NITI Aayog
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Methanol: A Competitive Alternate Fuel

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सत्यमेव जयते

Methanol: A Competitive Alternate Fuel

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India has been giving a push for alternate fuels such as Ethanol and, more recently, Methanol to improve its energy security. India meets 85% of its crude oil requirement, 53% of its natural gas requirement, and 25% of its coal requirement through imports[3]. Ethanol is primarily used for blending with gasoline citing twin benefits: substitution of gasoline to arrest rising crude imports and using a relatively cleaner fuel than gasoline. The Government of India regulates the prices of ethanol derived from various sources and procures it through the Oil Marketing Companies at pre-determined prices. However, ethanol primarily derived from molasses and sugarcane juice can ignite a fuel vs food security debate; Methanol, on the other hand, can be derived from different sources such as natural gas, coal, naphtha, biomass etc. Natural gas is the most widely used feedstock to produce methanol across the world accounting for almost 70% of the global production. India has given a strong push for methanol from coal since coal is abundantly available in India whereas natural gas is a scarce resource.

India is on the cusp of a major transformational change as it transitions toward a low carbon economy. The energy policies of the country and those on the anvil demonstrate and focus on the country's transition toward cleaner fuels in a sustainable manner. And coal gasification of domestically available coal to produce methanol (deployed with Carbon Capture & Storage- CCS) presents an opportunity to accelerate this transition in an energy secure manner.

This document will focus on the economic comparison of ethanol, methanol, and gasoline. Both ethanol and methanol can be used for blending with gasoline.

[3] PPAC, Ministry of Petroleum and Natural Gas, Government of India

2. Ethanol:

2.1. Ethanol Production:

Ethanol Blending Program (EBP) has been a priority of the Government, especially since 2014. The National Biofuels Policy of India in 2018 had set a target of 20% blending with gasoline by 2030. The ethanol production increased from 38 Cr liters in 2013-14 to 173 Cr. liters in 2019-20, a jump of 4.5X. Considering the strong performance, the Hon'ble Prime Minister of India set a new target of 20% blending by 2025-26, reducing the timeline for the target to be achieved, by 5 years.

Ethanol Production and Blending %		
Year	Production[4] (Cr Liter)	Blending %age PSU OMCs
2013-14	38.0	1.53%
2014-15	67.4	2.33%
2015-16	111.4	3.51%
2016-17	66.5	2.07%
2017-18	150.5	4.22%
2018-19	188.6	5.00%
2019-20	173.0	5.00%

Table 2.1 - Source: NITI Aayog

The table 2.1 shows that the supply of ethanol increased at a CAGR of 128% over the last 6 years. And the blending % with gasoline increased from 1.53% in 2013-14 to 5% in 2019-20. The tentative figure for the ethanol production in 2020-21 is 332 Cr liters which is almost double the production in 2019-20. This will take the blending to 8.5%, a significant jump over the previous figure of 5% in 2019-20. The current production capacity of ethanol is 684 Cr liters which must rise to 1500 Cr[5] liters by 2025-26 to achieve an ethanol production of 1016 Cr liters for a 20% blend with gasoline.

[4] The production figures of ethanol in table 2.1 are only for blending, not the overall production of ethanol which will include the ethanol production for various other uses.
[5] NITI Aayog's Report on Ethanol Blending Program

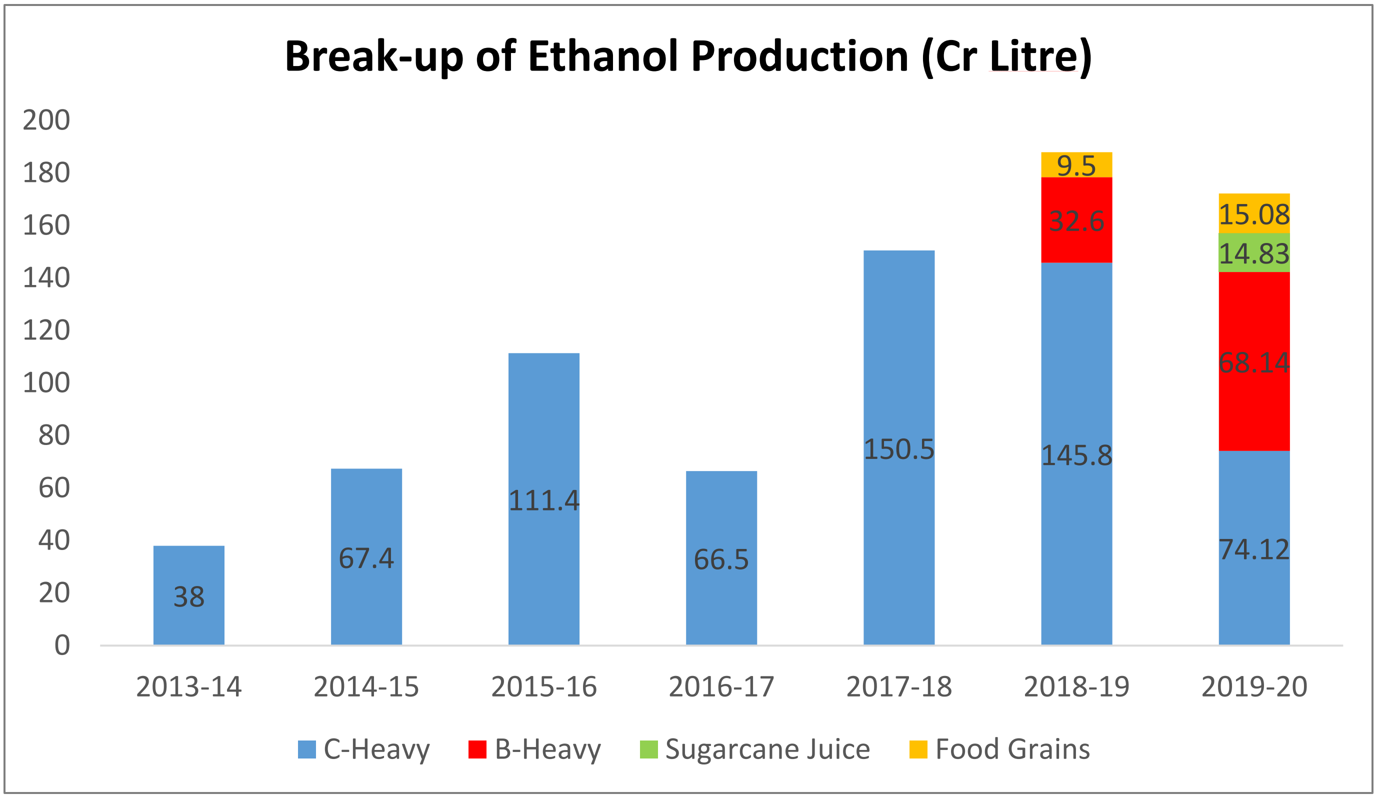

Figure 2.1 - Source: NITI Aayog

As shown in Figure 2.1, Until FY 18, C-Heavy molasses had been the primary source of feedstock for ethanol production, however, since FY 19, different kinds of raw materials such as B-Heavy molasses, sugarcane juice and damaged food grains have been used as well to produce ethanol.

