



# **India's Leapfrog to Methanol Economy\***

By

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\*Disclaimer: The views expressed in this paper are exclusively those of the authors. They do not represent the views of NITI Aayog.

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## **I. Introduction:**

Energy is considered as of the key inputs for economic development of the Country. India is poised to play a significant role in the Global energy space, as it is likely to account for 25% of the rise in global energy demand by 2040<sup>3</sup>. Our Country's energy demand is expected to rise at a compounded annual growth rate (CAGR) of 3.5% till 2040 as it advances on the path of development<sup>4</sup>. India imported 37% of its total primary energy demand in 2015-16, whereas the import dependence of crude oil and natural gas has increased from 73% and 17% in 2005-06 to 81% and 40% in 2015-16 respectively. However, there has been a dismal growth in domestic oil (CAGR – 1.4%) and natural gas (0.01%) production over the last decade. Methanol and Dimethyl ether (DME) can play an important role in order to contain the rising imports and improve the energy security of India.

## **II. Brief description of Methanol and DME:**

Methanol ( $\text{CH}_3\text{OH}$ ) is a single carbon compound which can be produced from coal, natural gas, biomass (i.e. products which are capable of producing syngas), whereas DME ( $\text{CH}_3\text{OCH}_3$ ) which is the simplest ether compound can be produced from methanol or directly from syngas.

Methanol is an efficient fuel (octane number 100) and emits lesser  $\text{NO}_x$  and Particulate matter (PM) than gasoline and produces no  $\text{SO}_x$  as there is no sulphur in methanol. It can be blended (or be completely substituted) with gasoline to use as a transport fuel along with other applications. However, methanol is more corrosive than gasoline and may require new equipment for storage and distribution of the same and is also toxic to humans if ingested.

Like Methanol, DME is also an efficient fuel (cetane number – 55-60) and burns with lesser  $\text{NO}_x$  and PM, no  $\text{SO}_x$  than diesel. It is a viable and clean diesel alternative and can also be blended with LPG. It is a non-toxic compound and is safe to handle.

The tailpipe emissions from methanol usage (i.e. at the consumption end) are quite low in comparison with conventional fuels like gasoline and diesel, however, the well to wheel (WTW) emissions for coal to methanol production in comparison with gasoline are more. WTW emissions for coal to methanol production is 190 grams of  $\text{CO}_2\text{e}/\text{MJ}$  of fuel, whereas the same number for gasoline production is in the range

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<sup>3</sup> India Energy Outlook 2015 released by International Energy Agency (IEA)

<sup>4</sup> As per the calculations from India Energy Security Scenarios (IESS)

of 95-100<sup>5</sup>. However, the emissions for methanol from coal can be brought down to 80 grams of CO<sub>2</sub>e/MJ of fuel if a cogeneration plant for electricity generation or a CCS equipment is employed along with it. But, the above numbers would firm up only when India sets up a coal to methanol plant. Moreover, the above numbers are subject to variation depending upon the different technologies used, mode of transportation used for transporting methanol from plants to dispensing stations, distance of methanol plant from coal mines and other minor factors. Having discussed the emissions scenario for coal to methanol production, it is to be noted that the per capita emissions of India (1.7 tons CO<sub>2</sub>e/capita) are just 1/3<sup>rd</sup> of the World average and much below that of China (7.7 tons CO<sub>2</sub>e/capita), US (16.1 tons CO<sub>2</sub>e/capita) and Brazil (12.3 tons CO<sub>2</sub>e/capita). As India moves ahead with its ambitious developmental agenda, it has the right to use its carbon space, though, India has taken effective measures to reduce its emissions.

### III. Developments in Methanol, DME & Olefins Globally & in China:

China is leading the world with the largest production of Methanol & DME. China with 47 Million Tons (MT) of production in 2015 accounted for 55% of the global methanol production (85MT). China also produced 3.8 MT of DME in 2015 which is highest in the World.

