bse methanol

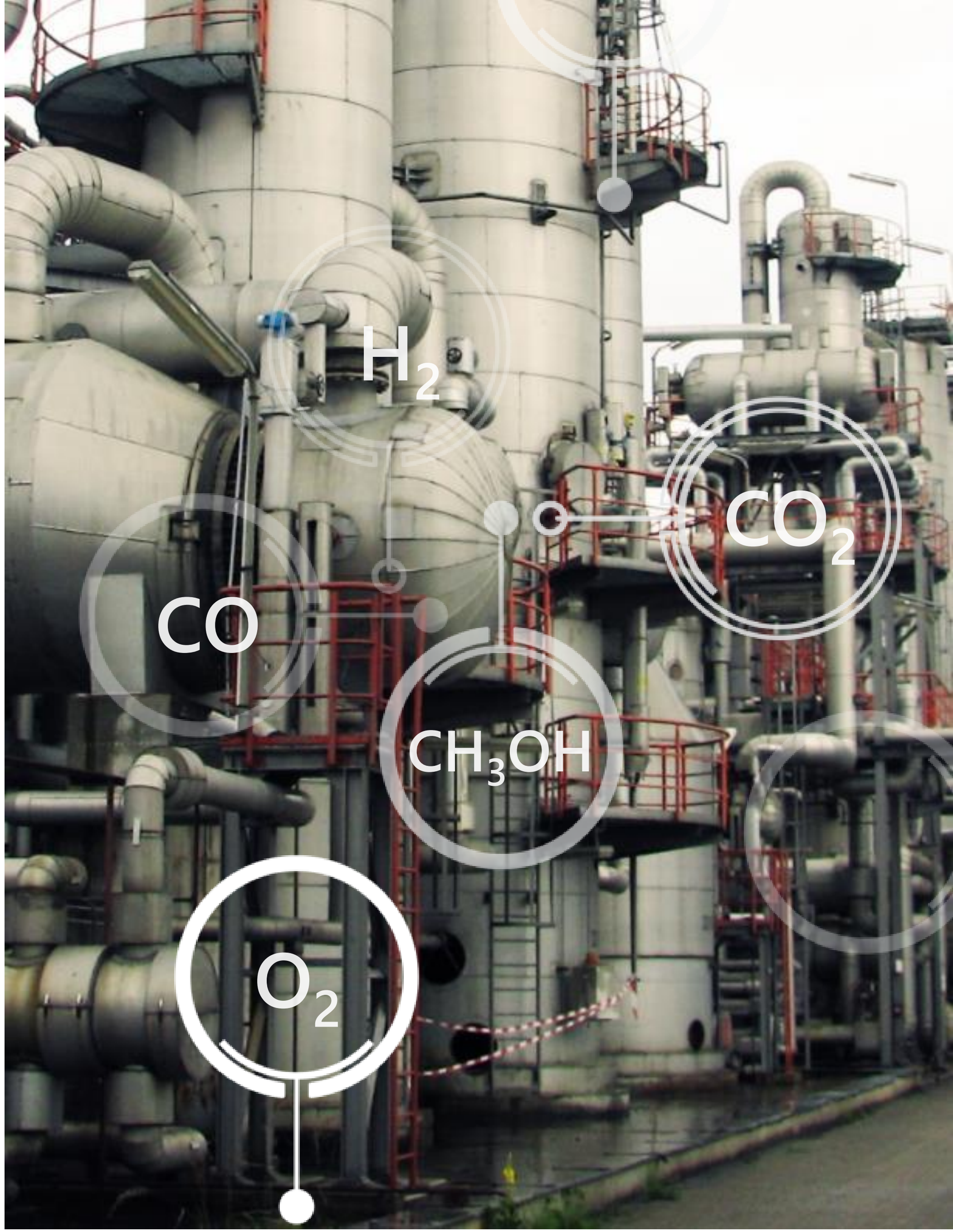
Process-Economic optimised CO_2-Conversion from the Source to the Product

Synthetic Fuels Technologies

CO_2 Capture, Storage & Reuse 2023 Conference, Copenhagen
16-17 May 2023

Agenda

- CO_2-Demand and Supply
- PtX-Technologies Overview and Derivates
- PtX in the Maritime Transport sector
- PtX Case study *Methanol as Solution*
- *Flex*Methanol®



