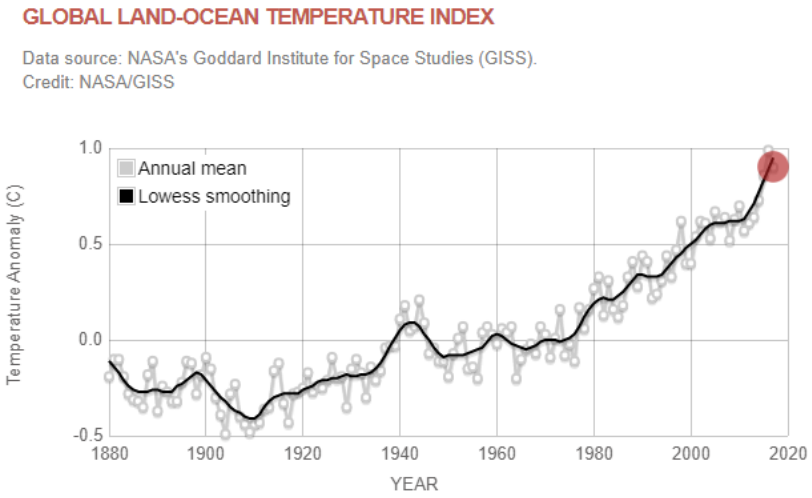
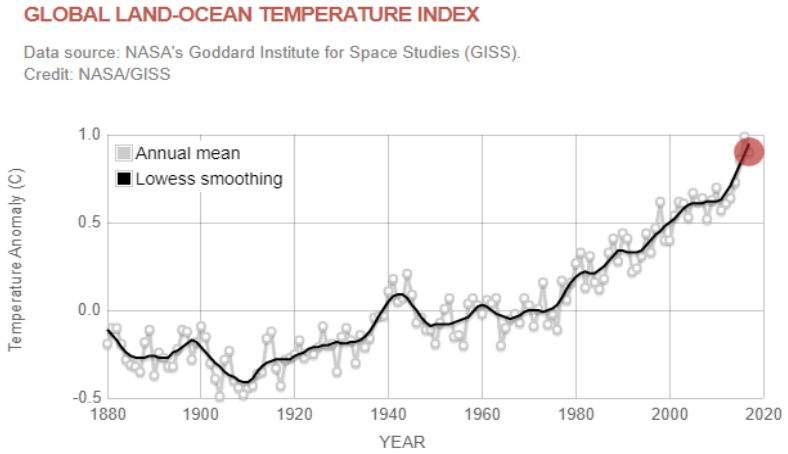
Methanol/hydrogen as the interim energy source before zero-carbon energy source is ready

Bin, MH Rei

Green Hydrotec Inc

Apr, 2-3, 2018





Beyond any doubt that the earth is getting warmer and CO_2 concentration is increased rapidly and steadily.

Besides upgrading the efficiency of vehicle engine, lighting device and housing insulation, **the wind turbine and solar panel for power generation is viewed as the best zero-carbon energy source.**

Energy evolution should not be a black/white change?

- With the fossil fuel gradually being pushed out as the sources of future energy after 2030 or 2040 by the zero-carbon energy sources or by politician, the lost of losing multibillion dollars revenue from the existing fossil fuel industry and the million of lay-off from the industries will have serious impact on the economy and society.