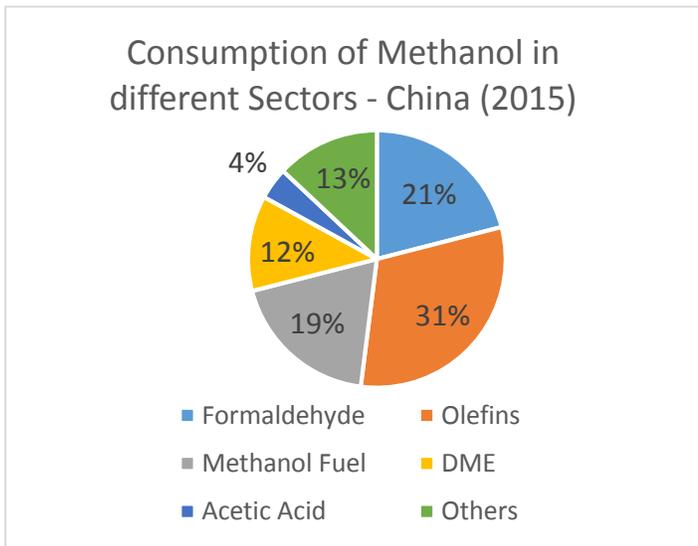


Figure 1- Source: Methanol Institute

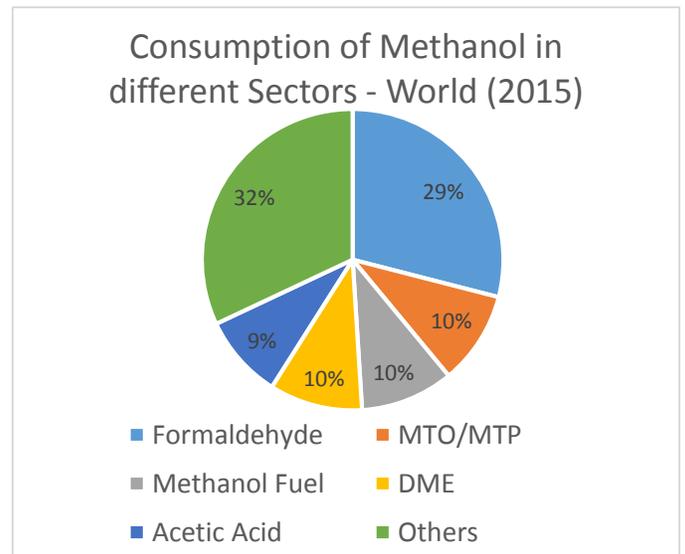


Figure 2- Source: Methanol Institute

<sup>5</sup> Dr. Anirudh Gautam, Executive Director, RDSO has given critical inputs with regards to emissions numbers.

The two figures above depict the sectoral consumption of methanol globally and in China in 2015.

It is to be noted that China produces 70% of its methanol from Coal as it has the third largest coal reserves in the World, although, other countries (US, South America, Iran) are largely producing methanol from natural gas due to its abundant availability in those countries at low prices. India can also follow the footsteps of China as our Country has the 5<sup>th</sup> largest coal reserves in the World and if used efficiently, can contribute significantly in methanol and DME production.