EU27: CO_2-Demand

Own Estimation and Calculation by 2050

Product	Sector	CO_2-Emissions (today)	Electrification (future)	PtX-Potential	CO_2-Demand (future)
Diesel/Gasoline-equivalent	Road	707.272.000	45%	Yes	315.909.000
Diesel-equivalent	Maritim	133.222.000	15 %	Yes	112.600.000
Kerosine-equivalent	Int Aviation	126.454.000	-	Yes	205.163.000
Kerosine-equivalent	EU Aviation	24.988.000	-	Yes	45.160.000
Diesel/NG-equivalent	Heat	436.293.000	67%	Yes	145.431.000
Organic Chemicals	Chemical	45.000.000	-	Yes	45.000.000
Syngas Chemistry	Chemistry	4.596.000	-	Yes	4.596.000
Total t/a		**1.477.828.000**			**873.861.00**

EU27: CO_2-Demand and Use

Own Estimation and Calculation

Product	Sector	CO_2-Demand	CO_2 for Fischer-Tropsch Products	CO_2 for Methan	CO_2 for Methanol
Diesel/Gasoline-equivalent	Road	315.909.000	78.977.000	-	236.932.000
Diesel-equivalent	Maritim	112.600.000	11.260.000	16.890.000	84.451.000
Kerosine-equivalent	Int Aviation	205.163.000	133.356.000	-	71.807.000
Kerosine-equivalent	EU Aviation	45.160.000	16.242.000	-	8.746.000
Diesel/NG-equivalent	Heat	145.431.000	7.272.000	72.715.000	65.444.000
Organic Chemicals	Chemical	45.000.000	33.750.000		11.250.000
Syngas Chemistry	Chemistry	4.596.000	-	-	-
Total t/a		**873.861.000**	**280.857.000**	**89.605.000**	**478.629.000**

EU27: Green CO_2-Supply

Own Estimation and Calculation

Source	CO_2-Emissions	Green CO_2	Grey CO_2	Potential
Waste incinerator	190.000.000	95.000.000	95.000.000	Increasing
Biogas purification	800.000	800.000		Increasing
Biogasincineration	2.800.000	2.800.000		Increasing
BioEthanol	6.000.000	6.000.000		Decreasing
Pulp and Paper	150.000.000	150.000.000		Decreasing
Heat from Biomass	21.850.000	21.850.000		Decreasing
Agricultural Residues	30.000.000	30.000.000		
Total t/a	**401.450.000**	**306.450.000**	**95.000.000**	
CO2 Demand		873.861.000		

There is a supply gap of app. 500.000.000 t/a of green CO_2.

PtX-Technologies Overview

bse methanol

Feedgas	Feedgas process	Process	Product	Derivates	TRL level
• Hydrogen • Carbon dioxide	• CO_2 scrubbing • Electrolysis	Sabatier	Methane	Syngas	TRL 9
• Hydrogen • Carbon dioxide	• CO_2 scrubbing • Electrolysis	Methanol synthesis	Methanol	• MTBE • FAME • DME • OME • Octanol • Butanol • Gasoline • Kerosene • Olefine	TRL9
• Hydrogen • Carbon dioxide	• CO_2 scrubbing • Electrolysis • Reverse water gas shift	Fischer Tropsch	Gasoline, Diesel Kerosene		TRL9
• Hydrogen • Nitrogen	Air seperator unit	Haber Bosch	Ammonia	• Urea • Nitric acid • Amines	TRL9

PtX-Technologies Overview

Process Conditions

Process	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	150-350 bara	
Temperature	250-400°C	200-280°C	200°C-350°C	350-550°C	
Hydrogen demand	0,50	0,19	0,43	0,18	t/t Product (stoichiometric)
Feedstock	CO_2	CO_2	CO_2	N_2	
Feedstock demand	2,74	1,37	3,03	0,82	t/t Product (stoichiometric)
Lower heating value	13,89	5,56	12,22	5,20	MWh/t
Flexibility	yes	yes	no	no	
Tech. 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)	