  Recycle or refurnish of service and human resource is needed

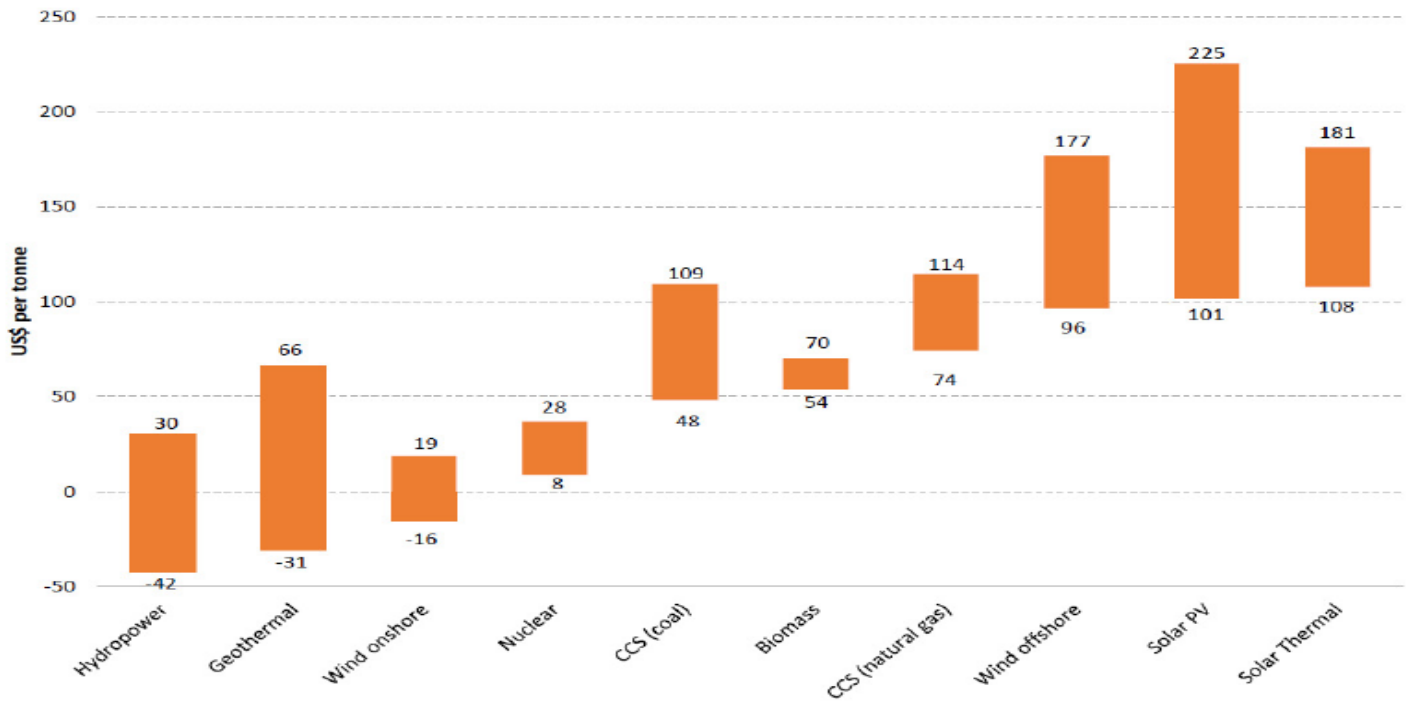
What extent do we need to reduce CO2

- Wind or solar energy reduces CO_2 emission almost 100% while natural gas (NG, shade gas or methane) reduces only 40% from combustion of coal. However, the former approach is expensive with high economic price to pay and has low net effect in the real world. After over 10 year and $1.2 trillion spending, the CO_2 reduction in German is only 8% in power generation whereas it is 12 % reduction in US by shifting coal fire to shade gas or natural gas(NG).

Is the zero-CO2 energy necessary

- The cases in Germany and in US shows that even the extent of abating CO_2 with shade gas(methane) replacing coal is only 40% reduction, the net effect on CO_2 abatement in US is greater than with solar or wind replacing coal with almost 100% reducing.
- Moreover, the cost of CO_2 abatement with methane replacing coal is only about $116 /ton of CO_2 with carbon capture and storage(CCS) and only $20 without CCS while that by PV is around €500- € 1870/t CO_2 and by wind energy is €110 to € 230/ tCO_2

FIGURE 5.3: Avoided cost of CO_2 for plant in the US, (2014 US$)



