Nourish Planet
Agnikosh Renewenergy Pvt Ltd.

Renewable Methanol Report

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WHY CONSIDER RENEWABLE METHANOL?

Growing recognition of the threat posed by man-made climate change has spurred government institutions, industry, and science to find clean fuels to power economic activity. In this context, renewable methanol has risen as a clean alternative to fossil fuels, offering a clear pathway to drastically cutting emissions in power generation, overland transportation, shipping, and industry.

Compared to fossil fuels, renewable methanol reduces carbon emissions by 65 to 95% depending on the feedstock and conversion process. That's one of the highest potential reductions of any fuel currently being developed to displace gasoline, diesel, coal, and methane. Additionally, the combustion of pure methanol produces no sulfur oxides (SOx), low nitrogen oxides (NOx), and no particulate matter emissions.

Methanol is already a well-known chemical commodity

Methanol is the world's most commonly shipped chemical commodity and more than 95 billion liters are manufactured every year. It has been stored, transported and handled safely for over 100 years. Since it remains liquid at ambient temperature and pressure, the infrastructure required to deploy it as a fuel is largely in place: combustion engines, fuel cells and power blocks could quite easily and affordably be adapted to methanol.

> To qualify for the advanced biofuels category, a fuel must reduce lifecycle greenhouse gas emissions by 50%. To qualify for the cellulosic and agricultural waste-based biofuel subcategory, fuels must reduce lifecycle greenhouse gas emissions by at least 60%.

Report structure

The first chapter shows how methanol can be made sustainably from renewable feedstocks which are abundant worldwide. These include CO_2 from industry or captured from the atmosphere, or sustainable biomass such as agricultural residue and municipal solid waste.

The report then explores the connection between renewable energy and renewable methanol, both as an input in methanol production and as a means to store excess power from variable renewables such as wind and PV.

Subsequent chapters describe three successful examples of large-scale commercial renewable methanol production: BioMCN, Carbon Recycling International (CRI) and Enerkem.

Finally, the report offers an overview of renewable methanol applications in power generation, heating, road transportation, and shipping.

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Feedstocks

Renewable methanol can be produced from a wide range of renewable feedstocks available worldwide.

Agricultural Waste

Agricultural activity yields a great deal of biomass that can be converted into bio-methanol without interfering with food prices or availability or encroaching on agricultural land.

Forestry Residues

A large amount of residual biomass, such as leaves, branches, needles and woodchip, is produced in the process of harvesting trees. These by-products can be used as a feedstock for producing biochemicals such as renewable methanol.

Municipal Solid Waste (MSW)

Using MSW to produce renewable methanol creates value from unrecyclable garbage and relieves pressure on landfill sites.

Instead of being wastefully curtailed, renewable electricity could be harnessed to generate renewable methanol, which could in turn be used to generate clean power or as a renewable fuel for cars and ships.

Carbon dioxide (CO_2)

Around 32.5 billion metric tons of CO_2 were released into the atmosphere in 2017 alone, rising 1.4% 2 from 2016. This rise is the equivalent of having 170 million new cars on the roads.

With current technology, it is possible to capture CO_2 from the atmosphere and from industrial exhaust streams. Power plants, steel and cement factories, and distilleries, among others, produce carbon dioxide that could be used as a source to produce methanol.

Carbon Recycling International takes 5,600 metric tons of carbon dioxide every year which is reacted with renewable hydrogen to synthesize 4,000 metric tons of renewable methanol

