bse methanol

*Flex*Methanol™

Methanol Production and Flexibility of the Synthesis Process

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4th European Conference HYDROGEN & P2X 2023
14-15 June Copenhagen, Denmark

Development of *Flex*Methanol™ Skids

2005	Successfull startup of 200 Mio. Euro biofuel plant as EPCM
2008	Joining the Methanol industry for a revamping of an existing Methanol plant.
2014	R&D project for benchmark of the available catalyst under flexible operation condition and pure CO_2 and H_2 Feed.
2017	Signing the Joint Development Agreement with BASF for process and catalyst development.
2018	Start of long-term testing catalyst under bse process conditions and 7.000 h operation achieved.
2021	Selected as process provider for the „first of its kind“ Power-to-Methanol plant in Antwerpen.
2021	Signing cooperation with MAN ES (DWE) to supply ***Flex*Methanol™** Skids on the global market.
2021	Preparation of ***Flex*Methanol™** 10 and ***Flex*Methanol™** 20 skid supply.
2022	Signing Joint Development Agreement with Green Hydrogen System for integration and to secure supply.
2023	PtM-Project Development exceeds 2,000 MW_{el} capacity.
2025	200 MW_{el} PtM constructed for maritime fuel • Serial Skid Manufacturing ready.
2030	1500 MW_{el} PtM under operation • Start methanol as hydrogen carrier & CO_2 infrastructure ready in Europe. • Building-up regional skid manufacturing capacities. • Start transition to additional markets like chemistry.
2040	15000 MW_{el} PtM under operation Significant increase of circular CO_2 use.
2050	40000 MW_{el} PtM under operation Start industrial DAC.

bse Reputation

- Technical due diligence passed by Proman Helm
- Technical due diligence passed by Inovyn/Ineos
- Technical due diligence passed by Wacker Chemie
- Technical due diligence passed by BASF
- Technical due diligence passed by MAN DWE
- Technical due diligence passed by MunichRE

- Recognised process provider at IRENA
- MOU for future projects with the consortium PtMA in place
- Standard and Poor´s/IHS process economic analysis in PEP Report 43G

- Ongoing Project developments around the globe

Power-to-X Overview

Processes

Parameter	Methanation, Sabatier	Methanol	Fischer-Tropsch	Haber-Bosch
Product/Commodity	SNG	Methanol	Kerosene Diesel Gasoline	Ammonia
Final Product	direct use	direct use & upgrading to derivates like Kerosene Diesel Gasoline	direct use	direct use
Process steps	Hydrogen generation	Hydrogen generation	Hydrogen generation	Hydrogen generation
	CO2 generation	CO2 generation	CO2 generation	N2 generation by air separtation
			Reverse water gas shift reaction	
	One throughput synthesis	Recycle loop synthesis	FT Synthesis	Ammonia Synthesis
	Drying	Distillation	Distillation & Processing	Cooling

Power-to-X Overview

Process Conditions Synthesis

Parameter	Methanation, Sabatier	Methanol	Fischer-Tropsch	Haber-Bosch	Unit / Remark
Reaction heat	164 kJ/mol	50 kJ/mol	ca. 165 kJ/mol	46 kJ/mol	all exothermic
Pressure	9-30 bara	40-80 bara	10-40 bara	150-300 bara	
Temperature	250-400°C	200-280°C	200°C-350°C	350-550°C	
Hydrogen demand	00,50	00,19	00,43	00,18	t/t Product (stoichometric)
Feedstock	CO2	CO2	CO2	N2	
Feedstock demand	02,74	01,37	03,03	00,82	t/t Product (stoichometric)
lower heating Value	13,89	05,56	12,22	05,20	MWh/t
lower heating Value	50,00	20,00	44,00	18,72	MJ/kg
Techological Maturity	TRL 9	TRL 9	TRL 9	TRL 9	
Physical	Gaseous Liquid at -162°C (atm. pressure)	Liquid under atmospheric condition	Liquid under atmospheric condition	Gaseous Liquid at -33°C (atm. pressure)	