Lawrence Irlam,Global Carbon Capture & Storage Institute, "The cost of CCS and others low-cost technologies in US", 2015

In addition, the cost of CO_2abatement in Germany is around € 500-1870/t CO_2 for PV and € 110-230/t CO_2 for wind according to J. Abrell, M. Kosch and S. Rausch of Swiss Federal Institute of Technology, Zurich, "The Economic Cost of Carbon Abatement with Renewable Energy Policies" 2017

Problem with methane as the fuel

- Methane is a popular fuel for heating in house, in industry and in power station; it has low CO_2 emission (0.22kg CO_2/KWh) and relatively clean in exhaust among common fuels. However, it is a gas (bp= -161.5℃) under ambient conditions and requires higher temperature to ignite (600 ^{O}C of autoignition temperature) and often catch fire by leakage into air (5%-15% of flammability range).
- As a result, dispensing of methane(NG) is expensive requiring high pressure piping or container or cryogenic cooling to liquify with the expensive special facilities. NG in US is around $2.5-2.6/MBTU(1MMBTU= 27M3), it is around $5.5-6.5/MMBTU in Germany(CNG) and $7-8/MMBTU in Taiwan and PRC(LNG).

Methanol as a substitute-1

- Methanol is a chemical in the market and has a potential to become as a fuel with its abundant capacity and relatively clean and potent in the combustion.
- **Heat in combustion**: Methanol yields 0.22kg CO_2 /KWh in combustion and delivers 438 time more heat (LHV=15,710MJ /M^3) than methane does (LHV=35.8 MJ/M^3) on volume basis. It has lower ignition temperature(468^{O}C) than has methane(600 ^{O}C), and can be ignited at -10^{O}C in catalytic heating, we even ignite an aq. mixture of 52-60% of methanol with water in our catalytic heater in the steam reformer.
- **Dispensing**: Methanol is a liquid(bp-64.5^{O}C) and can be stored and delivered for long distance with the ordinary equipment at a relatively low cost.

Methanol as a substitute-2

- **Safety**: **OSHA of US regards methanol as a safer fuel than LPG, gasoline or Diesel oil.** In case of leakage, it can be flashed with 3-times of water to prevent from catching fire. It is toxic when drink and it often emits trace amount of carcinogenic formaldehyde in processing and in combustion exhaust; however, we have overcome this with careful mix of air and fuel to control its emission to 0.03ppm (1.0 ppm, 0.06ppm and 0.091ppm as the limit in Taiwan, PRC, and in US respectively). This is an area requires more study for commercial heater.

Methanol as a substitute-3

- **Usages:** Methanol is a useful raw material for the syntheses of chemicals and polymer materials such as acetic acid, MTBE, Bakelite, PE or PP. Besides used as gasoline blend for automobile fuel, it is converted to gasoline or Diesel oil in the energy market today. Moreover, it is used in the synthesis of hydrogen for fuel cell power system and for industrial operations in chemical, metallurgy and electronic industries.

Methanol as a substitute-4

- **Production:** Methanol is synthesized from syn-gas (H2+CO or CO_2) which in turn can be converted from biomass, NG, coal, or from gasoline, Diesel oil or fuel oil if needed. As such, the supply of methanol is limitless. Today the annual world capacity of methanol is about 110 million tons; about 60 million ton from coal, mostly in PRC, and the rest is from NG

Onsite production of hydrogen

- Hydrogen is a useful chemical and clean fuel; it yields only heat(10.08MJ/M3) and steam in the combustion and it can generates electricity through fuel cell conversion. Thus, through hydrogen, methanol can provide both heat and electric energy.
- Being a light molecule with very low boiling point -252°C, hydrogen is expensive in dispensing like methane. Onsite production of hydrogen with methanol avoids the dispensing cost(about 1/3 to ½ of hauling-in high pressure gas hydrogen) and improve the safety in the user point by avoiding the onsite storage of large volume of high pressure hydrogen,