PtX-Technologies Overview

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			Nitrous oxide slip
Environmental Risk at disaster	GHG impact Atmosphere	Biodegradable	non biodegradable	• high polluting • high toxicity for water organism
Infrastructure	Existing Natural Gas Infrastructure is suitable	Existing Methanol Infrastructure is suitable	Existing Diesel/Gasoline Infrastructure is suitable	No common Infrastructure for transport
Compatibility with existing fleet in the respective time period	yes	yes	yes	post 2030

PtX-Technologies Overview

bse methanol

GHG Emissions tank to wheel

Emissions at use	Methanation, Sabatier	Methanol	Fischer Tropsch	Haber Bosch
NO_x	Yes, but less than fossil	Yes, but less than fossil	yes	
Particulates	no	no	yes	no
Nitrous oxide (N_2O)	no	no	no	**Yes!!**
CH_4	**Yes!!**	no	no	no
CO_2	yes	yes	yes	no
others				

FuelEU Maritime- **Proposed Approach**

Interinstitutional Preliminary Agreement by DG Move hold 29.03.2023

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:

- Focus on **fuel** and on **demand – promotion of uptake of renewable and low-carbon fuels** for maritime transport – complement to Energy Efficiency

- **Technology-neutral approach:** maritime operators will need to use an increasing proportion of zero and low carbon sustainable fuels, without obligation to use a specific technology

- **Establishes** limits on the yearly average GHG intensity of the energy used on-board **(CO_2eq/MJ) by:**

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

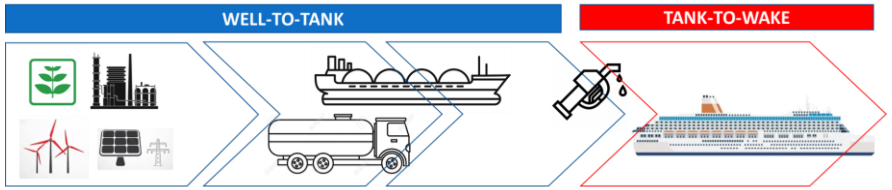
- **Scope:** ships above 5000 GT, intra-EU traffic + 50% international, EU ports

FuelEU Maritime- **Proposed Approach**

Interinstitutional Preliminary Agreement by DG Move hold 29.03.2023

- **Additional requirement for Zero-Emission moored at the quayside** (OPS and alternative zero-emission technologies) - compulsory as of 2030 for container and passenger vessels (some exemptions up to 2035)

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



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

- **Flexibility mechanism** via banking and borrowing: surpluses and (small) deficits can be carried over to the next year

- Voluntary and open **pooling mechanism** to reward/ incentivise overachievers and encourage the rapid deployment of the most advanced options

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

- Monitoring and Reporting is based on **MRV approach,** with some additional data (e.g. calculation of Compliance Balance)

FuelEU Maritime

PtX Comparison of Maritime Fuels

Emission at use	Methanation, Sabatier	Methanol	Fischer Tropsch	Haber Bosch
Flexible operation	**Yes**	**Yes**	**Limited**	**Limited**
Global existing Infrastructure	**Limited**	**Yes**	**Yes**	**Limited**
Carbon use	2,74	**1,37**	3,03	- **None –** **N demand: 0,82**
Risk at Handling, safety	**High**	**Low**	**Low**	**High**
Other GHG impact at use	**Yes**	**Non**	**Non**	**Yes**
Multiple use potential	**Yes**	**Yes**	**Yes**	**Limited**
H_2 Regeneration	**Yes**	**Yes**	**Limited**	**Low**
Market ready for product	**Limited**	**Yes**	**Yes**	**Limited**

Methanol has the shortes way to market.