Power-to-X Overview

Other Properties

Parameter	Methanation, Sabatier	Methanol	Fischer-Tropsch	Haber-Bosch
Safety Standards	existing	existing	existing	existing
Health		toxic non carcinogenic	toxic carcinogenic	high toxic
Safety	explosive	explosive	flammable	explosive
Environmental sustainability/Risk	Methane slip	-	Depending on fraction	Ammonia slip
Enviromental Risk at desaster	GHG impact Atmosphere	Biodegradable	non biodegradable	high pollutend high toxic for water organism
Infrastructure	Existing Natural Gas Infratructure is sutiable	Existing Methanol Infratructure is sutiable	Existing Diesel/Gasoline Infratructure is sutiable	No common Infratructure
Compatibility with existing fleet in the respective time period	yes	yes	yes	post 2030

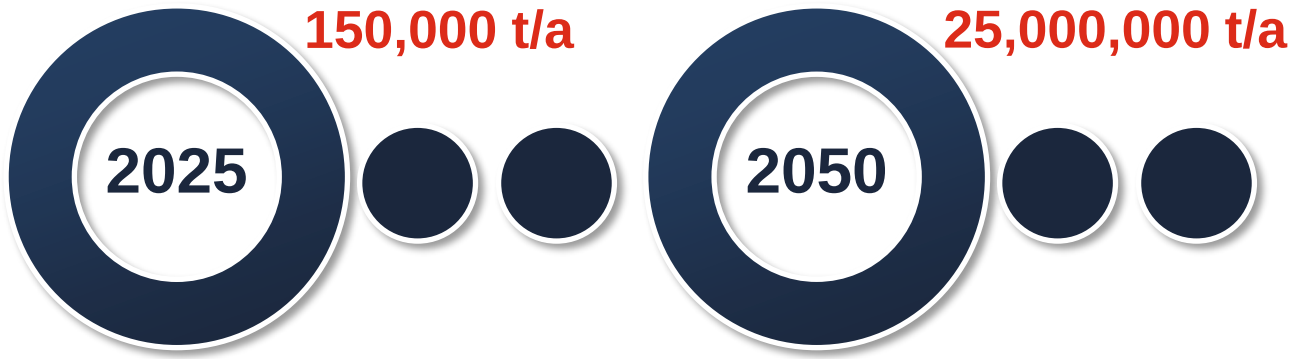
Power-to-X Overview

GHG Emissions tank to wheel

Emission at use	Methanation, Sabatier	Methanol	Fischer-Tropsch	Haber-Bosch
NOx	Yes, but less than fossil	Yes, but less than fossil	yes	
particulates	no	no		no
Nitrous oxide (N2O)	no	no	no	**Yes!!**
CH4	**Yes!!**	no	no	no
CO2	yes	yes	yes	no
others				

Methanol Market

- IRENA published a renewable methanol demand of **385** Mio. t per year by **2050**
- Fuels Europe published Investments into e-fuels up to **250 Bn. €**
- Maersk published demand of **30 Mio. t** in **2030** → other Shipping company's joining the strategy
- HIF/Porsche intents to invest in **3 Mio. t/year** capacity
- Ørsted intends to invest in up to 4.5 GW renewable power capacity
- **101 *Flex*Methanol** Skids in preparation
- Our Target for renewable methanol capacity:



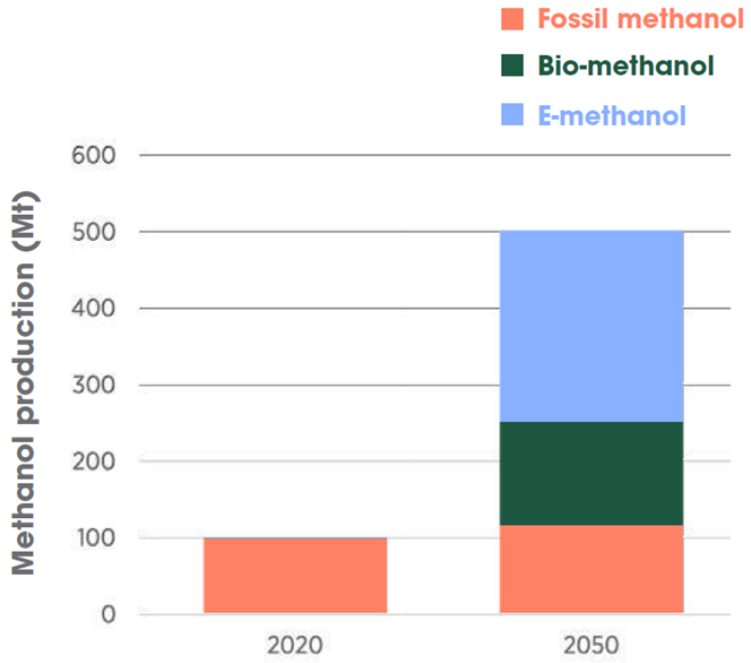


Figure 47. Current and future methanol production by source

It is a Supplier Market for e-Methanol and for the technology

Methanol Market

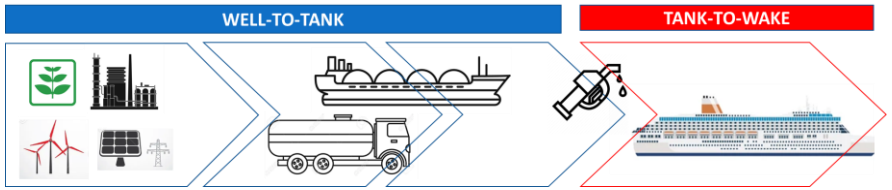
FuelEU Maritime- Proposed Approach

Under the Green deal of Europe/ Fit for 55 the decisions are made by End of March 2023
In here the FuelEU Maritime important impact are done:

- **Establishes** limits on the yearly average GHG intensity of the energy used on-board **(CO2eq/MJ) by:**

2025	2030	2035	2040	2045	2080
2%	6%	13/14,5%	26/31%	59/62%	75/80%

- Inclusion of **CO_2, methane and nitrous oxide** on a full Well-to-Wake calculation: allows fair comparison of fuels

