



Some are therefore speaking from a biogenic LPG, called DME, replacing fossil LPG (liquid propane gas) (Figure 2).

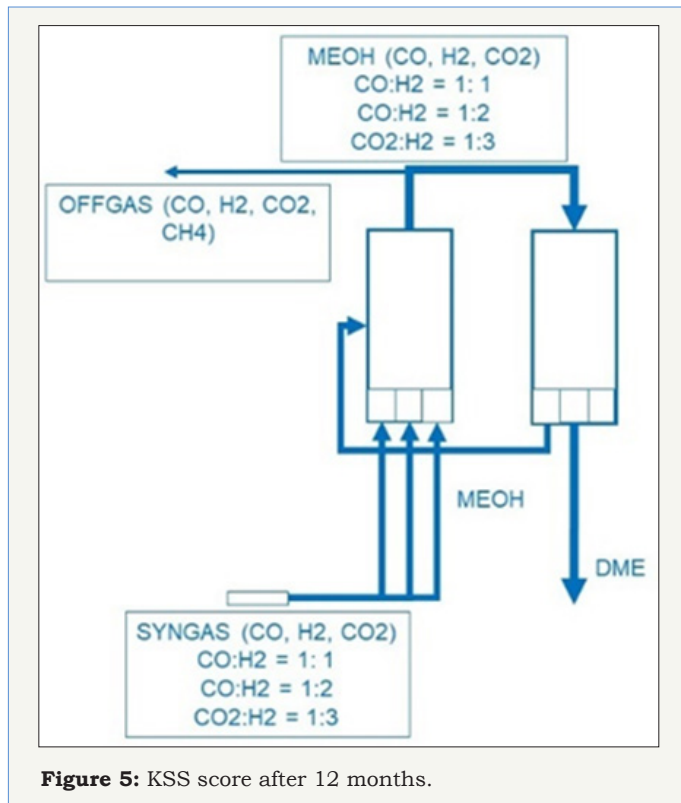


Figure 5: KSS score after 12 months.

**DBE**

Now the very important ideas of C. Weizmann are taking place. Using DME we can convert DME in very easy way to ethanol. This conversion of DME to ethanol is supported by carbonylation (carbon monoxide) and hydrogenation (hydrogen) over the intermediate product methyl acetate (CH<sub>3</sub>COOCH<sub>3</sub>). The conversion process of DME to ethanol is so simple and cheap, that in the next step ethanol can be converted to 1-butanol (sometimes also called n-butanol). Let us remember: the fermentation process with bacteria C... A... lead to a combination of acetone, butanol and ethanol, well known as ABE process invented by C. Weizmann [1]. The conversion of DME enables and supports the conversion to ethanol and 1-butanol.

The conversion efficiency is in the range of 50% up to 75%. At the end 1-butanol is in our main interest. Polishing 1-butanol by dehydration to dibutyl ether leads to very interesting properties: boiling temperature  $T_b = 141\text{ }^\circ\text{C}$  under environment pressure  $p \sim 1\text{bar}$ , flash temperature  $T_f = 25\text{ }^\circ\text{C}$ , molar weight  $MZ = 130\text{g/mol}$ . The thermodynamic properties caloric heat value  $Hu = 14.7\text{kJ/l} = 11.2\text{kJ/kg}$ , density  $\rho = 770\text{kg/m}^3$ . The chemical formula of dibutyl ether is C<sub>4</sub>H<sub>18</sub>O. The properties of Dimethyl ether C<sub>2</sub>H<sub>6</sub>O have the following properties: boiling temperature  $T_b = -24\text{ }^\circ\text{C}$  under environment pressure  $p \sim 1\text{bar}$ , flash temperature  $T_f = -41\text{ }^\circ\text{C}$ , molar weight  $M_z = 46\text{g/mol}$ . The thermodynamic properties caloric heat value  $Hu = 8.3\text{kJ/L} = 5.56\text{kJ/kg}$ , density  $\rho = 650\text{kg/m}^3$ . Fossil Diesel has heat caloric value between DME (Dimethyl ether) and DBE (Dibutyl ether) (Figure 3)