Role of PtX in the Energy Transition

The Evolution of the energy transition:

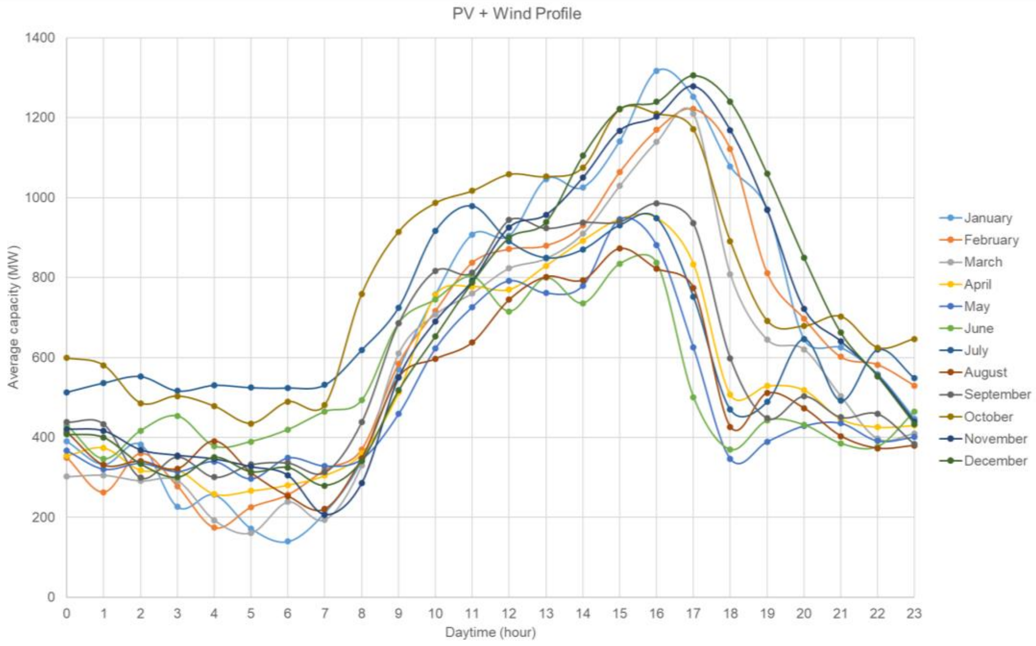
1st level **Building up renewable power plant capacities**

2nd level **Power storage via Hydrogen**
→ **by Serial manufacting of electrolyzer**

3rd level **„Making“ hydrogen transportable in the infrastructur for existing user markets**
→ **via methanol**

Bottlenecks and Challenges are:

- Land availability
- Volatile Power supply
- CO_2 supply from EU
- H_2 regeneration in EU
- Access to water



Power supply is the Challenge.