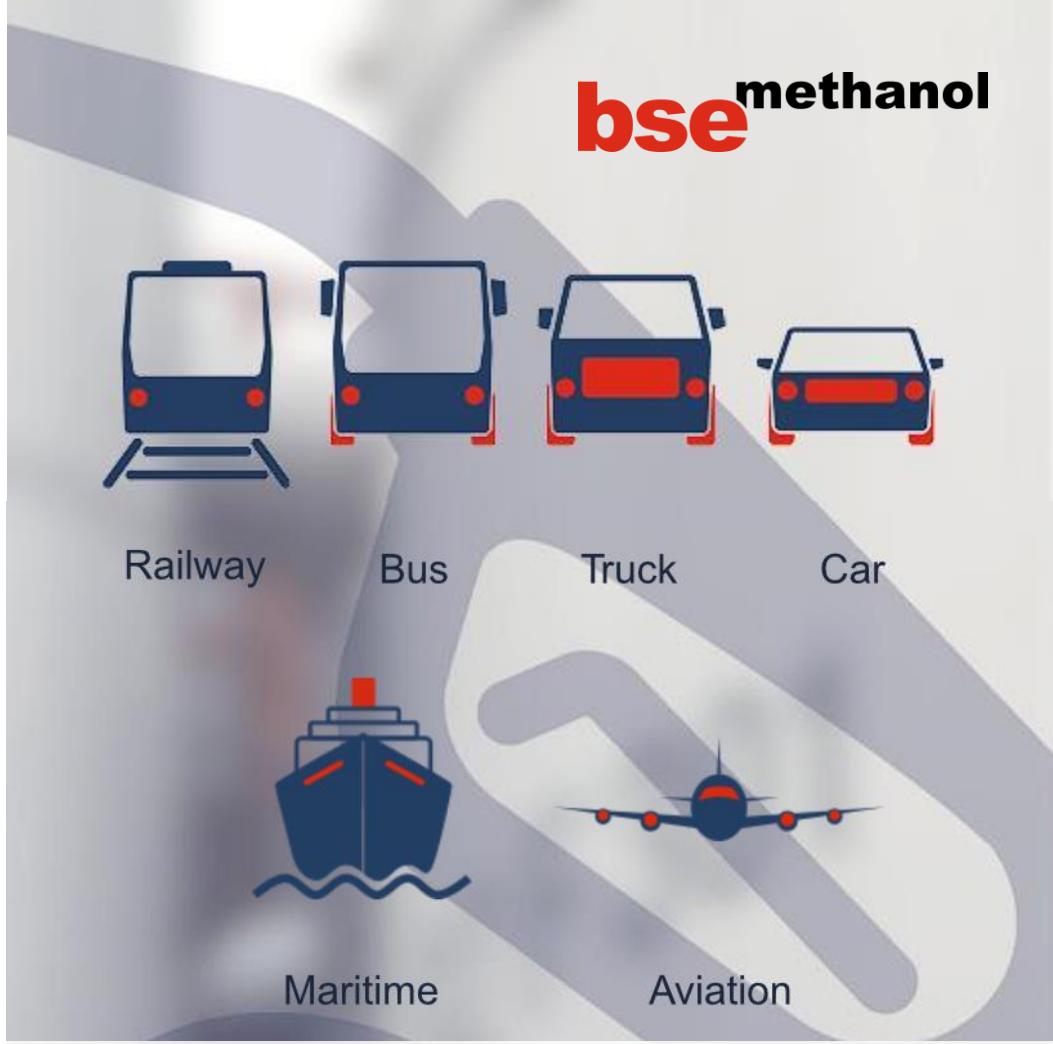


$$\boldsymbol{GHGe}\left[gCO_{2eq}\right] = (\boldsymbol{WtT}\ (fuel, electricity) + \boldsymbol{TtW}(\text{combustion}, \text{slip}))$$

- **Non-compliance** – deterrent financial penalty

Conclusion E-Methanol

- Renwable E-Methanol reduce cost impact from Emission Trading Systems.
- Renewable E-Methanol prevents penalty via blending and GHG saving methodology.
- Methanol complies in existing road fuel specifications gasoline (MTBE), direct blending and biodiesel.
- Methanol is known in the REDII as biofuel.
- E-Methanol road fuel is under implementation - Delegated Acts and REDIII are published
- Market of e-methanol as **maritime fuel** is ready, legal implemenation has started.
- Implementation of **Power-to-methanol as aviation fuel** has to start (jet fuel certification) and EU certification kicks off.