Capture of CO2 with hydrogen for methanol

- As mentioned above methanol is synthesized from syn-gas and methanol can be readily converted to hydrogen. If low cost surplus electricity is available from wind or solar energy operation in a less developed area power, then the low cost and abundant hydrogen will be available from the electrolysis of water for carbon capture to form methanol. Thus, methanol becomes an energy sink for long term storage for shipping out or converted to electricity power via H2/FC system.
- **With the convenient inter-conversion between methanol and hydrogen and between methanol and high carbon fuels methanol/hydrogen coupling becomes a bridge between carbon abatement and the existing fuels.**

Onsite production of hydrogen from methanol

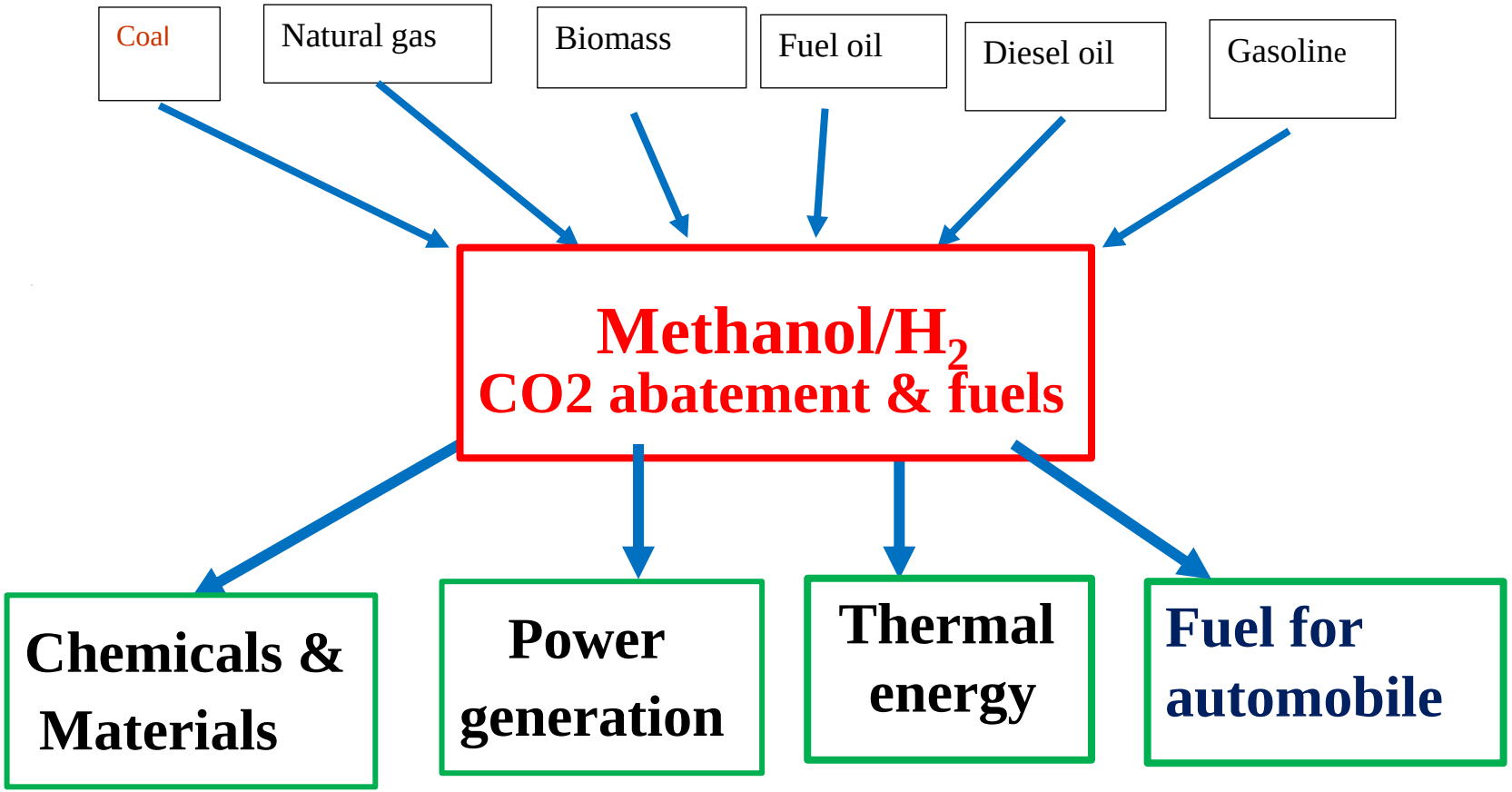
Onsite production of 15M^3/hr of 99.9995%H2 at 20MPa from methanol for industrial operation in Kaoshiong, Taiwan