2.2. Pricing of Ethanol:

The prices for ethanol produced from sugarcane sources is fixed by the government and approved by the Cabinet Committee for Economic Affairs (CCEA), whereas the price of ethanol derived from damaged food grains or rice is fixed by the Oil Marketing Companies. The following steps taken by the government has given a strong push to the indigenous production of ethanol[6]:

- The Government of India re-introduced the administered pricing for ethanol in 2014.
- Reduction in Goods & Service Tax (GST) from 18% to 5% on ethanol meant for EBP Programme.
- Interest Subvention Scheme for enhancement and augmentation of the ethanol production capacity by Department of Food and Public Distribution (DFPD).

[6] Department of Fertilizers, Government of India

- Differential ethanol pricing based on raw material utilized for ethanol production – this helps to consider the economic viability of ethanol produced from different sources.

Above all, there has been a stable policy and a consistent push for ethanol production in India, especially since 2014, which has enhanced the production by almost 8X from the 2013-14 levels.

An overproduction of sugar in India has suppressed the sugar prices, hurting the sugar mills which in turn causes a delay in the payment to the sugarcane farmers. 32 Million Tons (MT)[7] of sugar is produced in a typical sugar season, whereas the domestic requirement is to the tune of 26-27 MT. Hence, a 6-7 MT of surplus which remains unsold causes a liquidity problem (of around INR 19000 Cr)[8] for sugar mills resulting in arrears for the sugarcane price to be paid to the farmers. Though, the government is extending financial assistance to export the surplus sugar and can do so till 2023 as per the WTO arrangements, the government is encouraging the diversion of surplus sugar to produce ethanol as a long-term solution.

It is expected that in 2021-22, 3.5[9] MT of sugar will be diverted toward ethanol production and this figure is likely to rise to 6 MT by 2025. If so, this will solve the problem of surplus sugarcane and the cane price dues of farmers will be cleared on time. Therefore, to encourage ethanol production, the prices of ethanol derived from various sources have been revised upward a couple of times in the past 2-3 years. The current prices of ethanol derived from various feedstock sources is as below:

Differential Pricing for Ethanol based on different Raw Materials	
Different Sources for Ethanol Production	**INR/Litre**
'C' Heavy Molasses	45.69
'B' Heavy Molasses	57.61
Direct Cane Juice	62.65
Damaged Food Grains/Maize	51.55
Surplus Rice (FCI)	56.87

Table 2.2 - Source: Department of Fertilizers, Government of India

Table 2.2 captures the prices of ethanol derived from various sources. It must be noted that the above prices for ethanol do not include the subsidies given by the government in the agricultural sector on electricity and fertilizers for sugarcane production. Though a by-product of the sugar

[7] https://pib.gov.in/Pressreleaseshare.aspx?PRID=1674340
[8] https://pib.gov.in/Pressreleaseshare.aspx?PRID=1674340
[9] https://www.livemint.com/news/india/indias-ethanol-distillation-capacity-to-double-by-2025-11623757246439.html

process, molasses, is used for ethanol production, the actual cost incurred by the government to procure ethanol would be higher than the ones mentioned above. Since, the above prices for ethanol will incentivize the sugar distilleries to produce ethanol and will further encourage farmers to produce more sugarcane, the government has to be cautious whether the subsidy provided for sugarcane inadvertently ends up subsidizing ethanol production.

2.3. Land and Water Requirement for Sugarcane Production:

Sugarcane is one of the most water and land intensive crops. Sugarcane requires between 1,500 and 3,000 litres[10] of water per kilogram of cane. Of the crops grown in India, only rice and cotton require more water than sugarcane. Sugarcane and rice are grown in 40 per cent of the country's gross farmed area but consume about 80 per cent of its irrigation water[11]. India accounts for only 4% of the world's water resources but houses around 17% of the global population. Thus, India should be very careful in using its groundwater resources and grow crops that are less water intensive. On the contrary, India is currently the world's biggest extractor of groundwater — more than China and the U.S. combined — accounting for almost a quarter of the total extracted globally. Between 2000 and 2017 its groundwater depletion increased by as much as 23 per cent[12]. The situation becomes even more grave for the water scarce regions of the country such as Marathwada in Maharashtra. Sugarcane is cultivated in only 4% of the state's cultivable land but consumes 70% of its irrigation water[13].

The Government has encouraged to cultivate crops other than sugarcane. A task force at NITI Aayog recommended that about 3 lakh hectares of area under sugarcane, which yields about 20 lakh tons of the crop, should be used to grow other crops. Therefore, the government must take a balanced approach taking into consideration- the advantages of using ethanol as an alternate fuel which helps in oil import reductions and the adverse implications of growing more sugarcane in India.

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[10] https://www.futuredirections.org.au/publication/supporting-farmers-in-the-switch-from-sugarcane-could-be-a-small-piece-of-the-indian-water-crisis-puzzle/

[11] https://economictimes.indiatimes.com/news/economy/agriculture/rising-water-crisis-forces-indian-farmers-to-rethink-their-crops-selection/articleshow/77098970.cms?from=mdr

[12] https://economictimes.indiatimes.com/news/economy/agriculture/rising-water-crisis-forces-indian-farmers-to-rethink-their-crops-selection/articleshow/77098970.cms?from=mdr

[13] https://www.financialexpress.com/opinion/maharashtras-water-wars-state-must-discourage-sugarcane-farming-fix-water-usage/1516661/

2.4. Tax loss incurred by the Government on Ethanol Procurement for EBP:

There is a GST of 5% on Ethanol, whereas gasoline attracts a slew of taxes as shown in the table below.

Break-up for the Price of Petrol[14]	
Elements	**INR/Litre (May 2021 @$66.95/bbl of crude oil price)**
Price charged to dealers (excluding excise duty and VAT)	35.99
Excise duty	32.90
Dealers' commission (average)	3.79
VAT (including VAT on dealers' commission)	21.81
Total	**94.49**

Table 2.3 - Source: PPAC

As shown in table 2.3, the central government collects a whooping INR 32.90 as excise duty for every liter of petrol sold, whereas the state government collects a VAT of INR 21.81 per liter. Since, ethanol has only 5% GST and no other taxes, the central government forgoes the excise duty for the amount of gasoline replaced by ethanol. It is acknowledged that the state governments also give up VAT, but because of the complexities on the VAT collected by different state governments, this analysis focuses on the tax loss incurred to the central government.