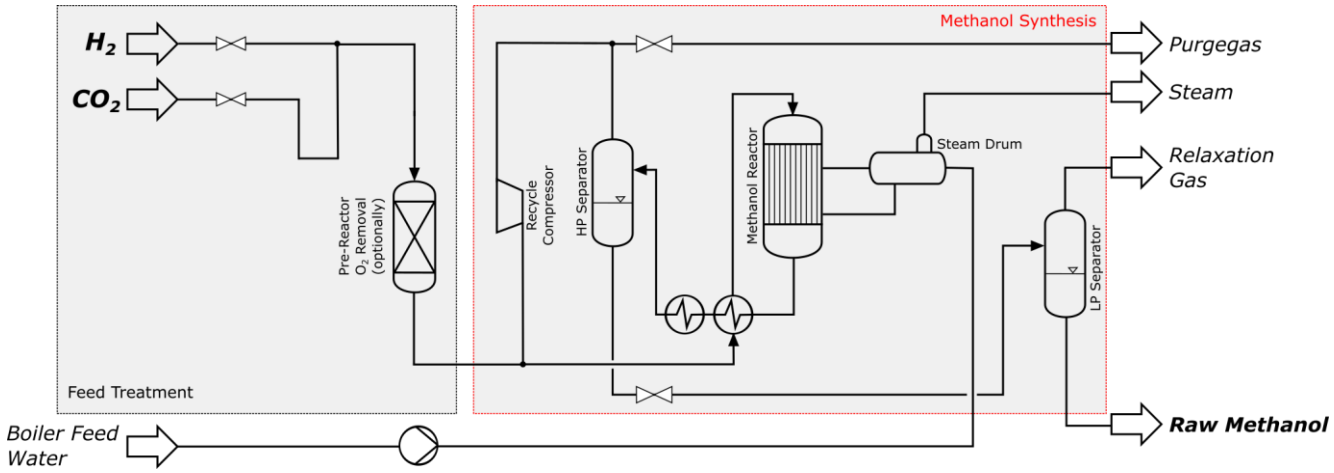


Methanol is already applicable as fuel without infrastructre adjustments

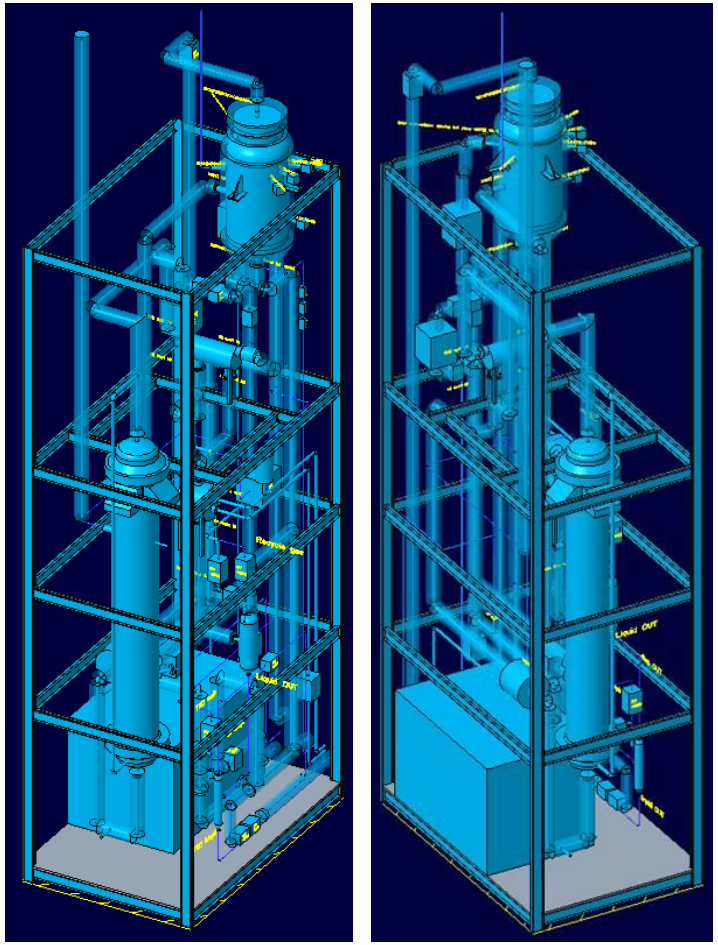
*Flex*Methanol *process*

Proven Process

$$CO_2 + 3\ H_2 \rightleftarrows CH_3OH + H_2O$$
$$CO_2 + H_2 \rightleftarrows CO + H_2O$$
$$CO + 2\ H_2 \rightleftarrows CH_3OH$$



- Reaction heat used for steam production, which is used in subsequent distillation
- Flexibility range: 10-100%
- Process conditions: 240°C, 40 bar
- Cu/ZnO based catalyst (BASF)



Methanol Plant

State of the Art

*Flex*Methanol *product*

Modular Standard Units

1st level power, 2nd level hydrogen and 3rd level flexible synthesis

Our Solution: Input orientend operation 10%-100% per module.

