



1 Sustainable power production.

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2 Power-to-Methanol plant for dynamic operation.

3 Storage and distribution of liquid energy carriers.

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## POWER-TO-LIQUIDS: SUSTAINABLE PRODUCTION OF CHEMICALS, ENERGY CARRIERS AND FUELS

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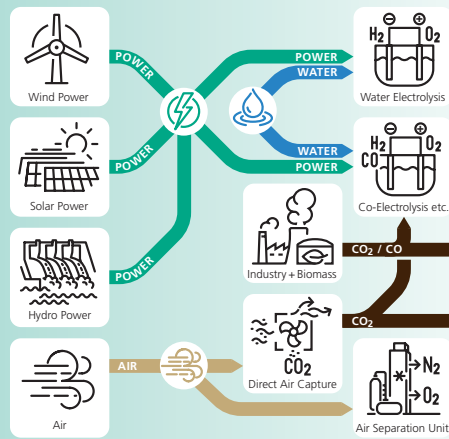
The term Power-to-Liquids (PtL) denotes the conversion of sustainable hydrogen or syngas into liquid energy carriers such as methanol, oxymethylene ethers (OME) or ammonia. They will be used as platform molecules for the chemical industry, as energy carriers or as clean fuels for combustion engines and turbines in order to reduce both CO<sub>2</sub> and soot/NO<sub>x</sub> emissions.

Thus, PtL will contribute to defossilize our current energy system as well as the transport and industry sectors. Since 2012 Fraunhofer ISE has been performing detailed investigations along the complete PtL process chain. Based on our unique chemical and engineering expertise, we can provide complete system solutions to the process, chemical, transport, finance and energy industries.

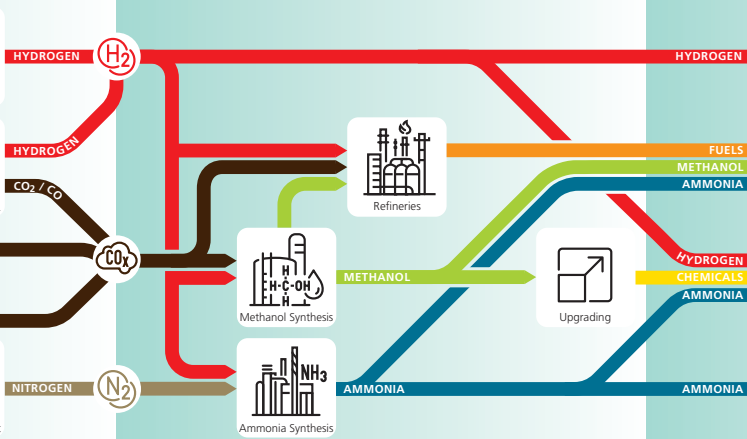
### Our Offer

- process development of more efficient, cost optimized processes using CO<sub>2</sub>/CO or N<sub>2</sub> and H<sub>2</sub> feeds
- techno-economic feasibility studies assessing the potential of PtL processes for your business case
- in-house design, construction, programming and operation of miniplants for PtL production
- assessment of complete PtL process chains by steady state and dynamic simulation
- Life Cycle Assessment (LCA)
- design, test and characterization of tailor-made catalysts for PtL processes
- multi-phase reactive distillation process development for raw PtL product purification

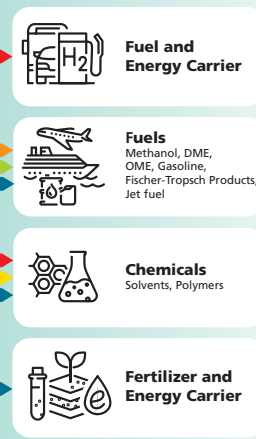
## Sustainable Feedstock



## Efficient Conversion



## Advanced Products



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### Techno-Economic and Life Cycle Analysis

Fraunhofer ISE analyzes and optimizes complete PtL processes from the renewable energy source to the engine end application. In addition, we assess product logistics, determine ideal boundary conditions and advise our customers by comparing different production routes. Furthermore, we assist our clients with in-depth knowledge about different electrolysis and water treatment technologies.

Using standard and in-house simulation models, we offer reliable levelized cost estimation of PtL products. Our detailed scientific understanding of the different process steps is a prerequisite for our economic models. We develop and benchmark new processes also considering environmental impact assessments. In order to calculate the CO<sub>2</sub> savings, we perform a well-to-wheel life cycle assessment of the PtL product to fit the needs of each customer.

### Process Simulation

We conduct process development and optimization for various thermochemical PtL processes using experimentally validated in-house models. The appropriate professional software solution is used depending on the task's scope and complexity.

#### Process Simulation tools

- ASPEN® Plus  
process feasibility, detailed process simulation, heat and mass balances, sizing, upscaling, pricing
- CHEMCAD®  
process flowsheet simulation, equilibrium simulations, energy integration with PinCh software
- MATLAB®/Simulink®  
steady state and dynamic process simulation, reaction kinetic modeling and validations
- Ansys Fluent® (CFD)  
Computational Fluid Dynamics
- Umberto® (LCA)  
economic/ecological evaluation

4 Power-to-Liquids process chain.

5 Matlab® simulation of a temperature profile for a methanol synthesis.

### Miniplant Design and Engineering

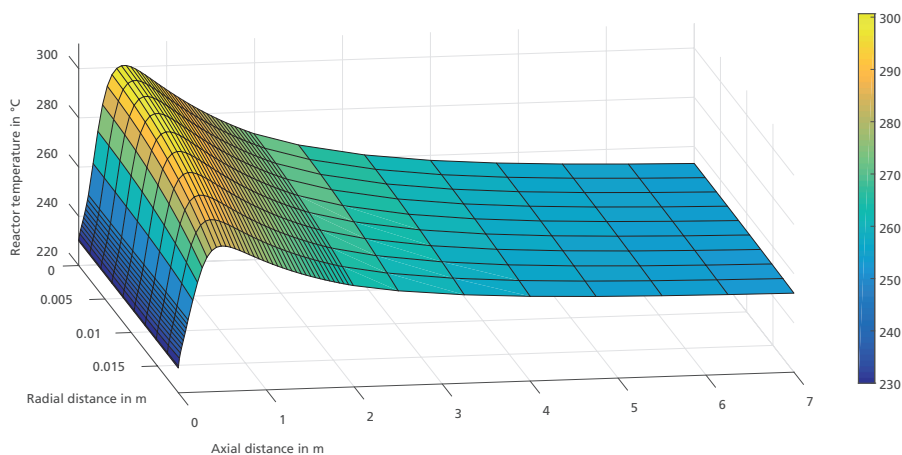
Using data from our simulation or preliminary tests, we design a miniplant (~1 l.h-1) according to the customer's needs, develop flowsheets, compile a bill of materials and build a plant for testing at our own state of the art facilities.

### Catalyst and Component Tests

Having operated kinetic reactors and miniplants for several years, we offer fast and highly qualified catalyst screening and characterization. Kinetic models can be established based on the experimental data allowing robust process scale-up. Process equipment such as reactors, distillation operations, absorption processes, etc. can be tested in our miniplants.

### Complex Mixture Separation

We support our customers with profound knowledge in complex mixture separation using membrane technologies and various distillation techniques from the micro-distillation to pilot plant scale.



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