[14] Petrol and diesel prices at Delhi as per IOCL as on 1st June 2021

Likely Tax Loss to the Government for the Ethanol sold in 2019-20					
Elements	Price of fuel (INR)	GST@ 5% (INR)	Tax foregone by the Central Government per liter of gasoline replaced by ethanol (INR)	Amount of Ethanol sold in 2019-20 (Cr. liter)	Total Tax loss to the Central Government (INR Cr)
C Heavy Molasses	45.69	2.28	30.62	74.12	2270
B Heavy Molasses	57.61	2.88	30.02	68.14	2046
Direct Cane Juice	62.65	3.13	29.77	14.83	441
Total tax loss					**4757**

Table 2.4

Table 2.4 shows the likely tax loss to the central government incurred due to the gasoline replaced by ethanol for ethanol blending with gasoline. The likely amount comes out to be INR 4757 Cr for 2019-20. The tax loss will increase in the future as the government has a target of 20% ethanol blending by 2025. The amount can increase to more than 5 times as the ethanol production has to be increased to 1000 Cr. Liters by 2025 from 173 Cr. Liters in 2019-20.

2.5. Food vs Fuel Security:

As India imports around 85% of its crude requirement, the government is focusing on ethanol blending program to give a push to alternate fuels. Though, the government is encouraging the use of excess food stocks to be used for fuel production, experts say that India needs to move ahead cautiously balancing its food security concerns[15]. As shown in figure 2.2, the government has in the recent years increased the prices of ethanol at which it is being procured. Hence, this provides an incentive for the distilleries to produce ethanol, which in turn also incentivizes the farmers to produce more sugarcane. Developments in the West show that there has been a fierce competition between food and fuel crops for land, which is fixed in supply. The government has to constantly monitor this trend as it can cause two disruptions – a supply and demand imbalance for food as more land gets covered for cash crops such as sugarcane and acute water scarcity due to cultivation of water intensive crops. This becomes even more significant because India holds only about 2.5% of the global land available, whereas additional 200 million people will be required to be fed in the next 15 years[16].

[15] https://www.hindustantimes.com/india-news/new-ethanol-targets-reshape-india-s-food-policy-101624419942244.html

[16] http://medcraveonline.com/APAR/APAR-07-00267.pdf

3. Methanol:

Methanol is another alternative fuel that can be blended with gasoline in the transport sector and can be used to produce many downstream chemical and petrochemical products such as DME, Olefins, Acetic Acid etc. Methanol can be produced through natural gas, coal, biomass, naphtha etc., however methanol derived from coal is the most economically viable option for India. India has abundant reserves of coal available at a relatively cheaper price than natural gas or crude oil, 55% and 85% of which are imported respectively.

Break-up of Coal Resources (MT) in India – Category wise as of 1.04.2019					
Coal Type	**Proved**	**Indicated**	**Inferred**	**Total**	**% share**
Prime Coking	4,668	645	0.00	5,313	1.6
Medium Coking	14,876	11,245	1863	27,984	8.6
Semi Coking	519	995	193	1,708	0.5
Sub-Total of Coking	**20,063**	**12,885**	**2056**	**35,004**	10.7
Non-Coking	1,34,958	1,27,494	27,416	2,89,868	88.8
Tertiary Coal	594	121	909	1,624	0.50
Grand Total	**1,55,614**	**1,40,501**	**30,381**	**3,26,496**	100.00
% share	48%	43%	9%	100%	

Table 3.1 - Source: Ministry of Coal

Table 3.1 shows that India 326 billion tons of coal reserves of which almost 50% are proved reserves, meaning technically and commercially viable to produce. India, with a 10% share of global proved reserves, has the 5th largest proved reserves of coal in the world[17].

[17] British Petroleum Statistical Review 2020

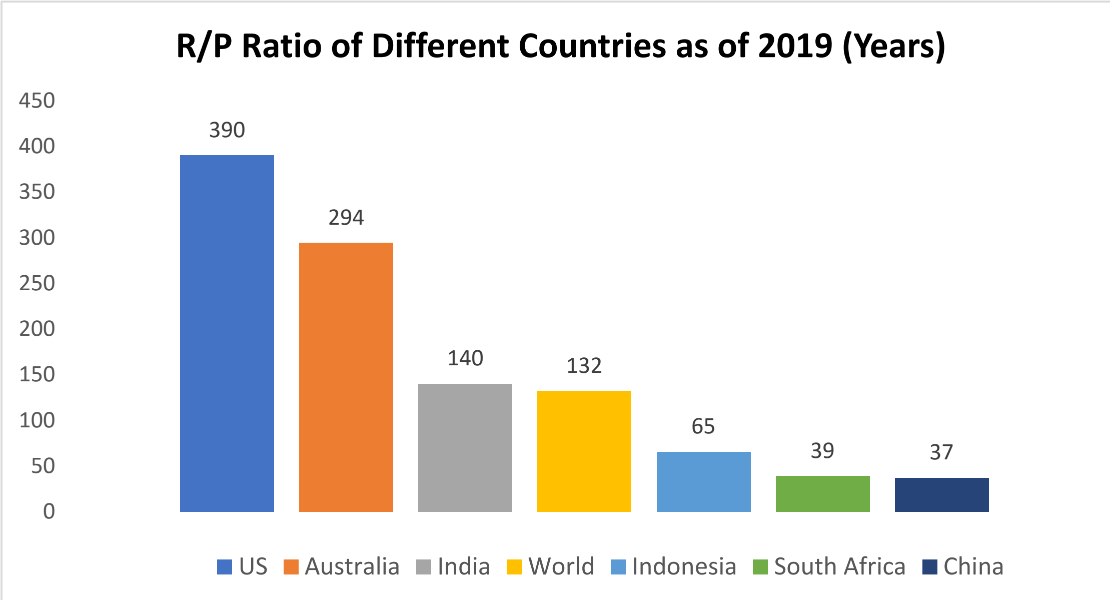

Figure 3.1 – Source: BP Statistics 2020

The coal reserves of India will likely last for 140 years at a consumption rate of that in 2019. Therefore, India must use its domestic natural resource, coal, in the most optimal way given that the use of coal is only likely to decline in the future.