- The modules have been designed and developed in two sizes

	Input to Electrolyzer	Methanol
*Flex*Methanol® 10	10 MWh	1 t/h
*Flex*Methanol® 20	20 MWh	2 t/h

- Partial loads and Full loads
- Direct tie-in with electrolyzer
- Scalable together with the electrolyzer as combined modules
- Skid Technology for Synthesis & Distillation

Pre-fabricated Skids

- Standardized with CE-Marking
- Cost-competitive
- Fast setup, broad rollout options
- Simple extension of capacity

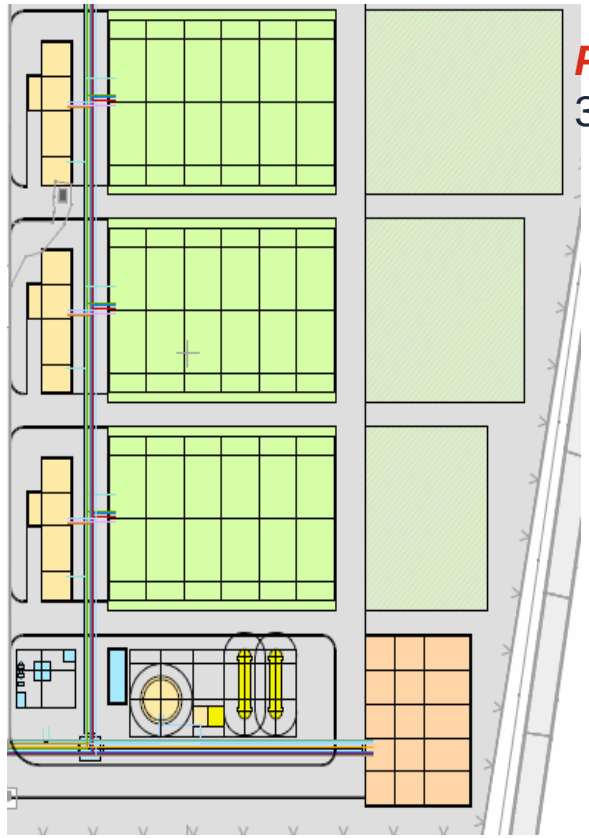
Figures are simplified and rounded

Our Customers Pain

- The requirement is to “harvest” volatile renewable energies like PV solar, wind power and limitation in size is the grid connection point.
- High flexibility, high availability, easy to maintain, easy to operate
- Short erection period and fast start up
- Minimizing CAPEX/OPEX
- Missing Supply

***Flex*Methanol®** skids are essential to reach the required capacities of e-methanol,

***Flex*Methanol®** combined modular Electrolysis is the solution for fast scalability



***Flex*Methanol 20**
3x Synthesis

Electrolyzer
3x 20 MW modules

Central Distillation

*Flex*Methanol process & skids supply

Benefits and Added Values 1/2

✓ No separate water-gas shift reaction	➢ There is no need for Steam Reforming
✓ Mild process conditions	➢ Low pressure & 240 °C
✓ Direct tie in of Hydrogen pipe from electrolyser	✓ No Hydrogen compression needed ✓ No Hydrogen storage needed
✓ Flexible operation of the methanol plant	➢ Min Load app. 10% up to 100% in minutes following the power supply
✓ No tars, no long chain carbon hydrates	➢ Minimizing number of equipment ➢ Minimizing Hydrogen losses
✓ Proven catalyst from BASF exclusively delivered by BSE	➢ Supply secured over aftersales contract
✓ Lowest OPEX	➢ Low power consumption ➢ High Hydrogen efficiency

Ready. Proven. Profitable.