Renewable hydrogen: harnessing renewable energy for electrolysis

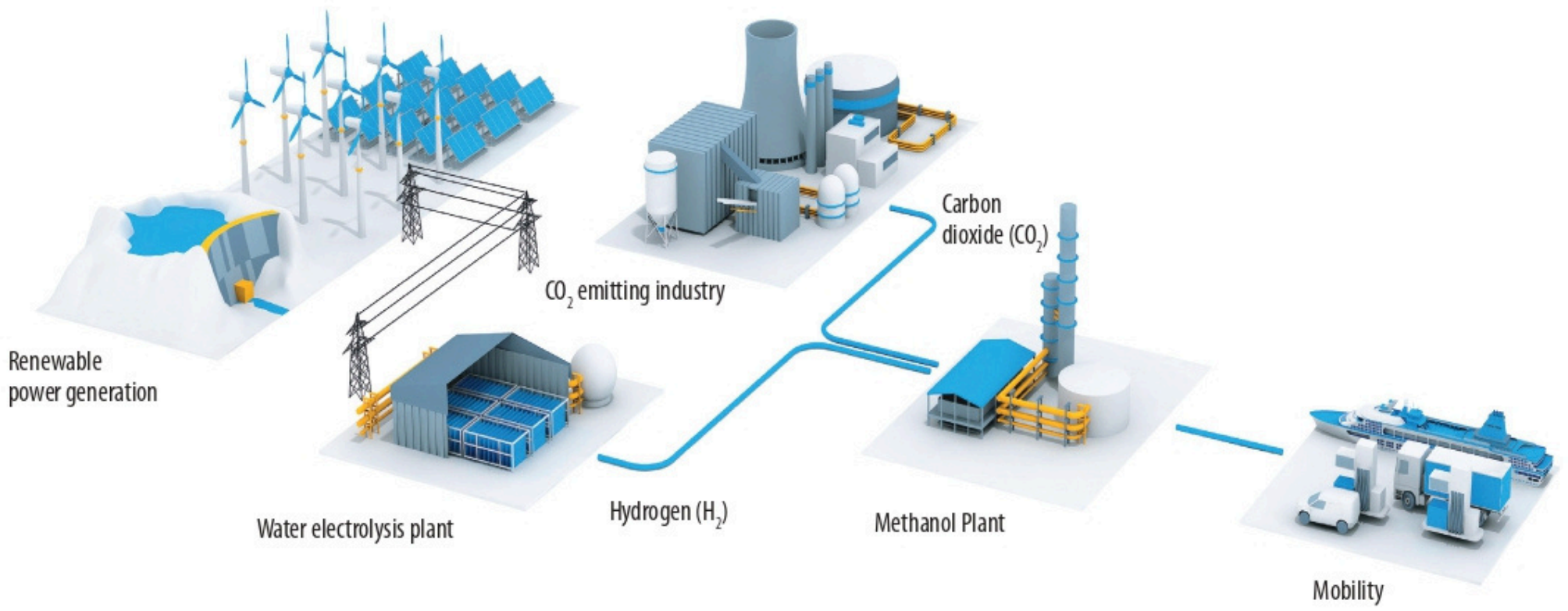
As shown in Figure 1, renewable electricity is used to obtain hydrogen from water by electrolysis.

In recent years, solar PV, hydro and wind have grown to account for a significant part of the energy mix in many parts of the world. These resources provide clean and affordable electricity, but maximum electric yield might not match peak demand. A wind power plant might peak at 3 am, when the wind blows strongly but there is little need for electricity. In this case, supply could outstrip demand and threaten to overload the electric grid.

When this happens, the transmission system operator (TSO) tends to disconnect the renewable resource to safeguard the integrity of the grid. As a result, renewable energy is wasted. In the energy industry, this is known as curtailment.

Curtailment costs can escalate. TenneT, a TSO, paid close to 1 billion euros in 2017 to wind energy

A number of companies are exploring the idea of harnessing excess renewable energy to obtain clean hydrogen from electrolysis. One of them is thyssenkrupp, which is also sourcing excess CO_2 from industrial sources to create renewable methanol.



Commercial methanol production

Several companies and institutions across the world are producing renewable methanol or bio- methanol. Many others are in research and development.

Low Carbon Methanol

In recent years, several companies have developed technologies that reduce the carbon intensity of methanol produced from natural gas. This is called Low Carbon Methanol (LCM).