3.1. Why is Methanol a good option as an alternative fuel?

India is already in the midst of a transition toward a low carbon economy. The share of coal in energy mix of India is likely to decline to 40% by 2040 from 46% currently. Moreover, it would not be surprising to see the sanctions tightening on the coal sector globally. Therefore, using domestic reserves of coal sustainably, gasifying it along with using CCS, provides an opportunity for India to use its natural resource at a relative discount to other fuels such as oil or natural gas. Coal gasification produces 31% less CO_2 emissions, 98% less SO_x emissions, and 84% less NO_x emissions relative to a coal fired power plant. And if CCS is used, the emissions can practically to brought down to zero. Therefore, developing coal to chemicals industry in a sustainable fashion is much in the interest of India.

Following are the 4 primary drivers for gasifying coal in India:

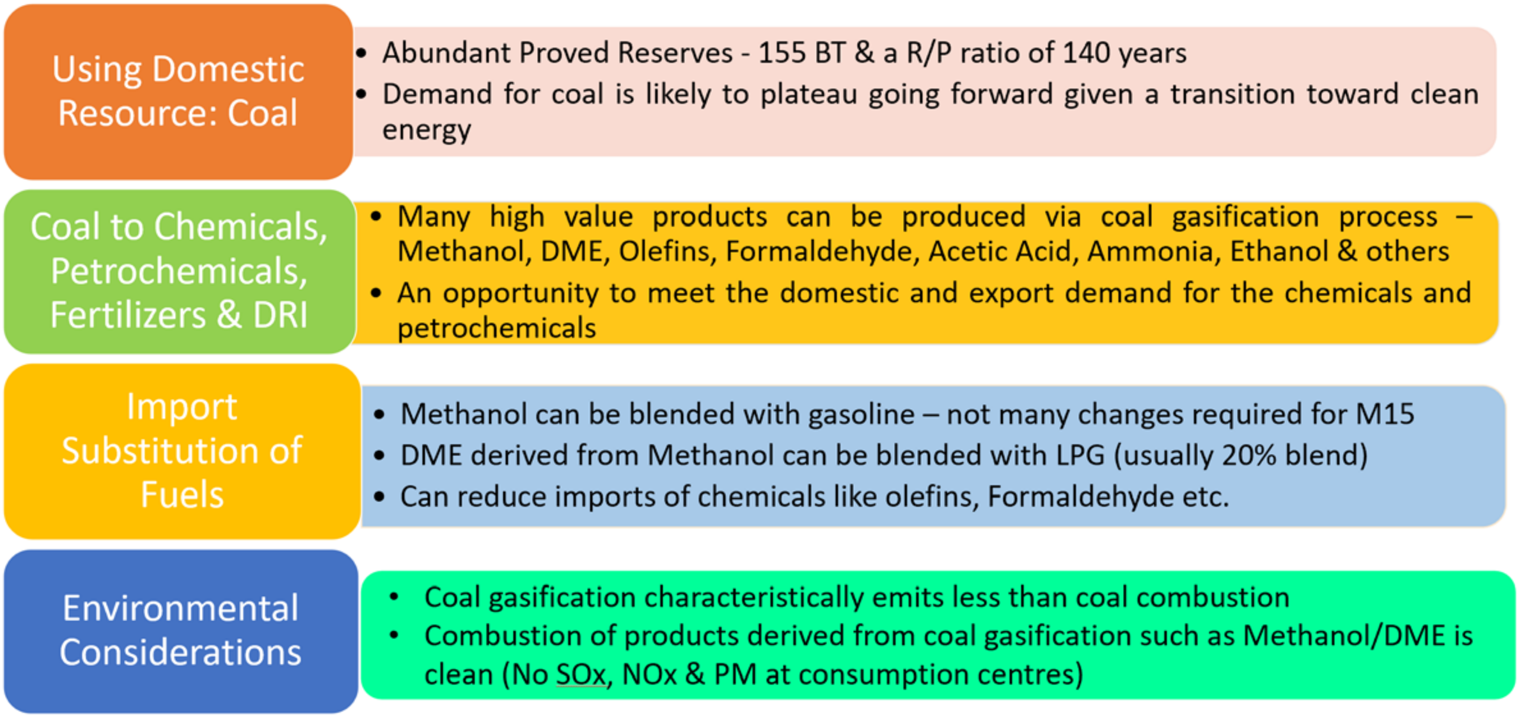

Figure 3.2

Figure 3.2 entails the 4 primary drivers for coal gasification in India. The low cost of coal in India provides an opportunity to produce a range of products from coal such as methanol, olefins, DME, and others at a competitive price.

The United States had successfully launched a methanol (M15 and M85) blending program primarily driven by air quality considerations in California in 1980s and 1990s. 15,000[18] M85 flexi-fuel vehicles were sold or operated in California during that time. However, Methanol did not become a successful alternate fuel as its introduction coincided with a period of low gasoline prices which faded away the economic incentive.

The government has launched the commercial coal mining in India with an objective to liberalize the sector to bring in more competition and increase production. In the future commercial coal block auctions, coal gasification has been incentivized as there is a provision for 20% rebate in revenue share provided the mine developer uses at least 10% of its production for coal gasification.

