineries, still mill, municipal solid waste (MSW) syngas, etc.) can be used to produce ethanol using a biocatalyst-based technology. IOCL is setting up 128KL per day ethanol plant, using gas-fermentation technology from Pressure Swing Adsorption (PSA) of gases (containing CO, H2, and CO2) at its Panipat refinery in Haryana. The technology also helps in CO2 mitigation, along with minimum water footprint per tonne of ethanol produced. Ethanol production will also support our refineries in meeting the ethanol blending mandate. Besides, CO2 is also consumed during the process, which helps reduce GHG emissions. The total project cost has been estimated at Rs 4.5bn.

Mandate for ethanol in various countries

Country	Targets
Brazil	Ethanol up to 27.5% + Flexi fuel cars, 10% for Bio-diesel; National biofuels policy.
USA	Ethanol E10 currently and E15, E30 by 2030, 4bn gallon Bio-diesel, Renewable fuel, standard (RFS) program.
Chile	E5 and B5
Mexico	E5.8 to E10
EU	E10, 12.4% by 2032; RED- Renewable energy directive
Australia	E10 and B2 policy
China	E10 and target 15%
Indonesia	E25 by 2025
Malaysia	B15 policy
Thailand	E20 and B10 (Alternative Energy Development Plan -AEDP form 2018-2037 programme)

Source: PhillipCapital India Research; Note: E10 – 10% ethanol and B10- 10% Bio-diesel

Bio-diesel – the next thing

Bio-diesel is a diesel substitute, produced from vegetable oils and animal fats. In USA and the EU, bio-diesel is commercially made from edible oils such as soyabean and rapeseed oil. India is deficient in edible oils and as such, it promotes the use of only non-edible oils for making bio-diesel.

Bio-diesel is an environment friendly fuel which has almost no sulphur and no aromatics, with c.10% built in oxygen. It needs no separate infrastructure for storage and dispensing, and it can use existing diesel tankage and dispensing stations. It is safe to handle and its flash point is in fact even higher than conventional diesel. Blending of bio-diesel with diesel would result in the reduction of un-burnt hydrocarbons, carbon monoxide, and particulate matter in auto emissions.

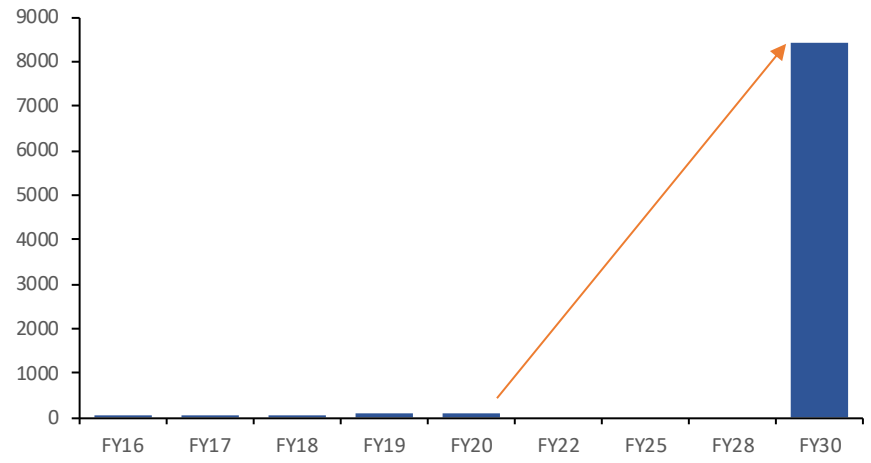
In 2002, the planning commission, under National Biodiesel Mission (NBM), launched the Mission on Bio-diesel

BIS standards for bio-diesel

The Bureau of Industrial Standards (BIS) has specification for BIS 1460 for High-Speed Diesel covering 5% bio-diesel – known as B5. BIS has also standards for B100, pure bio-diesel, which is an Indian adoption of the American Standards. The Indian government says that blending up to 20% requires no modification in engine specifications when used as transportation fuel.

OMCs have started bio-diesel blending from August 2015 and biodiesel procurement was 105mn ltr in FY20. For 2019-20, the quantity of biodiesel tenders was 1.46bn ltr against which the supply was 105bn ltr. The national policy on Biofuels - 2018 has set a target of 5% blending by 2030, which would mean the supply has to rise to c.8.5bn ltr. India has c.56 biodiesel plants with a production capacity of 1,126 tonnes per day, and promotion of bio-diesel could increase this opportunity substantially.