Generation of 20KW and hot water from methanol via onsite H2 production for pool in NTUST

The multi-facets role of methanol

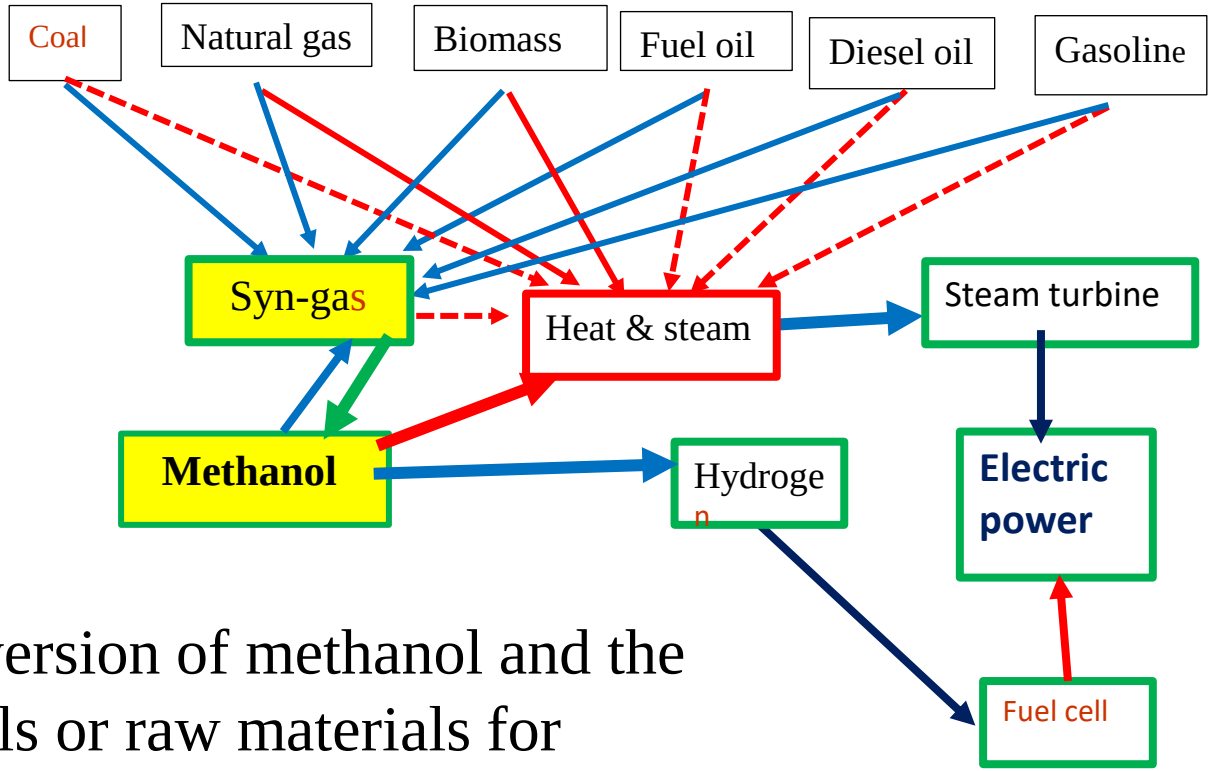
- **Clean fuel and chemical**: low emission as a fuel, versatile chemical material in chemical industry.
- **Sourcing**: abundant and limitless from wide variety of carbonaceous materials such as biomass, NG, coal, Diesel oil or even gasoline when they are phased out because of pollution issue. This eases the loss of revenue and problem of unemployment when they are phased our in future.
- **Reservoir for long term energy storage:** methanol is stable, using conventional storage facility and low cost in shipping. It can be obtained from surplus H_2 of wind or solar energy operation through carbon capture, and can easily be converted back to H_2 by onsite hydrogen production.