[18] Methanol: Properties and Uses report by SGS Inspire

3.2. Status of Methanol in India:

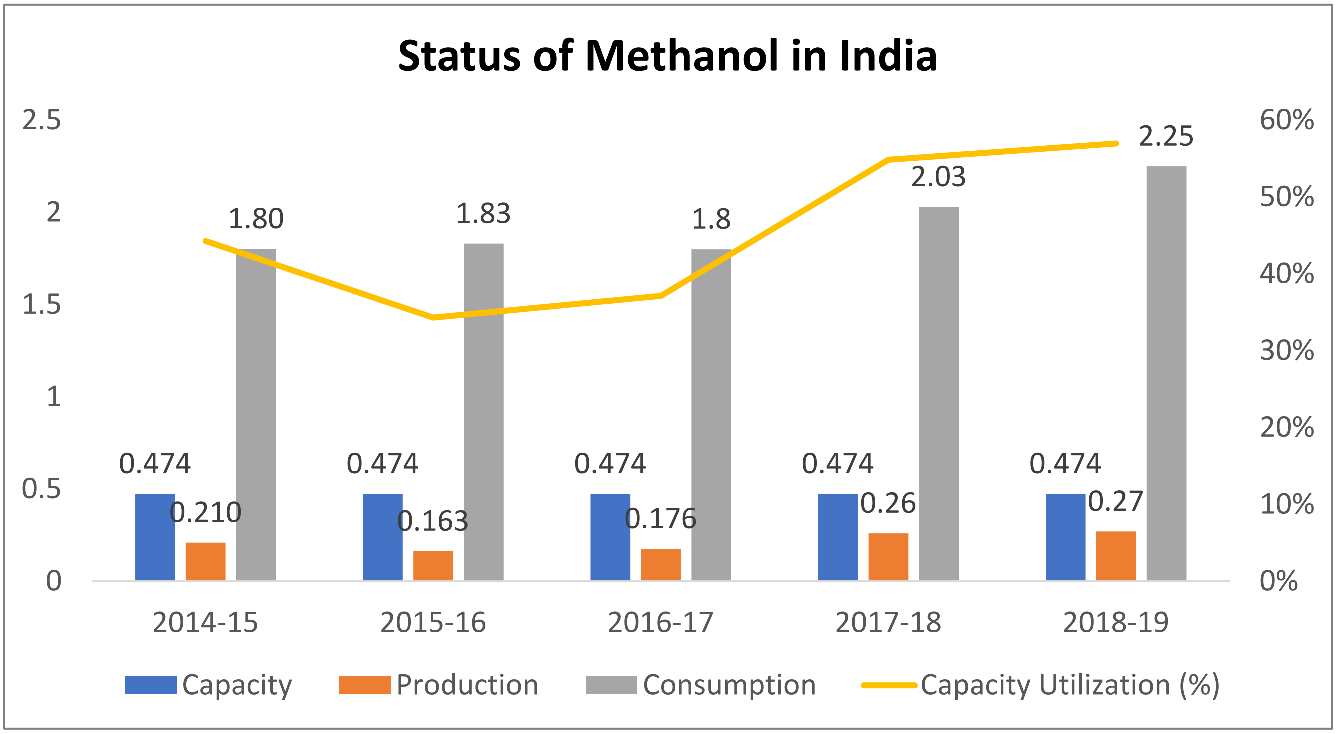

Figure 3.3 – Source: Chemical and Petrochemical Statistics 2019

It is evident from figure 3.3 that 90% of the methanol demand in India is met through imports, whereas the capacity utilization of domestic plants in India hovers around 45-50%. This is so because the domestically produced methanol[19] (from natural gas) is not competitive with the imported methanol, largely from the gulf[20] where natural gas is abundantly available at very low prices. The consumption of Methanol has grown at a CAGR of 7% over the last 5 years. There is a high latent demand for methanol in India. If India were to domestically produce methanol from coal at a competitive price, methanol can be readily consumed in the chemical and petrochemical sector.

[19] Imported LNG is primarily used to produce methanol in India. The price of imported LNG at the plant gate which includes regasification costs, transportation costs and taxes does not cost less than $8-10/mmbtu, even during low natural gas price environments. The price of natural gas in the West Asia and North America hovers between $1.5-3/mmbtu which is significantly lower than that in India. Therefore, it is highly unlikely that India will be able to compete with the West Asian or North American producers of methanol if the feedstock is natural gas. However, the economic viability completely changes if India shifts to a coal to methanol route.

[20] Almost 100% of methanol is imported from the gulf. For example, in 2018, 2/3rd of the methanol was imported from Iran and another 25% from Saudi Arabia. The rest comes from Oman, Qatar, and Russia.

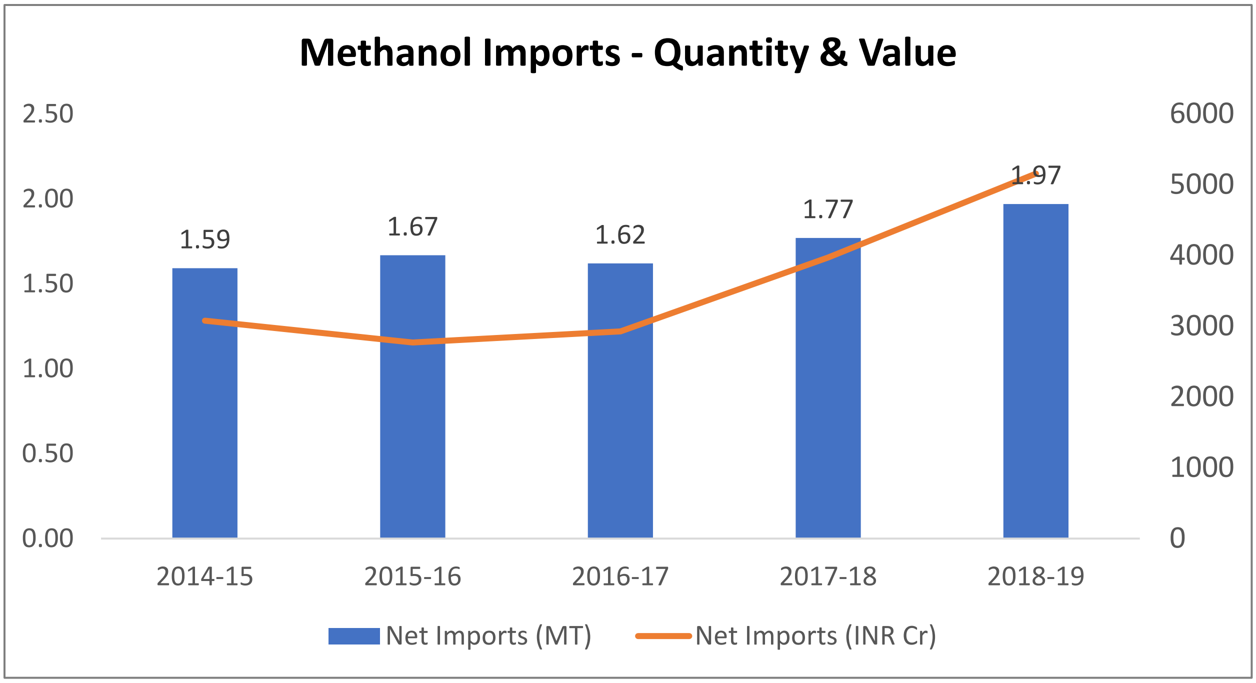

Figure 3.4 – Source: Chemical and Petrochemical Statistics 2019

The Methanol imports have grown at a CAGR of 5.4% and the import value is to the tune of $700 Million in 2018-19. Therefore, domestic production of methanol derived from coal will be an opportunity for India to substitute methanol imports.

Methanol can be blended with gasoline, so it provides an opportunity to substitute gasoline. Different volumes of Methanol blends such as M5, M10, M15, M85 or M100 can be used depending upon the application. In 2016, China blended around 21 MT of methanol with gasoline, whereas India has not even started using methanol as a transportation fuel[21]. 15 provinces of China are already using different Methanol blends (M15 to M100) as transportation fuel and the trend is likely to grow.

China has successfully commercialized the coal to methanol projects and is the world's largest producer and consumer of Methanol. China has developed a huge MTX industry i.e., a methanol-based platform where methanol is converted to olefins, gasoline, aromatics, dimethyl-ether, and methyl tertiary butyl ether. The large number of Coal to X plants in China not only enhances its energy security but also opens avenues for chemical and petrochemical sectors where methanol is a major feedstock.