APPLICATIONS AND USES OF RENEWABLE METHANOL

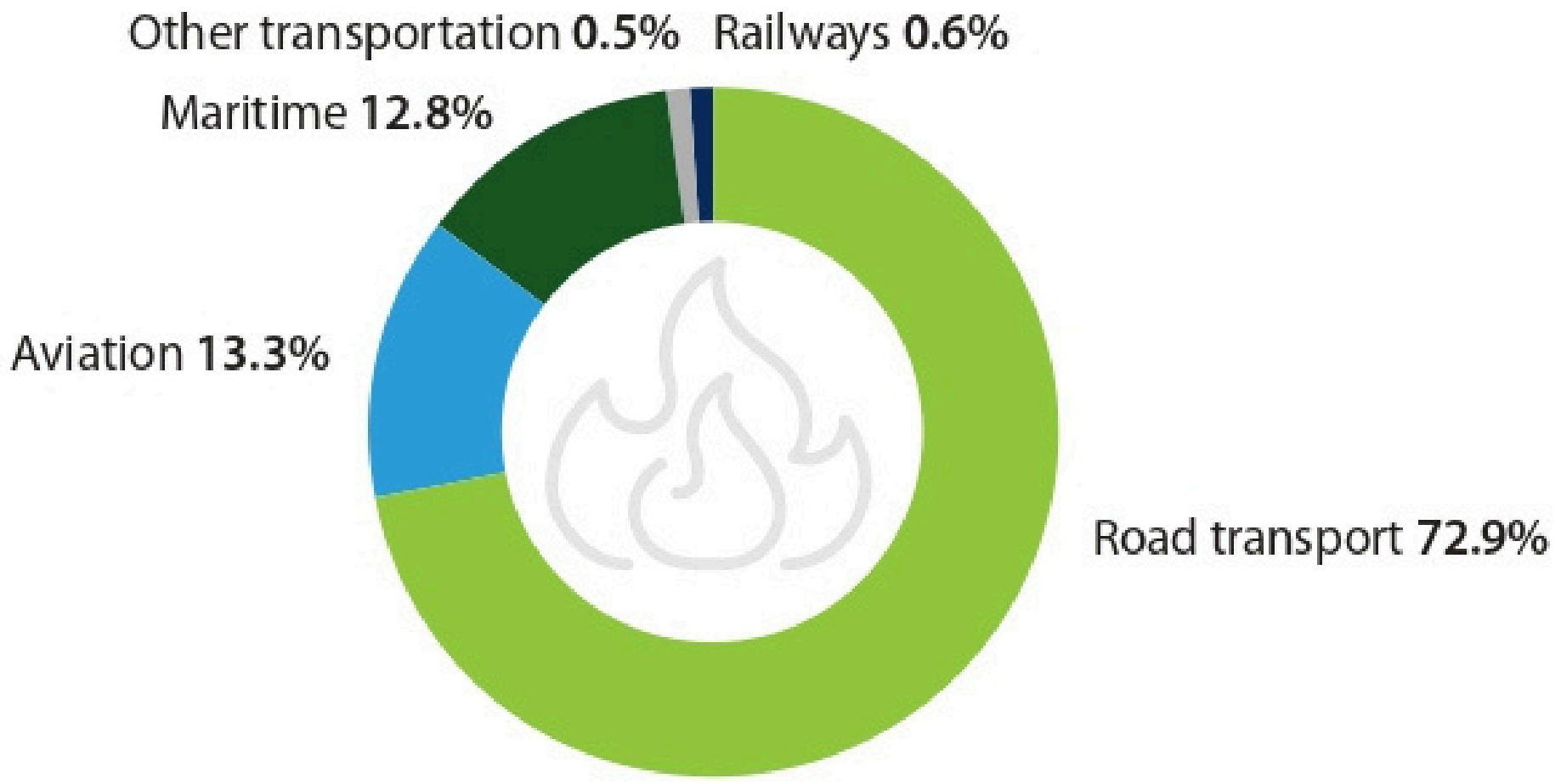
Benefits to human health

The World Health Organization (WHO) states that reducing emissions of greenhouse gases through better transport, food and energy-use choices can result in improved health. The WHO estimates that climate change, driven mainly by man-made greenhouse gas emissions, will cause 250,000 additional deaths per year worldwide between 2030 and 2050, because malnutrition, diarrhea, malaria and heat stress will all increase. In the US alone, the WHO estimates that the direct cost of damage to health will be $2-4 billion annually by 2030, excluding increased costs in agriculture, water and sanitation supply networks. Making and using renewable methanol doesn't only reduce carbon dioxide emissions, it also reduces other harmful air pollutants including nitrogen and sulfur oxides (NOx and SOx), volatile organic compounds (VOCs), particulate matter and other toxic pollutants.