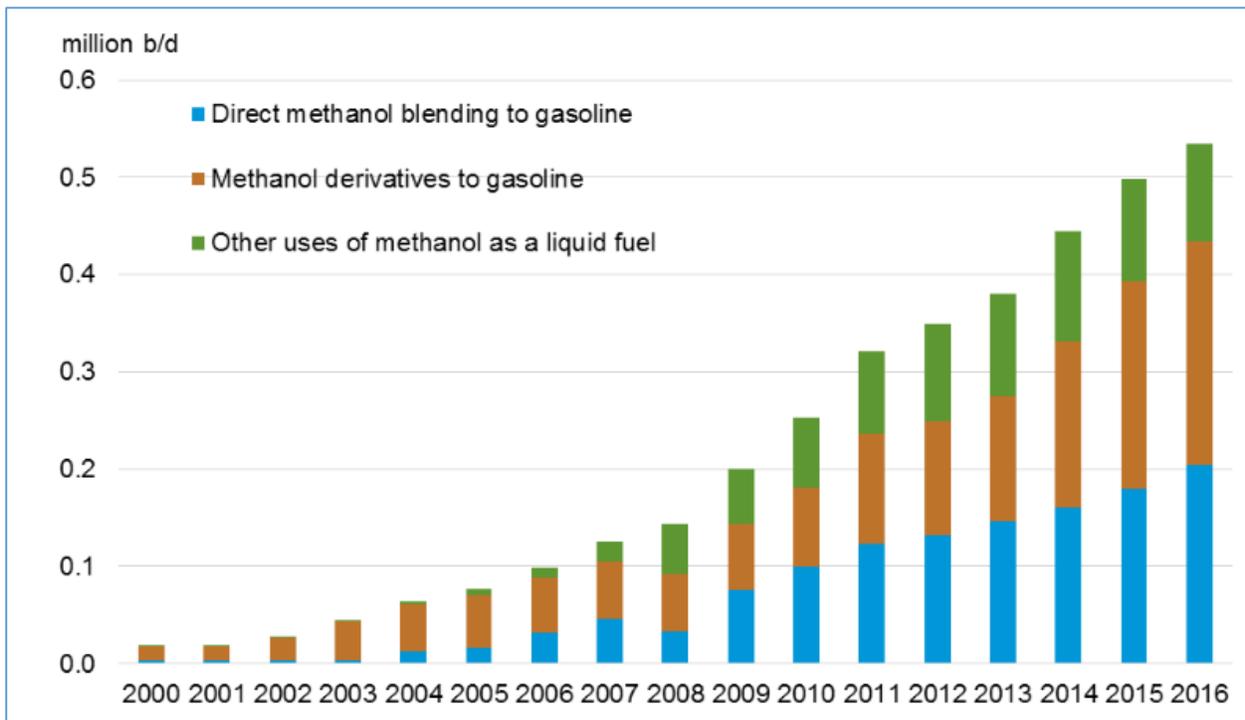


Figure 3: Source – Energy Information Administration

It is evident from Figure 3 that the consumption of methanol in China has seen a rapid expansion at a CAGR of 18% over the last decade. In 2016, China blended around 21 MT of methanol with gasoline, whereas India has not started using methanol as a transportation fuel. Let alone, India’s gasoline consumption was 22 MT in 2015-16 which is approximately equal to the amount of methanol blended with gasoline in China. Moreover, 90% of the total DME production in China goes into LPG blending, where DME is permitted as 20% blend on a weight basis. This shows that China has been aggressively pursuing the agenda of alternative fuels, especially using methanol to reduce its import dependence. 15 provinces of China have already been using Methanol (M15 to M100) in millions of vehicles and now it plans to take methanol to all its provinces. Moreover, a Chinese auto

manufacturing company, Geely, has already commissioned methanol fueled automobile plant which will manufacture 200,000 cars annually.

United States is a classic example which adopted a multipronged strategy to reduce its crude oil import dependence and today, it has become the second largest producer of crude oil in the World. Though, Shale oil revolution has played a major role in this, US has given a lot of importance to alternate fuels. The United States ran several methanol programs, especially in California from 1980 to 1990 for the conversion of gasoline run cars to methanol blended fuels (M15 and M85). However, by the late 1990's, the use of methanol as a transportation fuel in the US went down for a couple of reasons – California methanol program of 1980 was initiated amidst falling petroleum prices due to which the economic benefit of using methanol decreased significantly and there was no strong pitch made for methanol to be used as a transportation fuel like ethanol. Eventually, post 2005, ethanol mainly displaced methanol in California. This led to ethanol blending having displaced 7% of gasoline in 2010 and the number of flexible fuel vehicles (FFVs) running on E85 reached 8.3 Million in US in 2011.

Olefins derived from coal, natural gas or methanol are significantly contributing in the production of petrochemicals like ethylene, propylene apart from acting as a starting material for plastics and detergents globally and in China. In 2015, China had a coal to olefins production capacity of 4.5 MT and produced 3.9 MT. However coal to olefins through methanol is a proven technology and is commercialized globally, the low crude prices have declined its competitiveness temporarily. The commercial operations in China have indicated that the break even for coal to olefins (CTO) production is around \$40-42/bbl.