PtX Case Study

bse methanol

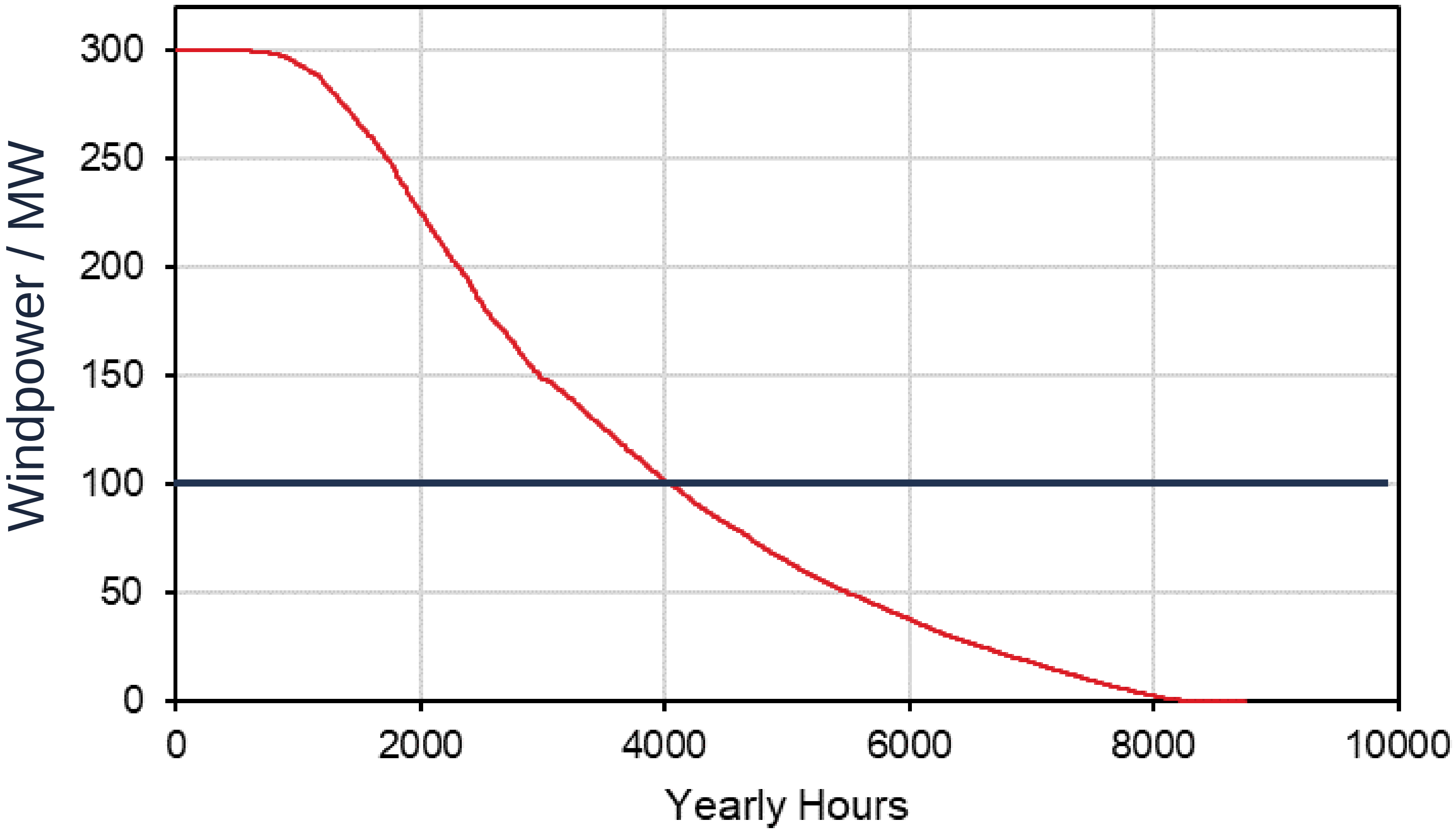
Example Wind Power Supply

There are two variants of the power-based methanol production:

- **Continuous operation at 80 bar**
- **Flexible process at 40 bar** /FlexMethanol approach

The impacts on the OPEX, CAPEX and operation mode in the power based production are significant.

On the right side is shown a power supply curve (red line) to a 100 MW methanol plant.