The multi-facets role of methanol/H_2



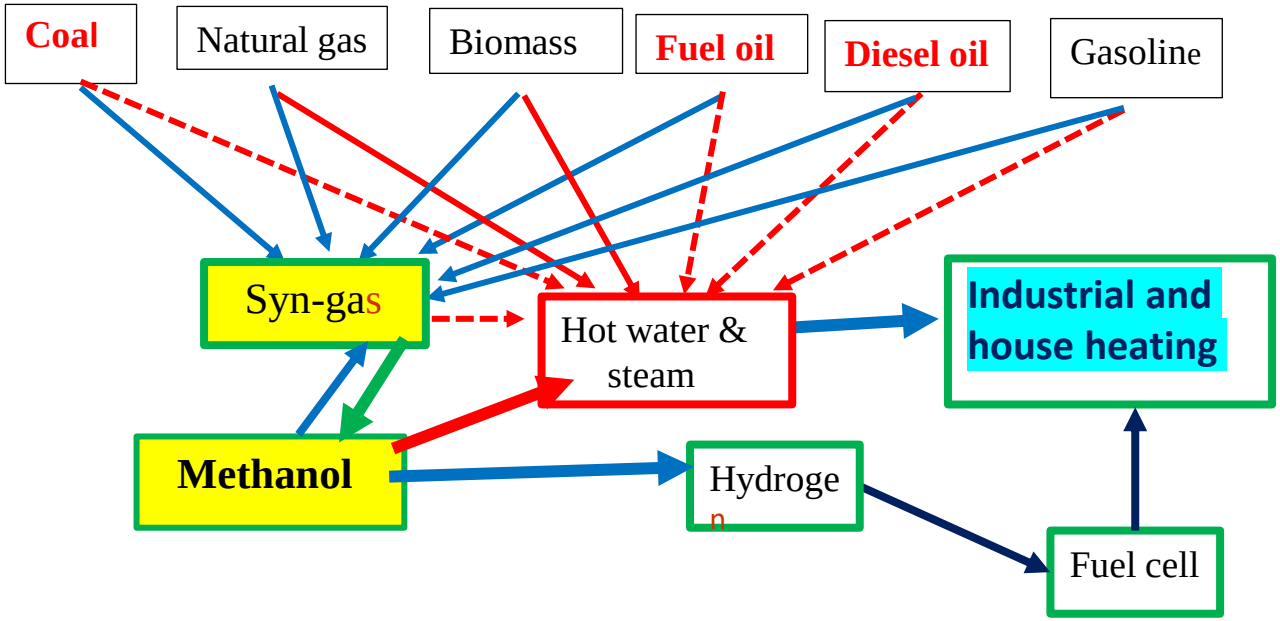
Methanol/H2 becomes a long term storage sink and bridge between carbon abatement and fuels