[21] India's Leapfrog to Methanol Economy, NITI Aayog, published by Dr. V.K. Saraswat and Ripunjaya Bansal

3.3. Pricing of Methanol:

Since 90% of methanol requirement is met through imports, India is exposed to the price and supply volatilities of the international market. The price of imported methanol depends on the price of natural gas, feedstock for methanol in the Gulf and West, and the supply and demand dynamics.

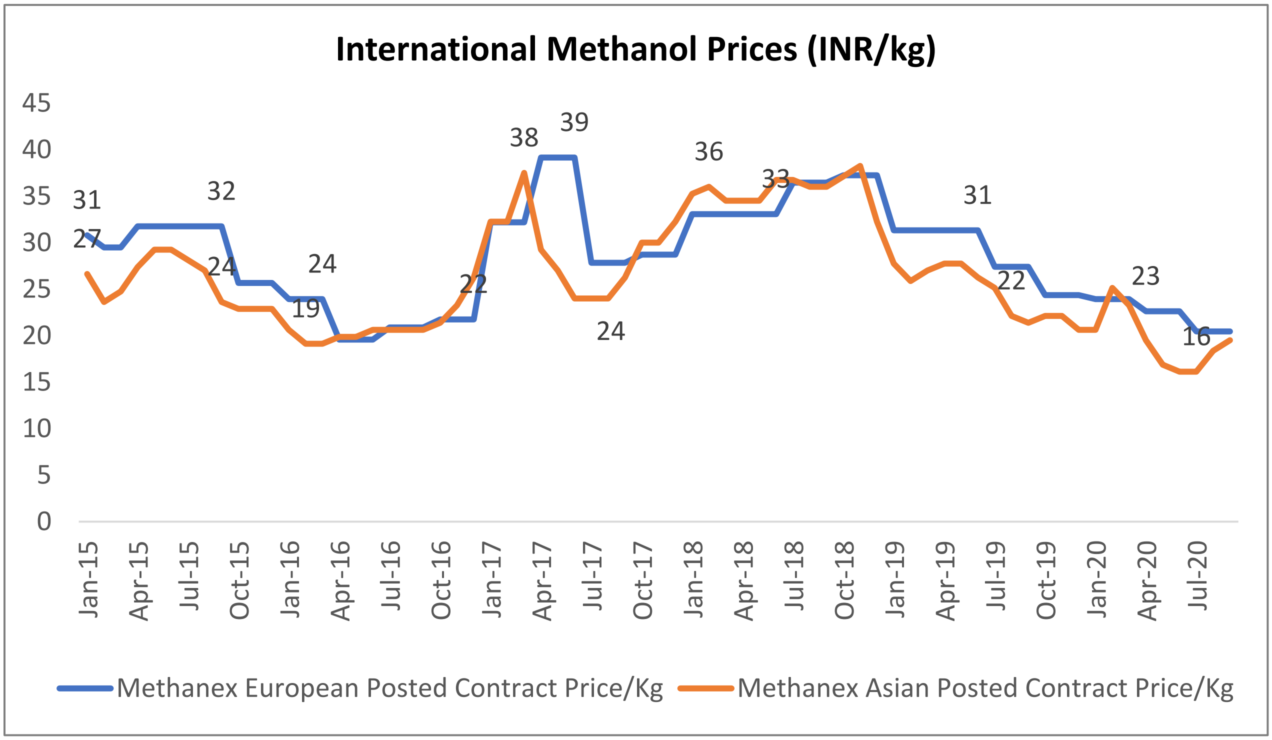

Figure 3.5: Source – Methanex

Figure 3.5 shows the price volatility of methanol in international markets. The above are the prices posted by Methanex, one of the world's largest producers of methanol. Over the past decade, the price of methanol has varied between INR 20-40 per Kg, whereas between July, 2018 and July, 2020, the price varied from INR 24-36 per kg. Though, during the covid-19 pandemic, the prices crashed to INR 16-19/Kg, but bounced back within a period of 3-4 months. Therefore, domestic production of methanol from coal will ensure a steady supply at a competitive narrow price range relative to the imported methanol.

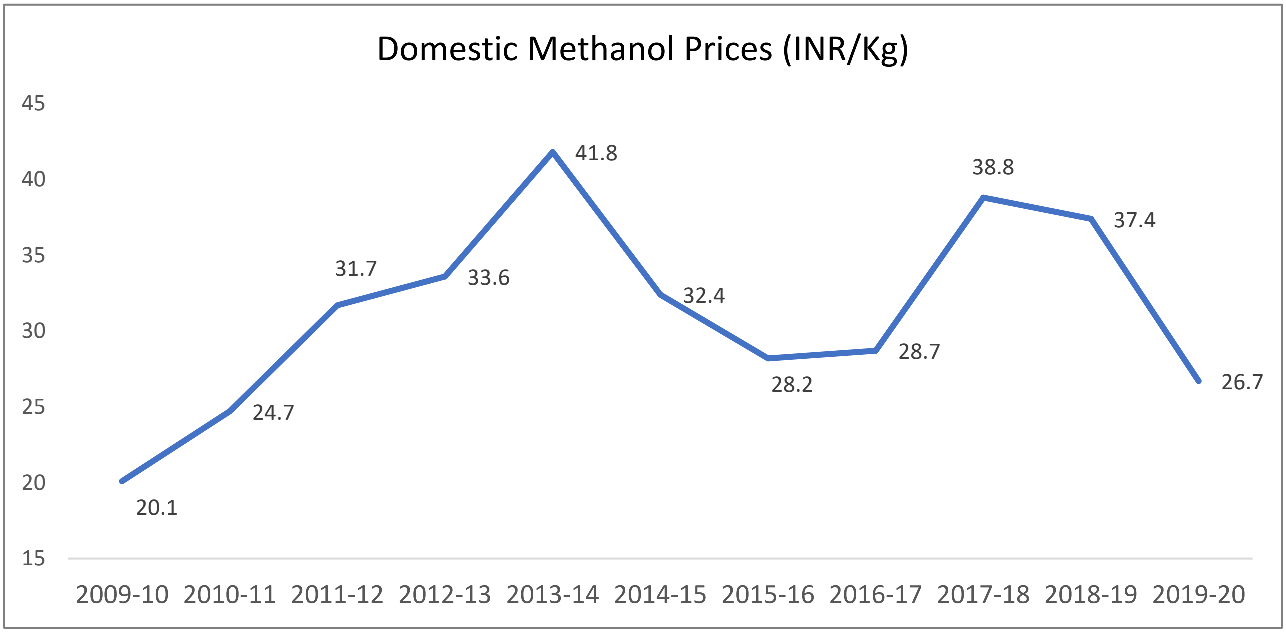

Figure 3.6 – Source: CMIE database

Figure 3.6 gives the price of domestic methanol derived from natural gas. Since 90% of methanol requirement in India is met through imports, domestic production becomes viable only when the import prices are high enough to support the high cost of domestically produced methanol from natural gas. The high cost of methanol production is attributed to a high cost of feedstock, which is natural gas. RLNG is primarily used to produce methanol which is not below $8-10/mmbtu by the time gas reaches the plant gate.