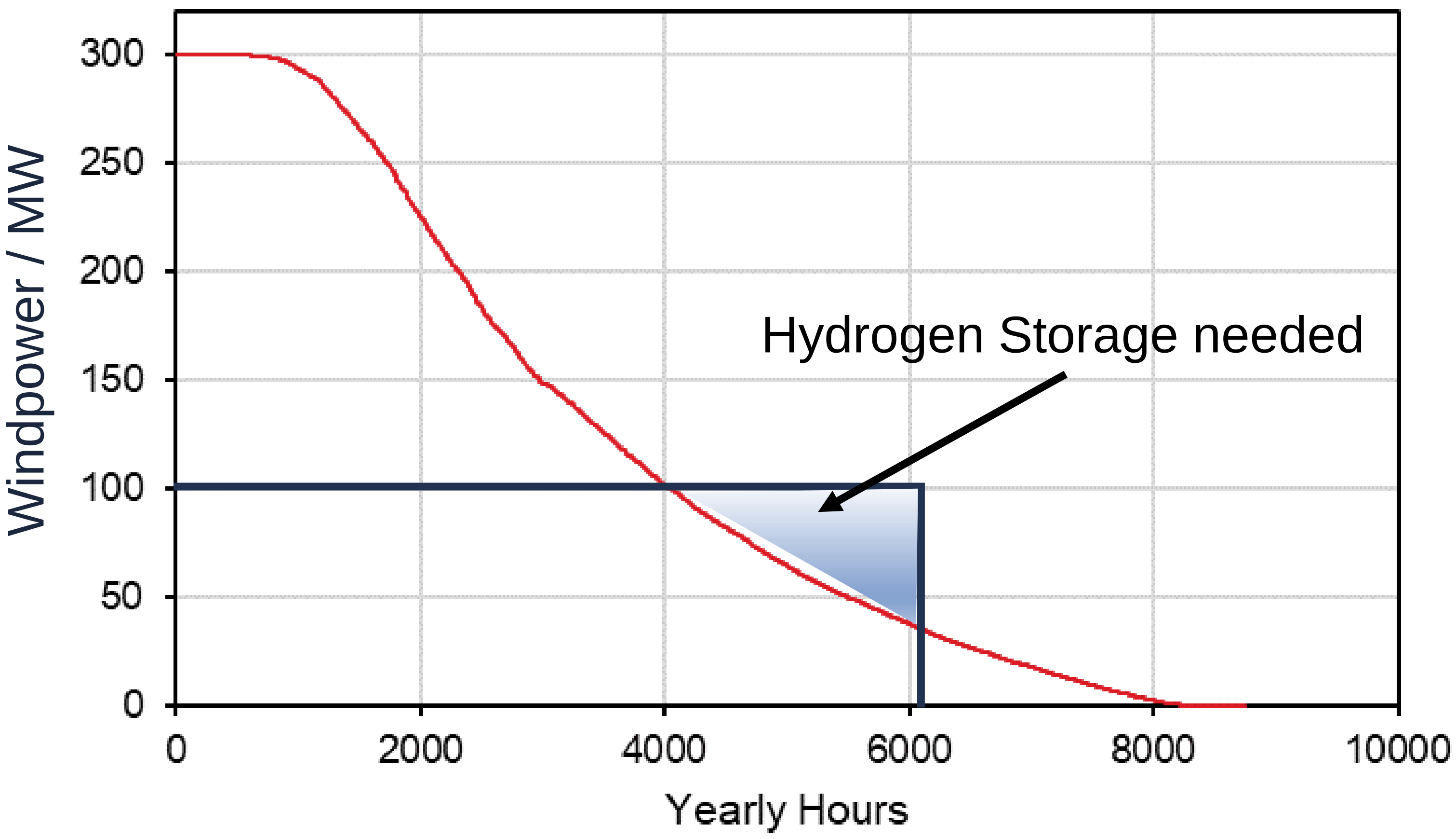


PtX Case study

Wind Profile and 6.000 hours operation of the methanol plant

Continuous at 80 bar

- 100 MW Methanol Plant in continious operation requires a hydrogen storage tank
- Max. 6,000 hours of operation are achievable
- Additional to that 20 days down-time for maintanace
- Methanol output **max. 60,000** tons per year