Government's target is 5% bio-diesel blending by 2030 (mn ltr)



Source: PhillipCapital India Research, Company Data

Biodiesel five-year pricing

Period	Basic Price	Note
Aug-19- Sep-20	Rs 51/ ltr	Fixed for one year for date of EOI
Oct-20- Sep-21	Rs 52.7/ ltr	Based on 3.4% avg CPI inflation
Oct -21- Sep-22	Rs 54.5/ ltr	
Oct-22- Sep-23		CPI index will be applied on September 2022 price
Oct -23- Sep-24		CPI index will be applied on September 2023 price

Source: PhillipCapital India Research

To maintain standard quality for blending in diesel, manufacturers need to get their samples approved from the oil companies. Jatropha and Pongomia are considered effective plants for bio diesel in India and Chhattisgarh, Rajasthan, Uttaranchal, Tamil Nadu, and Andhra Pradesh have already formed nodal agencies for biofuel development, and announced draft biodiesel policies.

Thailand bio-diesel industry

- Thailand consumes c.1.9bn ltr of biodiesel (more than ethanol use of 1.5bn ltr) and targets c.3bn ltr (lowered from 5.1bn ltr due to limited supply of palm oil) by 2037.
- The government continues to impose mandatory blending of biodiesel and diesel for certain sectors, mainly for on-road use.
- In 2020, the government increased the mandatory blend rate to B10 to help absorb excess supplies of palm oil, but still allowed B7 and B20 for older vehicles that are not compatible with B10.
- All gas stations are required to sell B10.

Sustainable Aviation Fuel (SAF) for a cleaner sky

The aviation sector has ambitious target targets for 50% reduction in GHG emission by 2050

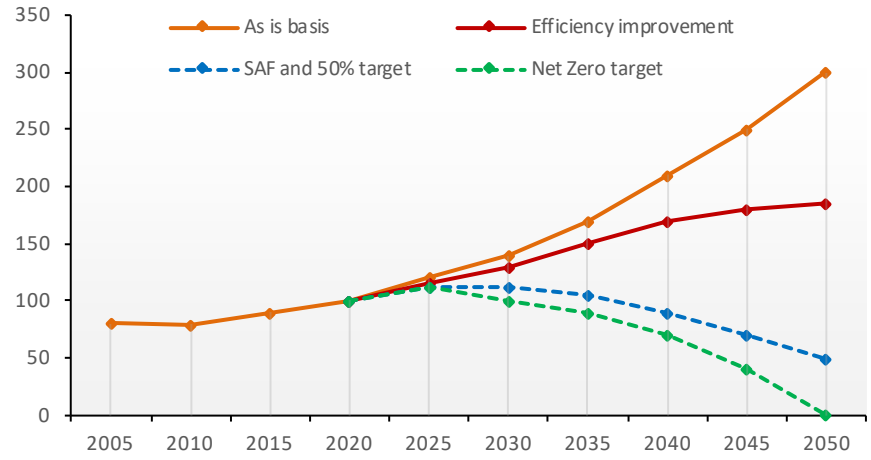
All sectors need to contribute to de-carbonization and GHG reduction.
Aviation is of particular interest for biofuels as it is difficult to shift to EVs in this sector. Pay load is important for aviation and weight of fuel (ATF) get reduced as it is consumed while in case of EV batteries it remains same as well as energy output per unit of weight is very low in EV batteries making EV as unviable option for aviation and will continue to use ATF/Biofuels for foreseeable future.

The aviation sector has ambitious target targets for 50% reduction in GHG emission by 2050 with a base of 2005. Out of global production of c. 390bn ltr of ATF, only 14mn ltr is SAF. Switching from fossil fuels to low carbon SAF is the most efficient way to achieve those targets and protect and enhance the ecosystem. Industry research shows that the higher cost of SAF (2.5-4 of ATF) is a major barrier at present, but the cost curve should come down with scale and process efficiency improvements.

SAF is "drop-in fuel" meaning no changes to planes, engines, or infrastructure would be required.

Raw material availability is not a major problem for replacing aviation fuel. Oil-based raw materials based on HEFA (hydro processed esters and fatty acids) are likely to contribute to a major share of SAF. Alcohol-to-Jet Synthetic Paraffinic Kerosene (ATJ-SPK) is Sustainable Aviation Fuel (SAF) that is one of the few non-fossil based alternative jet fuels available for commercial use. SAF are drop in fuels which does not require adaptation of the separate fuel distribution network or the engine fuel system.

Global aviation sector has set 50% GHG reduction by 2050



Source: PhillipCapital India Research, Industry

Zero carbon flying

India has conducted SAF trials on both military and commercial planes. Indian Air Force aircraft (AN-32) lead the Republic day parade on 26 January 2019 with 10% blended fuel made from Jatrpha seeds using a technology patented by the Council of Scientific and Industrial Research (CSIR) and the Indian Institute of Petroleum, Dehradun.

SpiceJet operated a 45min flight from Dehradun to Delhi (a Bombardier Q400) with 25% bio jet fuel.