3.4. Cost of Domestically produced Methanol from Coal:

Based on the internal research done by the Ministry of Coal in collaboration with private investors, coal gasification companies, and technical experts, the price of methanol is likely to hover around INR 22-25/Kg[22] or INR 17.5 – 19.8 per liter (density of methanol – 0.791 kg/liter). Since, India does not have a commercial coal to methanol plant yet, it would be difficult to come up with a definite price of methanol derived from coal. For the analysis here, we assume a conservative price of methanol i.e., INR 19.8/liter.

As evident from figure 2.2, the cost incurred to the government for ethanol being procured on a per liter basis at INR 45.69 – 62.65 is much higher than that of methanol. On an energy equivalent basis, 1.28 liters of methanol will be required to produce the same amount of energy as available from a liter of ethanol. Therefore, 1.28 liters of methanol will cost INR 25.3, whereas the same amount of energy is available for INR 45.69 – 62.65 in case of ethanol. In the subsequent sections, a comparative economic analysis for ethanol, methanol and gasoline is done.

[22] This price assumes a coal price of INR 1000/ton and assumes a return of 10% for the mining company. Since, the Ministry of Coal is in the midst of inviting tenders for coal to methanol projects, we refrain from giving more details. However, the price of methanol should not vary much, might be another INR 2 per kg higher or lower.

4. Vehicular Fuel Efficiency and Emissions:

Various research studies have been conducted to compare the fuel efficiencies of ethanol, methanol, and ethanol-methanol fuel blends with gasoline. The experimental results indicate that the low methanol and ethanol blends up to 30% volume have a similar calorific value to gasoline. For higher methanol and ethanol blends, the calorific value of blended fuels decreases significantly, meaning the efficiency of blended fuels decrease.

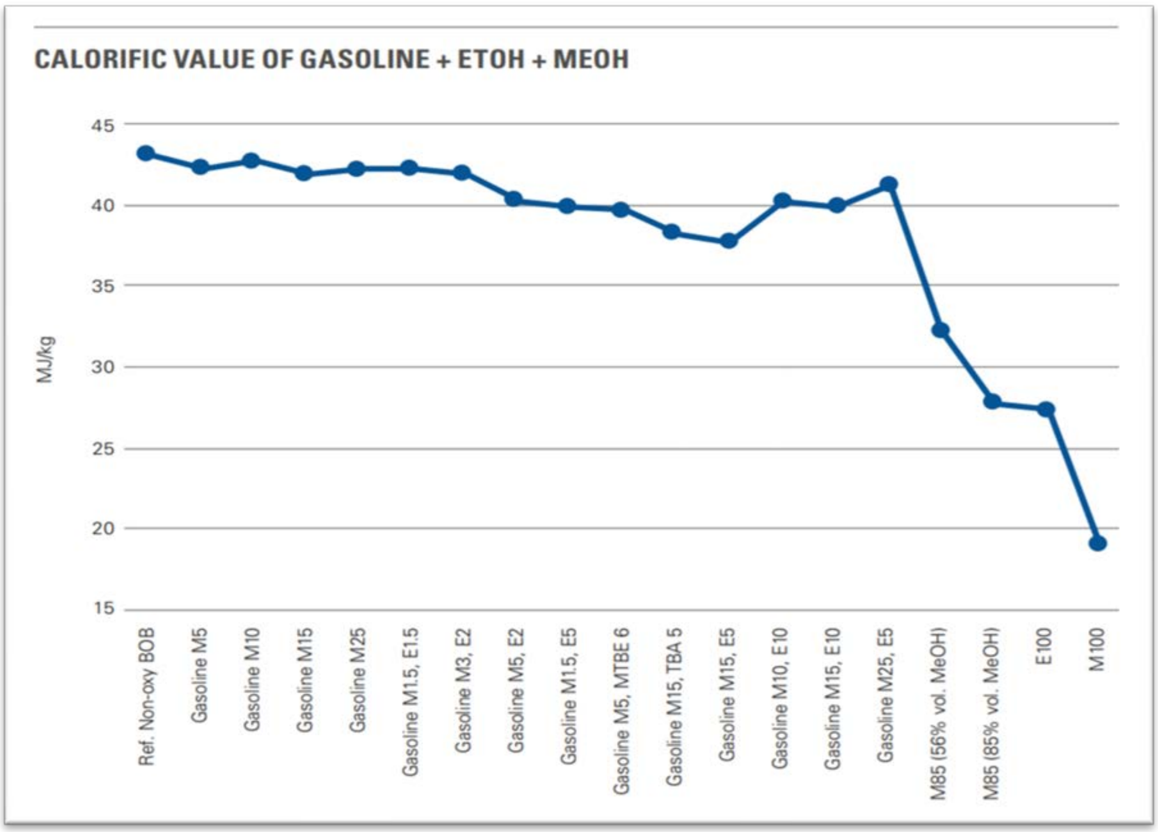

Figure 4.1: Source: Report on 'Methanol: Properties and Uses' by SGS Inspire

It is evident from figure 4.1 that the calorific value of M5-M25 blends with gasoline is similar to that of unblended gasoline. And similar are the results for lower ethanol blends. Various studies indicate that few changes are required for methanol-gasoline blends to be used in Spark ignition (SI) engine. Though, following changes were done for M15 vehicles in China[23]:

- Fuel nozzles of the carburetor were enlarged to adjust the AFR to the stoichiometric value of the actual blend.
- The mixture was heated before it entered the engine at cold start.

[23] The experimental results from the research illustrated in the report 'Methanol: Properties and Uses' by SGS Inspire have been taken.

- The carburetor and fuel line were modified to avoid vapor locks and damage to some of the parts (plastic and rubber, especially) because of corrosion and material degradation.

A research study was undertaken by Automotive Research Association of India (ARAI), Indian Institute of Petroleum (IIP) and Indian Oil Corporation (R&D) in 2014-15 to determine the suitability of E20 ethanol blend fuel in vehicles. Though, some minor challenges occurred, there was no severe malfunction or stall observed at any stage of vehicle operation.