Cyclic economy of methanol for power generation



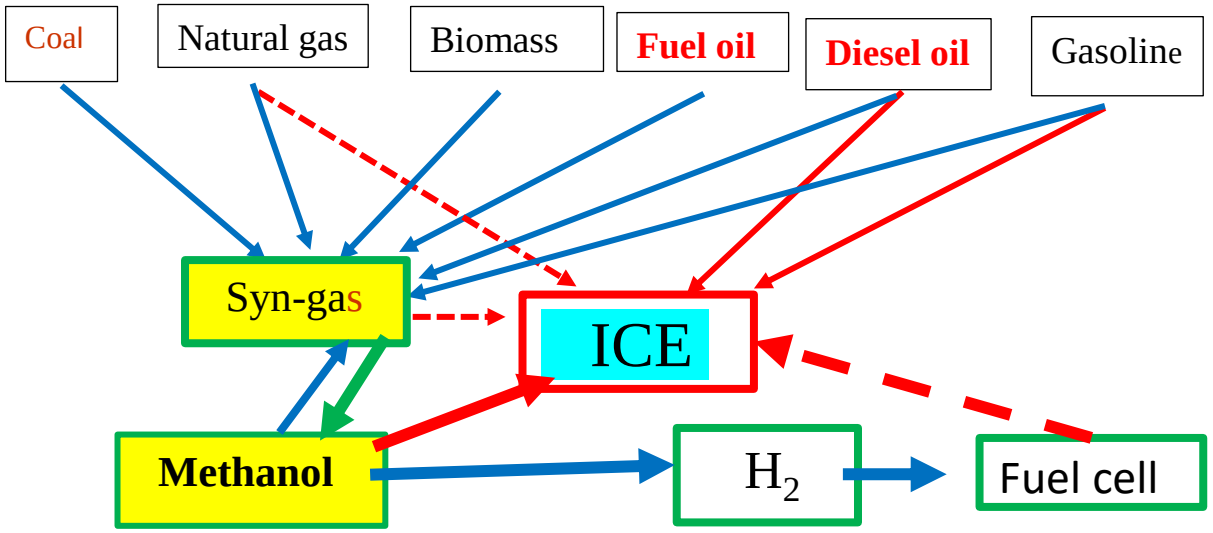
Cyclic conversion of methanol and the existing fuels or raw materials for **power generation**

Cyclic economy of methanol for thermal energy



Cyclic conversion of methanol and the existing fuels or raw materials for **industrial and household heating**

Cyclic economy of methanol for internal combustion engine(ICE)



Cyclic conversion of methanol and the existing fuels or raw materials for **internal combustion engine**

Methanol as a smooth successor of coal, Diesel oil fuel oil in energy applications

- It is easier to be accepted and practiced for methanol to assume the role of energy application of those high carbon fuels than does the RE; therefore, even with the extent of carbon abatement is only about 50%, the net result could be profound as did shade gas in US. Moreover, the employment profile can also keep a minimum change. Therefore, methanol can smooth out the change with minimum disturbance when these high carbon fuels are phased out in the near future.

Conclusions-1

1) With its low CO_2 emission, high energy content and low cost in dispensing, methanol can also play the role of CO_2 abatement in a convenient way.
2) Methanol can share with NG as an interim low carbon fuel.
3) With its higher boiling point, stability in long term storage and low dispensing cost, methanol is a better energy sink or extender for the surplus electricity than H_2 does
4) Methanol/H_2 can succeed the application roles left by the phasing out of the current high pollution fuels.

Conclusion-2

5) Methanol/H_2 coupling bridges the CO_2 capture and fuels applications in the all energy modes.

6) Methanol is made from syn-gas which can be obtained from biomass, NG, LPG, Diesel oil, coal and fuel oil, hence, methanol can ease the pain in economy and un-employee difficulty when some of them are phased out because of pollution issue.

7) The process of phasing out those high polluting fuels is then cycled by the low polluting methanol/H_2 with minimum disturbance to ensure the benefit of abating high carbon fuels.

Thank you very much for your listening

and now is your turn to comment & question.