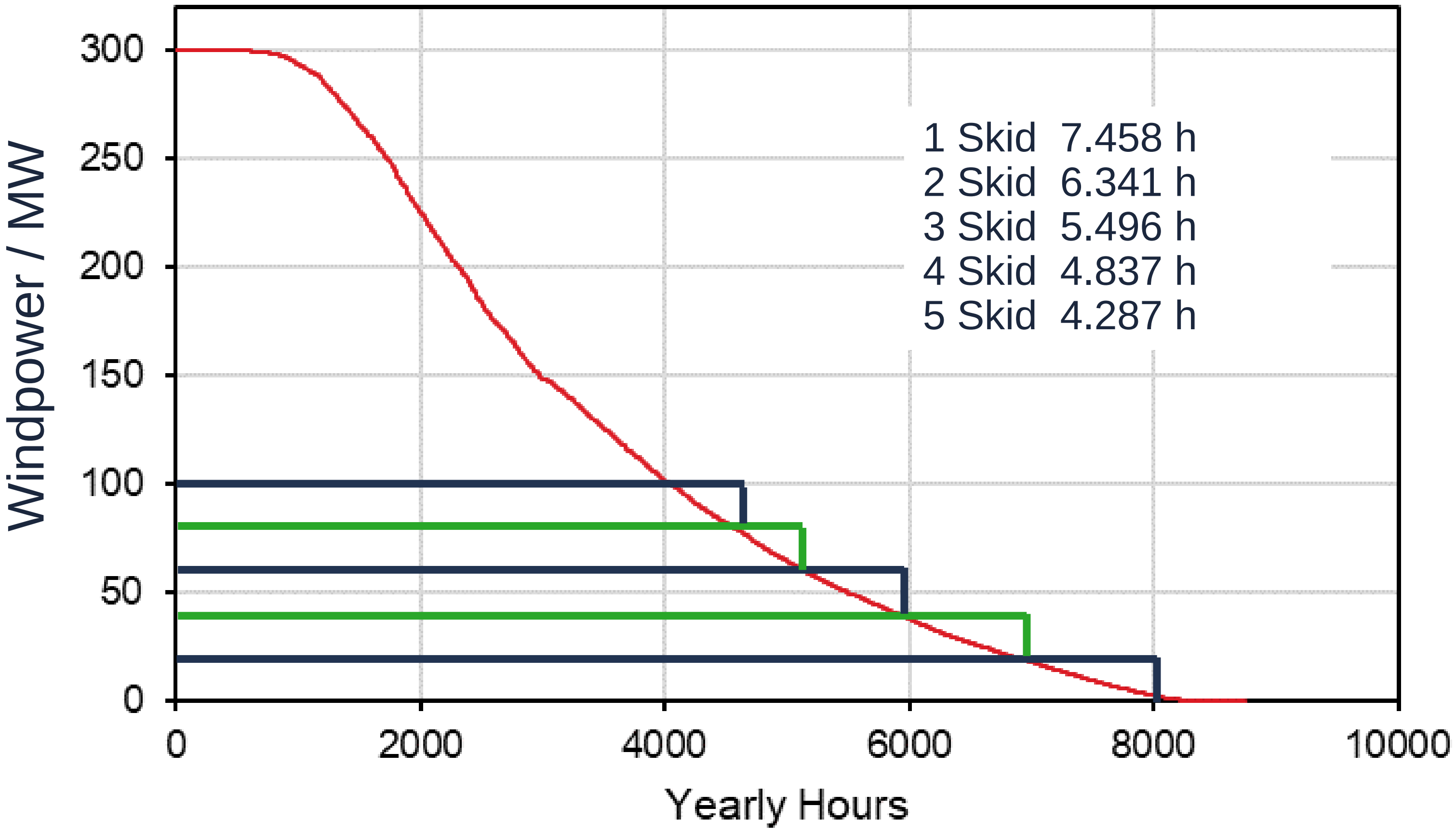


PtX Case study

Wind Profile and all year around operation of the methanol plant

Flexible process at 40 bar /*Flex*Methanol

- 100 MW Methanol Plant with 5 FlexMethanol Skids in flexible operation
- The plant is 365 days per year available.
- No down-time of the total plant for maintanace.
- Methanol output **min. 60,000** tons per year



*Flex*Methanol®

Proven Process in Modular Standard Units

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

Our Solution: Input orientend operation

- 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

*Flex*Methanol®

Key Performance Indicators

Categories	Unit	*Flex*Methanol 10	*Flex*Methanol 20
*Output**			
Raw Methanol	t/y	12,500	25,000
Methanol	t/y	8,000	16,000
Water	t/y	4,500	9,000
Usable steam generated (235°C) (if not used in distillation)	MWh/a	3,200	6,400
*Input**			
Power Demand	MWh/a	2,000	4,000
CO_2 Demand (40 barg)	t/y	11,360	22,720
H_2 Demand (40 barg)	t/y	1,560	3,120
Technical Depreciation			
Physical lifetime	a	25	

*based on 8,000 full load hours

Starting from 1 t/h methanol outlet
scalable to any needed size!