It is highly recommended that a research must be undertaken in India to evaluate the vehicular performance for methanol-gasoline blends.

With regards to emissions, the methanol gasoline blends have the lowest hydrocarbon (HC) and carbon monoxide (CO) emissions when compared with ethanol gasoline blends or methanol-ethanol-gasoline blends. The Methanol fuel blends (3%-10% volume) show lower CO and UHC emissions than the ethanol blended fuels by about 6% and 7%, respectively.

Emissions Reduction Potential for Ethanol Gasoline Fuel Blend					
		Two-Wheelers		Two-Wheelers	
Emissions	Gasoline	E10	E20	E10	E20
Carbon Monoxide (CO)	Baseline	20% lower	50% lower	20% lower	30% lower
Hydrocarbons (HC)	Baseline	20% lower	20% lower	20% lower	20% lower
Oxides of Nitrogen	Baseline	No significant trend	10% higher	No significant trend	same

Table 4.1: Source – NITI Aayog's report on Roadmap for Ethanol Blending in India

The table 4.1 gives the emissions reduction potential for ethanol gasoline blends in comparison to unblended gasoline fuel. Though, there is a reduction in CO and HC emissions for ethanol gasoline fuel blends, there is no significant trend for nitrogen oxides.

5. Comparative Analysis for the cost of Ethanol, Methanol, and Gasoline:

In the previous sections of the document, we have discussed the tax loss incurred to the government due to the amount of gasoline replaced by ethanol for blending. Moreover, the likely price of domestically produced methanol from coal is also discussed. Therefore, a comparative analysis for the cost of ethanol and methanol is done with gasoline on an energy equivalent basis.

Cost Comparison of Ethanol and Methanol with Gasoline

S.No	Parameters	Ethanol[24]	Methanol	Gasoline (Petrol)
#1	Calorific Value (Kcal/Kg)	7100	5500	11,110
#2	Density (kg/litre)	0.789	0.791	0.750
#3	Price of 1 liter of fuel (INR/liter)	45.69[25]	19.8	35.99[26]
#4	Energy Equivalent units for 1 liter of Petrol	1.48	1.90	1
#5	**Price paid by the government (excluding taxes) for different fuels to replace 1 liter of Petrol on energy equivalent basis (INR/liter)**	**67.62 (#3*#4)**	**37.62 (#3*#4)**	**35.99 (#3)**
#6	Tax on respective fuels (INR/liter)	2.28 (@ 5% GST)	undefined[27]	58.50[28]
#7	**Price (including taxes) paid by consumer for different fuels to replace 1 liter of Petrol on energy equivalent basis (INR/liter)**	**69.9 (#3*#5 + #4)**	**37.62[29] (#3*#5)**	**94.49 (#3 + #4)**

Table 5.1

It can be clearly seen from table 5.1 that methanol is much more economically competitive relative to ethanol when considering blending with gasoline. Since the calorific values of ethanol, methanol, and gasoline are different, the amount of energy received from each unit of fuel is

[24] Ethanol derived from different sources have different prices. Since, 100% of ethanol was derived from C-Heavy molasses until FY 18 and 75% of it in FY 19 and 45% of it in FY 20, the price of ethanol used is for C-Heavy molasses. However, table 2.2 gives prices of ethanol derived from different sources.

[25] This is the price for ethanol derived from C-heavy molasses, which is the major source for ethanol production. The figure 2.1 gives a production break-up source wise. This price does not include GST.

[26] Table 2.3 gives the price of gasoline charged to dealers excluding any taxes (excise duty or VAT)

[27] Since, there is no commercial coal to methanol plant in India, government is yet to decide the tax structure for it.

[28] This includes an excise duty of INR 32.90, VAT of INR 21.81, and the dealer's commission of INR 3.79. The break-up for the price of gasoline is given in table 2.3.

[29] The tax on methanol is not included as this policy decision is open for discussion.

different. Gasoline has the highest calorific value followed by ethanol and methanol. This means that on an energy equivalent basis, we will need 1.48 liters of ethanol and 1.90 liters of methanol to get the same amount of energy as derived from a liter of gasoline. Therefore, on an energy equivalent basis, ethanol is rather much expensive than methanol. It is to be noted that we have used the price of ethanol derived from C-heavy molasses which is the cheapest. However, if the price of ethanol derived from B-heavy molasses and sugarcane juice is used, the cost of ethanol to replace a liter of gasoline will be even higher on an energy equivalent basis. Even if a tax rate of INR 58.50 is levied on methanol, its price will become INR 96.12 on an energy equivalent basis with gasoline which will be in the range of current gasoline prices prevailing in India. A high gasoline environment incentives alternate fuels, thus, this is the right opportunity to establish methanol as a commercial alternate fuel in India.

6. Conclusion:

From the above analysis, it is clear that methanol is much cheaper than ethanol. A liter of methanol costs around INR 19.8, whereas the cost of ethanol lies between INR 45.69 – 62.62 per liter depending upon the source as shown in figure 2.2. Since, the calorific value of ethanol is 7100 Kcal/Kg, whereas that of methanol is 5500 Kcal/kg, 1.28 liters of methanol would be required to produce the same amount of energy as derived from a liter of ethanol. Therefore, on an energy equivalent basis, 1.28 liters of methanol will cost INR 25.3 to replace a liter of ethanol.

When comparing the cost of ethanol, methanol, and gasoline, methanol is the cheapest alternate fuel available. The cost of gasoline including taxes is INR 94.49 per liter and the cost of ethanol including taxes on an energy equivalent basis with gasoline is INR 69.9 as shown in table 5.1. Whereas the cost of methanol on an energy equivalent basis with gasoline is INR 37.6 as evident from table 5.1. Since, there is no commercial coal to methanol plant in India, the government is yet to define the tax structure on methanol. However, even if the government levies a tax of INR 58.50 on methanol, it's price will become INR 96.12 on an energy equivalent basis with gasoline which is very much in the range of current gasoline prices prevailing in India. Unlike ethanol, methanol will not ignite a food vs fuel security debate. Rather, using coal to produce methanol will help India monetize its domestic resources to reduce crude oil imports.

A high gasoline price environment incentives alternate fuels such as methanol and ethanol. Therefore, India must deploy large scale coal to methanol plants (preferably deploying CCS) to use methanol as an alternate fuel for blending. This will support and encourage the existing ethanol blending program.

A National Coal Gasification Mission must be formulated to evaluate the status of coal gasification in India and suggest a roadmap for a sustainable coal to chemicals and petrochemicals industry, including coal to methanol. This will give a strong push to atmanirbhar Bharat as domestic coal will be used to produce different chemicals and petrochemicals.

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