#### **IV. Status of Methanol in India:**

India is at a nascent stage in methanol production and usage, but it has a large potential given its wide applications. There are 5 main producers of methanol in India – Gujarat Narmada Valley Fertilizer & Chemicals limited, Deepak Fertilizers, Rashtriya Chemicals and Fertilizers, Assam Petrochemicals and National Fertilizers Limited. The following figures would give an overview of the methanol industry in India.

Year	Capacity (MT)	Domestic Production (MT)	Consumption (MT)	Capacity Utilization (%)
2010-11	0.496	0.375	1.14	76%
2011-12	0.496	0.360	1.44	73%
2012-13	0.474	0.255	1.47	54%
2013-14	0.474	0.307	1.54	65%
2014-15	0.474	0.210	1.80	44%
2015-16	0.474	0.163	1.83	34%

Table 1: Source – Ministry of Chemicals and Petrochemicals

Table 1 suggests that the domestic production of methanol has fallen by 57% from 2010-11 to 2015-16, whereas the consumption has risen by 61% over the same period. Since, the installed production capacity of methanol has largely been static, falling domestic production has led to constant decline in the capacity utilization factors of Methanol Industry.

Year	Imports (MT)	Exports (MT)	Net Imports (MT)
2010-11	0.81	0.044	0.77
2011-12	1.20	0.120	1.08
2012-13	1.40	0.185	1.21
2013-14	1.31	0.082	1.23
2014-15	1.64	0.049	1.59
2015-16	1.71	0.044	1.67

Table 2: Source - Ministry of Chemicals and Petrochemicals

Table 2 above shows that there has been continuous increase in methanol imports in India as they have more than doubled from 2010-11 to 2015-16. Though, India has been exporting methanol as well, the amount is very small in comparison with the imports.

It can be inferred from Table 1 and 2, that inspite of having unutilized capacity in India, it imports methanol in order to meet its requirements. Rather, 90% of methanol requirement is met through imports. This is primarily because, it is cheaper for India to import methanol in comparison with domestic production. India imports 99% of its methanol from Iran (1.31 MT) and Saudi Arabia (0.38 MT), where methanol is produced from natural gas which is abundantly available in latter countries at extremely low prices. On the other hand, India relies on imported natural gas for

methanol production due to which it loses its competitiveness in comparison with imports. However, India does not have a commercial coal to methanol plant, since, India has large coal reserves, it can produce methanol using coal as a feedstock at competitive prices.

Moreover, there is a considerable forex outgo on the imports of methanol which is indicated in the figure below.