Transport fuel

In Europe, the transport sector contributed 25.8% of total greenhouse gas emissions in 2015. 72.9% of these were caused by road transport. 44.5% came from passenger cars and 18.8% from heavy vehicles. Transport emissions were more than 23% above 1990 levels in 2015 and will need to fall by 68% by 2050 to meet emissions targets.

Share of transport greenhouse gas emissions 2015*



> Widespread adoption of vehicles powered by renewable methanol would dramatically lower CO_2 emissions in transportation.

Type	Current status	Green scenario
Diesel	132g/km	100g/km
Gasoline	176g/km	123g/km
Hybrid	142g/km	80g/km
Battery electric	98g/km	2g/km
Hydrogen	178g/km	3g/km
Methanol	**83g/km**	**2g/km**

Shipping fuel

There's a huge global demand for marine fuels, with recent estimates of consumption at around 298 million metric tons per year. 25 Fleet numbers and volumes of goods shipped are increasing year on year. The international world trade fleet of ships increased by 1.5% from 2013-15: transport supply of chemical tankers and general cargo ships grew by 15%, cruise ships by 11% and container ships by 9%.

Properties of methanol vs other shipping fuels*

Properties	Methanol	Methane	LNG	Diesel fuel
Molecular formula	CH_3OH	CH_4	C_nH_m; 90-99% CH_4	$C_nH_{1.8n}$; C_8-C_{20}
Carbon contents (wt%)	37.49	74.84	≈75	86.88
Density at 16˚C (kg/m³)	794.6	422.5[a]	431 to 464[a]	833 to 881
Boiling point at 101.3kPa(˚C)[b]	64.5	-161.5	-160 (-161)	163 to 399
Net heating value (MJ/kg)	20	50	49	42.5
Net heating value (GJ/m³)	16		22	35
Auto-ignition temperature (˚C)	464	537	580	257
Flashpoint (˚C)[c]	11		-136	52 to 96
Cetane rating	5		0	>40
Flammability limits (vol % in air)	6.72 to 36.5	1.4 to 7.6	4.2 to 16.0	1.0 to 5.0
Water solubility	Complete	No		No
Sulfur content (%)	0	0	<0.06	Varies, <0.5 or <0.1

Renewable methanol could also play a key role in providing grid stability, by drawing excess renewable electricity from the system to power electrolysis, one of the key processes in the manufacture of renewable methanol. The resulting renewable methanol could then be used as a clean power plant fuel that can be dispatched to provide energy whenever it is required.

CONCLUSION AND HOW TO FIND OUT MORE

Industrial scale production of ultra-low carbon renewable methanol is already happening in Europe and North America. In Asia, the potential for methanol fuel is widely understood by governments and industry, with methanol-powered automotive fleets established in China and a clear determination to explore renewable methanol sources and implement them at scale.

Methanol has many applications, both as fuel and as a chemical feedstock to other vital industrial production and manufacturing processes. With a wealth of available renewable feedstocks, from biomass municipal waste to exhaust carbon and power from renewable sources, methanol has shown itself to be a versatile, affordable and stable energy source that's well suited to use in transportation and industry. It has clear potential to help reduce greenhouse gas emissions if it's adopted in place of fossil fuels.

There's no magic bullet when it comes to renewable energy. A range of solutions will be needed to meet different consumer, industrial and geographic demands for fuel, heat and power. For example, electrification is an excellent solution to many light-duty, land-based energy demands, but for heavy vehicles and in industries like shipping and aviation, the technology and infrastructure does not currently exist to make this possible. They will continue to require liquid fuels: renewable methanol is one of the most sustainable and cleanest options.

The diverse and successful trials in both production and application, along with substantial worldwide commercial investment in renewable methanol technologies, give a clear indicator that renewable methanol will play a significant role in transportation and chemical production in the coming decades.