*Flex*Methanol®

bsemethanol

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®

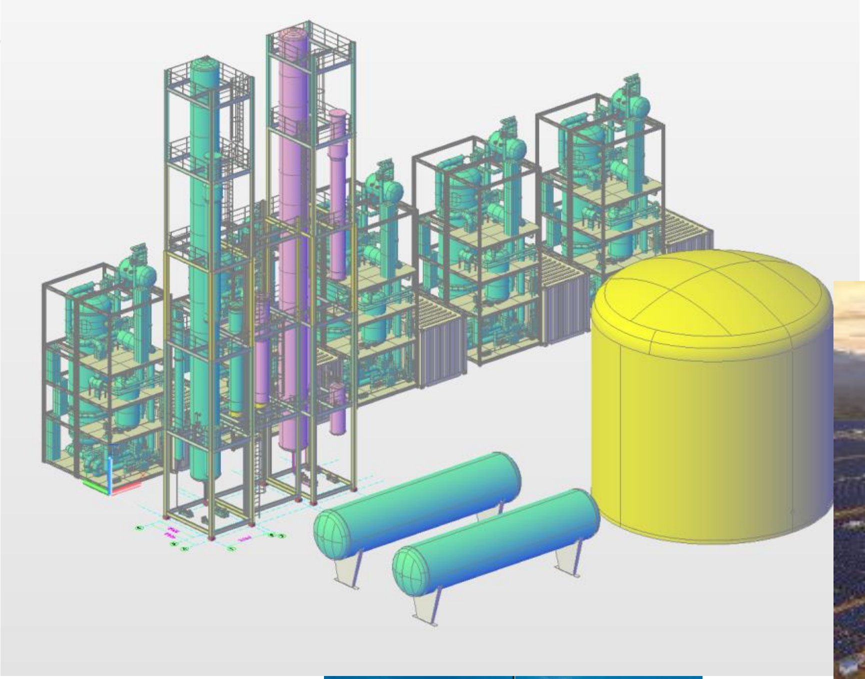
bsemethanol

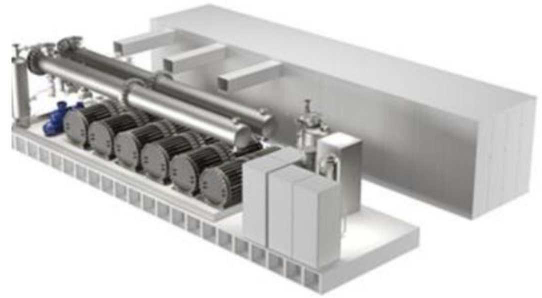
Benefits and Added Values 2/2

✓ Modular approach	➢ Electrolyzer and *Flex*Methanol is a 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.

Example PtX in MENA States





Key figures

- 400 ha Land
- 300 MW_p PV
- 200 MWh Energy storage
- Heat storage
- 6 FlexMethanol Skids
- 150kt CO_2 use
- 100kt E-Methanol Output
- 195kt DM Water
- (280 kt Raw Water)

- 1 Billion € Invest
- App. 90% Power usage
- App. 50 % Power to Product efficiency

100 kt Methanol Setup in Tunesia

TUNol

Ongoing Projects

MENA states	4 sites, among others TUNol* project **> 10 times *Flex*Methanol®20**	Approx. 1,000 ha area concentrated solar power
Central Europe	In total up to 14 sites (most progressed completion of Basic Engineering) **> 30 times *Flex*Methanol® 10 and 20**	Wind, PV solar power and waste incinerators and biomass boiler
South West Europe	In total up to 6 sites (most progressed completion Pre-Basic Engineering) **> 35 times *Flex*Methanol®10 and 20**	Wind and PV solar power
North Europe	2 sites (Feasibility completion, tender phase Basic Engineering) **4 times *Flex*Methanol® 20**	Wind and biomass boiler
South America	1st project discussion started ***Flex*Methanol® 10**	Wind, PV solar power and biomass boiler
East Africa	1st project in award phase for feasibility study ***Flex*Methanol® 10**	Geothermal and PV solar power

*funded by Federal Ministry for Economic Affairs and Climate Action

Meet us

Our Partners

In cooperation with BASF We create chemistry

14-15 June 2023 in Copenhagen, Denmark

- **4th European Conference Hydrogen & P2X**
  Hydrogen & P2X 2023 (fortesmedia.com)

25-26 September 2023 in Vienna, Austria

- **41nd World Methanol Conference**
  World Methanol Conference | Chemical Market Analytics by OPIS, A Dow Jones Company

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Thank You

Christian Schweitzer

bse Methanol GmbH
Mottelerstrasse 8
04155 Leipzig
Germany

phone +49 341 609 12 0
fax +49 341 609 12 15
mail office@bse-methanol.eu
web www.bse-methanol.eu