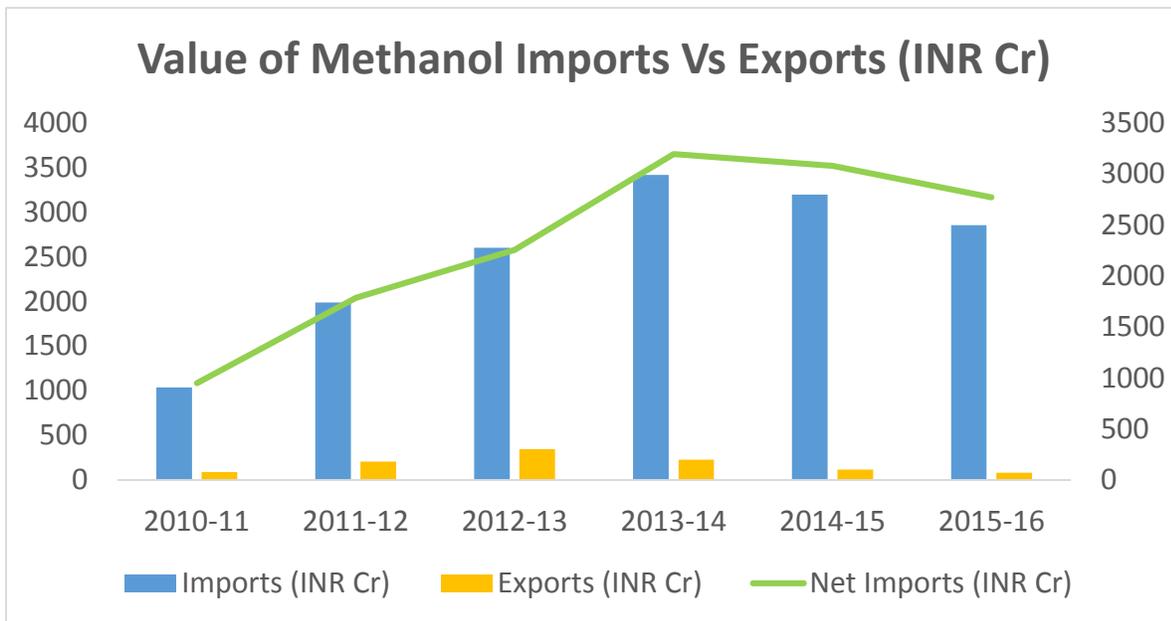


Figure 4: Source – Ministry of Fertilizers and Petrochemicals

In 2015-16, India imported methanol worth INR 2853 Cr, whereas it exported methanol worth INR 82 Cr, due to which the net import value was still quite high at INR 2771 Cr. Though, India’s methanol exports are marginal, Romania, UAE and Sri Lanka account for over 80% of exports.

#### V. Economic Viability of Methanol Production in India:

Since, India is producing all of its methanol from imported natural gas, it must use coal for methanol production which is expected to make it economically viable to produce methanol in India. India must set up a pilot plant for methanol production which would be followed by a commercial plant. As there is no commercial coal to methanol plant in India, it would be difficult to calculate the exact cost of per unit methanol production, though, there have been pretty fair estimates of the same as Coal to methanol technology is a proven technology across the World.

It is estimated that a 1600 tons per day of methanol plant will require a capital expenditure of ~INR 1200 Cr which would be able to produce methanol at INR 17-19 per liter which is comparable with the cost of imported methanol<sup>6</sup>. Whereas, presently, the per liter cost of methanol production in India is INR 25-27 or even more depending on the volatility in the price of imported natural gas. Apart from using coal as a feedstock, biomass/municipal solid waste and flared natural gas can also be used for methanol production, but the continuous availability of latter would be a challenge. Therefore, coal seems to be a promising fuel for producing methanol in India.

## **VI. Opportunity for India:**

Since, Coal to methanol is a proven technology, India must tap its large coal reserves to produce methanol (and DME & Olefins) to use it as a substitute or drop-in fuel for gasoline and (diesel). Weak global coal prices and stricter environmental laws are likely to offer firm coal to methanol margins. Methanol and DME offer the following opportunities in India:

### **1. Methanol and DME to be used as a Transportation fuel:**

Methanol & DME can be blended with gasoline and diesel, or can completely substitute the latter fuels respectively giving us an opportunity to reduce our dependence on imported crude oil. India has already set itself an ambitious target of 10% reduction in import dependence of oil & gas by 2022 in comparison with 2014-15 levels which can gel quite well with the use of methanol and DME as alternate fuels. High methanol blends offer significant vehicle efficiency improvement – potential of 25%.

This also offers an opportunity for the railway engines to run on methanol/DME blends.

Moreover, India envisages to roll out a massive water transportation system under the aegis of its flagship Sagarmala project where 40 MT of steel capacity is expected to be set up in coastal areas and around 80 MT of coal would be transported through waterways. Therefore, in order to check the pollution caused by diesel run ships, methanol and DME powered ships would not only be cost effective alternatives but would also produce far less pollution.

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<sup>6</sup> Various Industry sources

## 2. Methanol and DME to help in achieving the objective of access to clean cooking fuels:

India houses nearly 800 million people<sup>7</sup> without access to clean cooking fuels which largely rely on biomass to meet their cooking requirements. In view of the above, the Government launched an initiative, Pradhan Mantri Ujjwala Yojana (PMUY) in May, 2016 under which 5 Cr LPG connections will be distributed to Below Poverty Line (BPL) households which depend on solid biomass for cooking. India imported (9 MT) 46% of its LPG requirements in 2015-16 and in view of the Government's ambition of increasing access to clean cooking fuels through LPG, its imports are only going to rise in the near future. Since, crude oil prices have softened and the crude oil import bill has declined to \$64 billion in 2015-16 from \$144 billion in 2012-13, LPG imports are not hurting much owing to lower prices. However, keeping in mind the scarcity value of crude and its rising demand, the price of crude is going to increase in the long term. Therefore, methanol or DME blending with LPG or the complete substitution of latter through former can not only gradually displace LPG imports, but would also help in enhancing the access to clean cooking fuels in India.