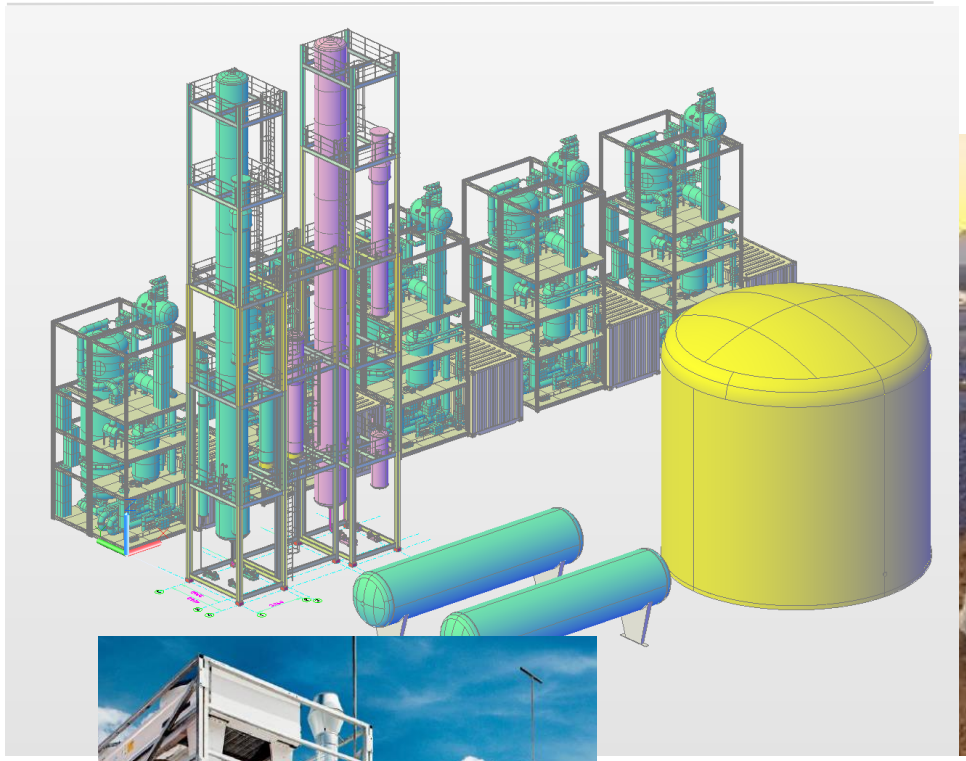
*Flex*Methanol process & skids supply

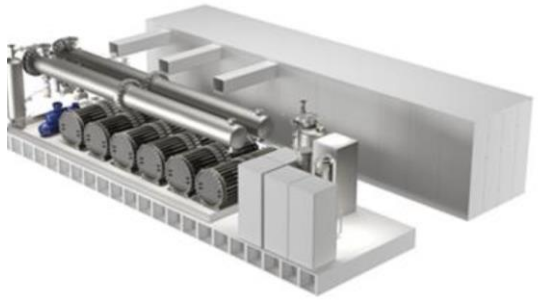
Benefits and Added Values 2/2

✓ Modular approach	➢ Electrolyzer and *Flex*Methanol can be one combined module ➢ securing power inlet at each level of supply
✓ pre-fabricated standardized skids	➢ Minimizing costumer Engineering ➢ short construction time and short start-up time ➢ Transportable around the globe ➢ Lowest CAPEX
✓ Core equipment's and package units from global leaders	➢ Methanol reactor supplied by global leading manufacturer ➢ Methanol distillation is downscaling from mega methanol plants
✓ multiple skids for larger capacities	➢ 365 days of operation, ➢ No complete shut downs necessary ➢ Easy to extend capacity at a later stage

Ready. Proven. Profitable.

*Flex*Methanol project





Our Clients

Our Partners

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Thank You

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