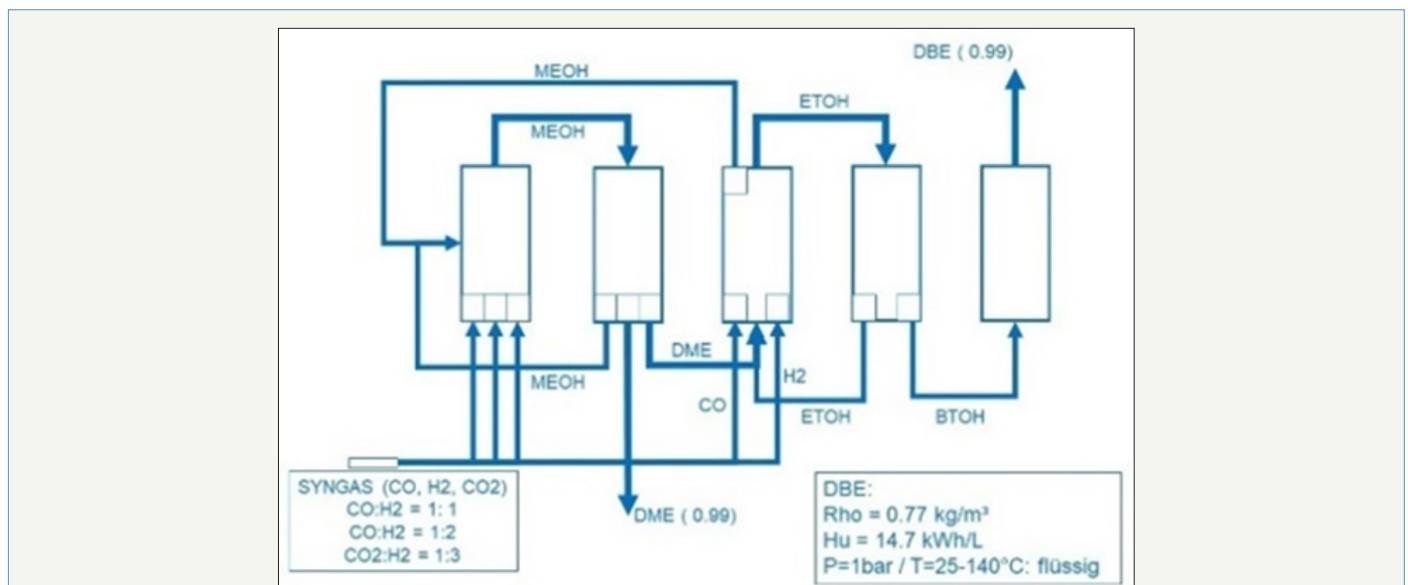


Figure 3: Conversion of DME to ethanol, 1- butanol and DBE.

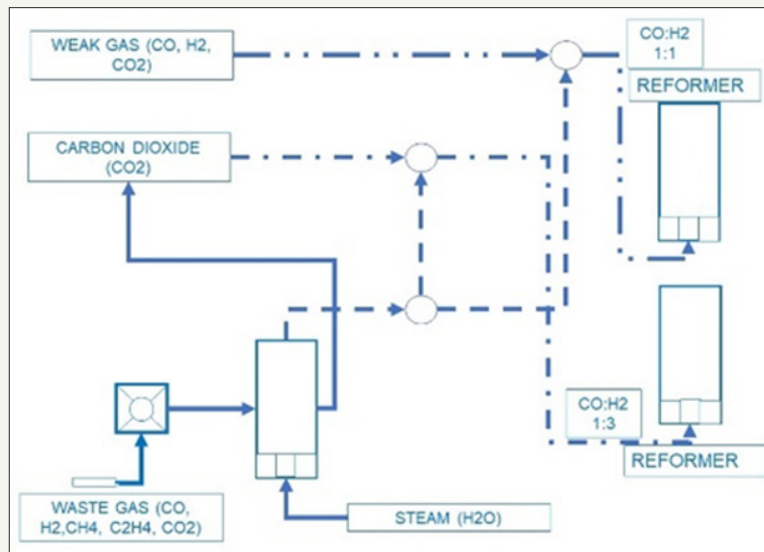
**Waste Gas from Industry**

In the next step we can combine the biogenic driven processes with industrial processes. Industrial processes like coke oven gas, or blast furnace gas, or landfill gas, or shale gas, instead of flaring we can use it. The combination of biogas, weak gas from biomass, and waste gas, enable to produce hydrogen with chemical looping supported by metal catalysis, in cheap and easy way. This hydrogen

generated from steam is used to refine and polish the gas mixture for the methanol synthesis. More than, this simple step enables to use more carbon dioxide than produced by the process of hydrogen generation itself, working as a strong carbon dioxide sink. The combination industrial waste gas, biogas, and weak gas form gasification lead to the integral and flexible preparation of the syngas mixtures used for the methanol synthesis (CO: H<sub>2</sub> = 1:

2;  $\text{CO}_2$ :  $\text{H}_2 = 1:3$ ) or dimethyl ether synthesis ( $\text{CO}$ :  $\text{H}_2 = 1:1$ ). This combination is supported by a cheap hydrogen production from water by metal and metal oxides, known as chemical looping, and

the steam reforming of carbon hydrates ( $\text{C}_1\text{...C}_4$ ) to carbon monoxide and hydrogen, are the additional basic properties to enlarge the production of methanol and dimethyl ether (Figure 4).



**Figure 4:** Gas refining, gas preparation to high quality syngas.

## Conclusion

In this short article we have remembered the possibility and benefits in substitution of fossil Diesel by Dimethyl ether. This is well known and a very successful application with high economic benefits- Dimethyl ether can be produced from biomass and biogas, and in combination of both processes. Hence possessing Dimethyl ether we can produce 1-Butanol and by dehydration Dibutyl ether in a very efficient way. The properties and the benefits of dibutyl ether are shown in this article. The aim of reducing the need of fresh new biomass from wood and agriculture, leads directly to a combination of the biogenic processes with industrial processes and waste gas from industrial processes is shown.

Let us do a look into the future: with these new green technologies we develop technologies we need colonizing our planets moon and mars, to survive. But we should be aware we need

new very high energetic resources entering space and travelling in a cheap and easy way to our next planets, leaving behind the fossil age.

## References

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