## 3. Displacing diesel in Telecom Towers:

A large number of telecom towers, especially in rural areas run on diesel for as long as 18-20 hours a day because of frequent electric cuts. Telecom towers in India consume around 2% of diesel (1.5 MT) consumption which is a significant amount indicating a vast potential for DME to replace diesel.

## 4. Production of various chemicals:

Methanol can be used for producing various chemicals like formaldehyde, acetic acid and olefins which can be exported and can be high foreign exchange earners.

## 5. Dovetailing with Swachh Bharat Mission:

Apart from coal, biomass/MSW to methanol can also be a viable option for India which can be dovetailed with Swachh Bharat Mission. The current availability of biomass in India is estimated to be in the range of 500-650 MT, however, a proper supply chain mechanism has to be created for the same so that there is a continuous availability of biomass for methanol production. Moreover, it can be an opportunity for India to use its landfills to convert it into methanol and avoid problems such as toxins leaching into the soil and release of GHG emissions etc.

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<sup>7</sup> As per the estimates of IEA

Therefore, the above options are low hanging fruits for India and have direct relevance with the current targets of the Government. Investment in methanol/DME production might not look much attractive amidst the low global crude prices which have been a huge relief for India, but as and when the prices spring back, Methanol & DME will attain significant importance.

## **VII. International Conference on Methanol Economy by NITI Aayog:**

NITI Aayog organized an international conference on Methanol Economy on 6-7<sup>th</sup> September, 2016 which saw wide participation from industry, academia, policy makers, Government officials etc. from India and across the world. The key takeaway from the conference was that, India must give a thrust on Methanol and DME as a fuel. NITI is working to have a demonstration plant on Methanol production to build a broad consensus in the Country that India can leapfrog to a Methanol Economy before the World including India transitions to a Hydrogen economy in the long term.

## **VIII. Way Forward:**

The first and foremost step should be create an innovation fund that will support the R&D activities for methanol/DME in India. This must be followed by a demonstration plant of coal to methanol production in India. It is necessary to have a sufficient amount of methanol production capacity in India so that the user industries are assured of supply. Once a threshold level of confidence is reached, there should be simultaneous development of flexi-fuel vehicles which would be able to run on methanol/DME fuel blends. A separate program for the development of methanol/DME cookstoves can also be launched. Similarly, another program can be launched for converting diesel powered railway locomotives to methanol/DME based engines.

India should also look at options to set up a manufacturing facility for methanol/DME in Iran or Qatar as both these countries having huge reserves of natural gas can provide the same at very low prices. Methanol/DME produced abroad can be imported in India for its direct application or for further conversion to chemicals like olefins. Though, India may ending up importing methanol in the above scenario, it is likely to be economically advantageous rather than importing crude.

Moreover, India must set up a mega coal based complex for production of power, methanol and fertilizer in an integrated manner which would significantly reduce the cost of various commodities produced.

A task force has been constituted which would work towards the development of overall framework of Methanol production, distribution and utilization in the country. The Government is likely to go ahead with a target of 15% blending by methanol/DME in gasoline/diesel by 2022 which if achieved could result in savings of around \$8 billion (based on the 2016-17 price of India basket of crude oil, which is likely to rise in the medium and long term) by 2022.

Recently, Coal India Limited (CIL) has unveiled its plan to set up a coal based methanol plant in West Bengal and has even invited bids from licensors of coal gasification technology to set up a coal to methanol plant which is a step in the right direction. Therefore, India can and must leapfrog to a Methanol Economy which could significantly reduce its import dependence and carbon footprint.