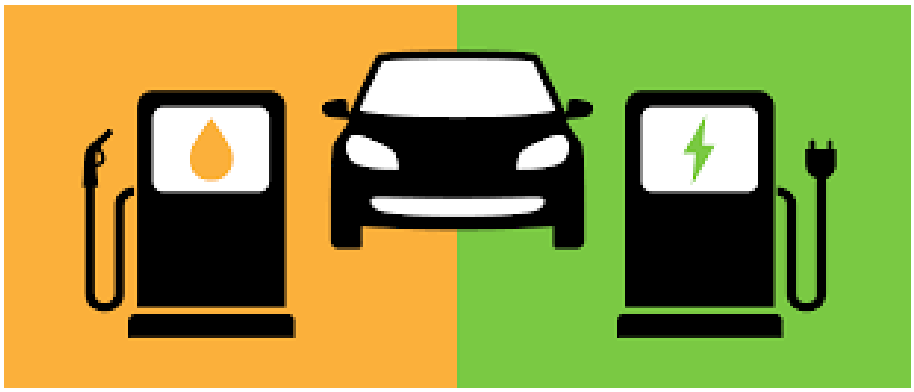
Biofuels and electric vehicles

Immediate opportunity vs. long-term commitment: Most countries are targeting complete transition to electric vehicles by 2030-40. However, the Indian government is promoting ethanol blending as an immediate opportunity to increase the share of renewal fuels and replace the import/use of fossil fuel.

Industry experts expect the share of electric vehicles in the total fleet to increase to 22% in 2030 from 2% of global share . Research by the Massachusetts Institute of Technology, indicates that EVs attaining a 50% market share of light-duty vehicles in the US by 2050 would be a result of "aggressive climate policy." And even if that were to happen, the research says global oil consumption will be higher in 2050 than it was in 2015. In 2040, there would still be more kilometres driven globally by internal combustion passenger vehicles than EVs.

EVs are expensive and require new infrastructure: The cost of EVs, particularly for four-wheelers is higher, so affordability is a concern. We expect wider acceptance of EVs in 2Ws and small cars. Developing countries will find it difficult for large-scale implementation due to costs and infrastructure requirements. On the other hand, biofuels require only small changes in infrastructure and the vehicles themselves, and existing manufacturing and supply chain can be used without impacting employment.

Electrons and molecules – can they co exists?



Biofuels are cost-effective

EVs are not an immediate solution, but biofuel is. Ethanol is available here and now. It is available at large scale and is commercially viable in most cases. Biofuels have an important role to play in reducing the dependence on fossil fuels and attaining meaningful climate goals and clean air, as most cars on the road would continue to be powered by liquid fuels for years to come. We believe both markets will co-exist rather than depend completely on one route.

Costing for ethanol from B-heavy molasses (Rs/ltr) at different transfer prices

Molasses Transfer price	RM Cost/ltr	Fixed Cost	Total Cost	Selling price
5500	17.2	12	29.2	57
6000	18.8	12	30.8	57
6500	20.3	12	32.3	57
7000	21.9	12	33.9	57
7500	23.4	12	35.4	57

Source: PhillipCapital India Research

Biofuels are supporting the agri economy. They reduce cycles in the sugar industry, provide better income to farmers, and lower pollution

- Government of India is promoting Ethanol blending to use extra agricultural production and turn it into ethanol, which should help it to save on fuel imports.
- The government's target is c.14bn ltr annual supply of ethanol by 2025 for 20% ethanol blending in petrol, out of which half (7bn ltr) will come from sugar and the remaining 7bn ltr will come from grain-based distilleries.
- Currently, India produces 4-6mn tonnes extra sugar annually, and for the surplus sugar produced, the government has to announce export subsidies. Converting this extra sugar into ethanol would be a win-win.
- In case of grains, damaged food grain (in FCI), broken rice, and maize can be converted into ethanol.
- 2G (ethanol from agricultural waste; cellulose raw material) technology also aims to reduce pollution by using agricultural waste like wheat and rice straw to make ethanol. Otherwise, farmers end up burning this waste in their fields and cause quite a bit of pollution.
- Grain-based distillation of ethanol will also give farmers an additional revenue of Rs 1,500-2,000 per tonne for their waste.

Example: US ethanol economy

USA is the largest producer of ethanol with annual production of ~60bn ltr. There are ~68,684 U.S. jobs directly associated with the ethanol industry, and it support an additional 280,327 indirect and induced jobs across all sectors of the economy. The industry created $23.3 bn in household income and contributed $43 bn to the national Gross Domestic Product in 2019. Moreover, the ethanol industry spent over $27 billion on raw materials, inputs, and other goods and services. Ethanol's Value-Added Proposition Based on average prices and product yields in 2019, a typical dry mill ethanol plant was adding roughly $1.20 of additional value or 31% to every bushel of corn processed.

Biofuels - Value addition to Agri economy

Corn cost per bushel = $3.9	Value of output with ethanol = $5.1 [Ethanol $3.82 + DDGS $1.11 + Corn Distiller Oil $0.17]

The sum value of different parts of grain are greater than the sum value of the whole and it also enhances environment sustainability.

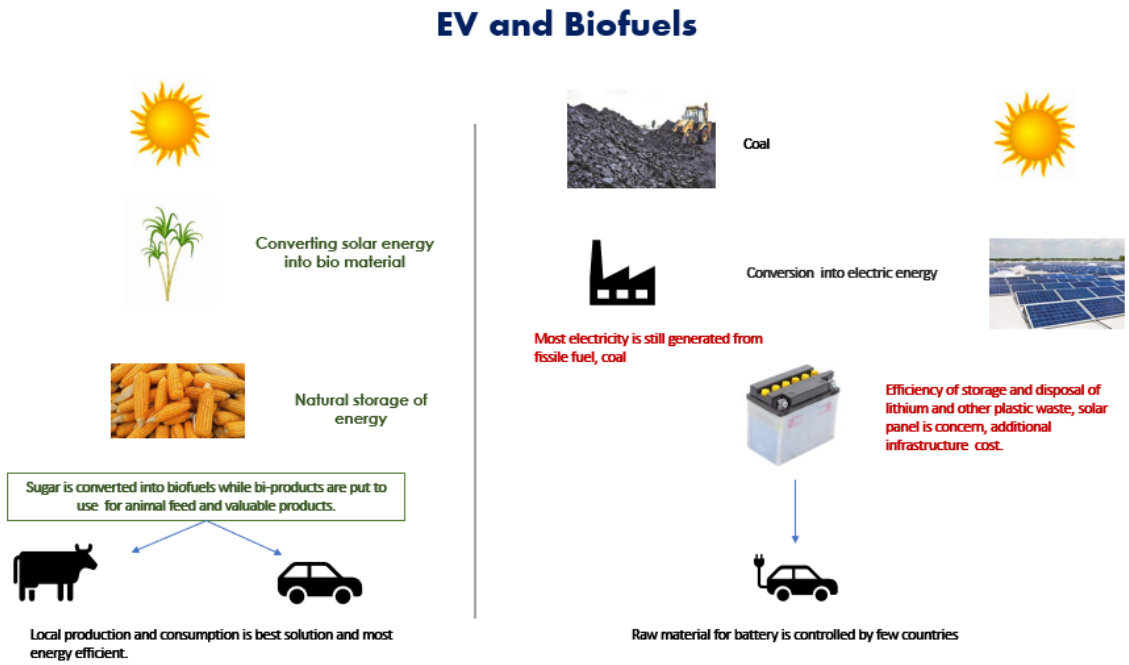
Total cost of ownership and cost to the economy

EV may not as cheap and environment friendly as seems if we include the environmental cost of producing batteries and generating electricity to charge them and cost of charging infrastructure. The climate benefits of electric vehicles are highly variable, depending on the source of electricity and the carbon intensity is increased when electricity generated from coal is used to charge them. The charging technology is complex for EV and grid stabilization at peak use will also be an issue and may require additional capacity addition in power generation to manage peak demand variation. Source of energy for EV is still mainly coal so without changing energy mix promoting EV may not serve the pursue.

In case of renewable fuels, we are using solar energy converted into sugar or starch by the plants and extracting it into ethanol while other valuable component like protein, fibre is used for cattle feed or other purpose. It is most efficient use of energy and is also cost efficient.

Biofuels – Extracting value from biomass with food and fuel approach.

Biofuels -an efficient way of using solar energy with shorter carbon cycle



Source: PhillipCapital India Research

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Govt hikes ethanol price by up to ₹3.34/ltr - The Hindu

Rating Methodology

We rate stock on absolute return basis. Our target price for the stocks has an investment horizon of one year. We have different threshold for large market capitalisation stock and Mid/small market capitalisation stock. The categorisation of stock based on market capitalisation is as per the SEBI requirement.

Large cap stocks

Rating	Criteria	Definition
BUY	>= +10%	Target price is equal to or more than 10% of current market price
NEUTRAL	(10% > to < +10%	Target price is less than +10% but more than (10%
SELL	<= (10%	Target price is less than or equal to (10%.

Mid cap and Small cap stocks

Rating	Criteria	Definition
BUY	>= +15%	Target price is equal to or more than 15% of current market price
NEUTRAL	(15% > to < +15%	Target price is less than +15% but more than (15%
SELL	<= (15%	Target price is less than or equal to (15%.

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