

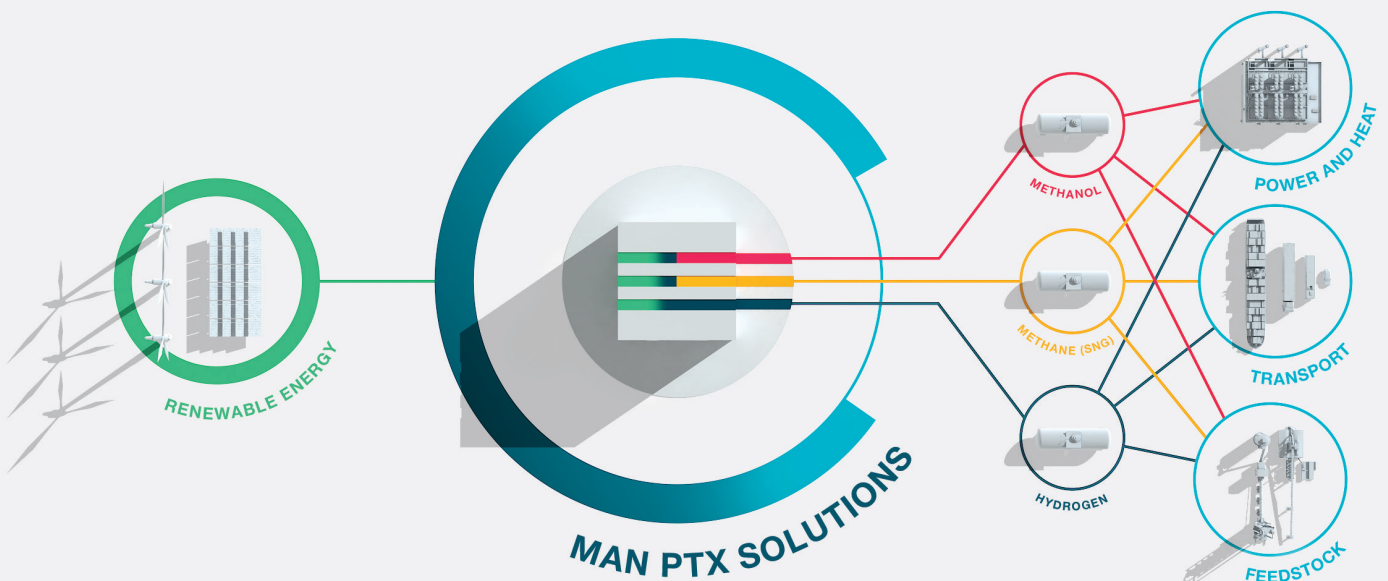
Power-to-X solutions

Renewable energy is key to the transition to a carbon-neutral world. Therefore, it is essential to ensure that the industrial, transport, heating and electricity sectors can apply as much energy from renewable sources to as many applications as possible.

Converting renewable energy into carbon-neutral and carbon-free fuels unlocks its full potential and makes it easy to transport and distribute at any time. In this way, we can use renewable energy in all areas that currently run on fossil fuels.

Benefits at a glance

- Substitute fossil fuels with CO₂-free and carbon-neutral alternatives
- Long-term storage of renewable energy
- Reduce carbon dioxide (CO₂) emissions
- Couple electricity sector with heating, cooling, and transportation
- Single-source solution
- Cost-optimized concept



Carbon-neutral energy for the future

General competence

Together with our partners in science and industry, MAN Energy Solutions is continuously optimizing its MAN Power-to-X (PtX) technologies and looking for new and more advanced process solutions to help our clients to reduce their energy costs and carbon emissions and improve their security of energy supply.

Power-to-X for decarbonization

The Paris Agreement provides a roadmap for economic growth based on the transition to carbon-neutral and carbon-free energy.

To achieve the 1.5 °C objective, a substantial growth of renewable energy technologies is required. In particular, wind and solar are becoming the primary sources of energy for electricity generation. MAN PtX technologies are the solution to unlocking the full potential of these volatile renewable energy sources and make them usable in applications that are hard to electrify.

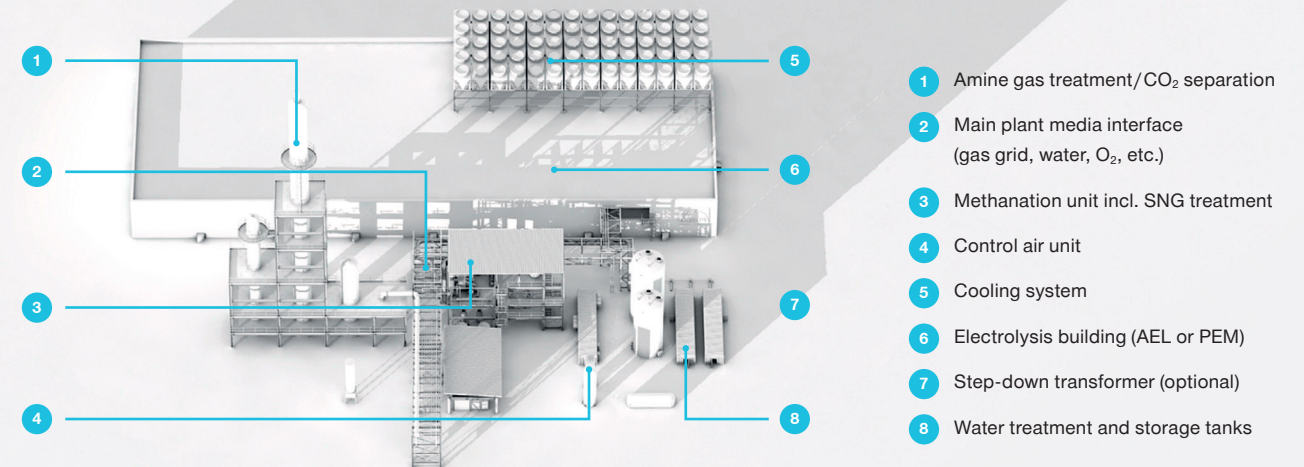
Managing supply and demand

The two main decarbonization challenges are:

- 1. Availability of renewable energy independent of time and location:** Unfortunately, the regions with the highest potential for wind and solar energy and the regions with the highest energy (electricity) demand do not match. Furthermore, the renewable energy sources are volatile and rarely match the required load profile.
- 2. Providing energy sources with high energy density (hydrocarbons):** Aviation and other applications in transport require energy sources/fuels with high energy density.

Converting renewable power into products of value using MAN PtX technologies can overcome these challenges. MAN PtX can be used to produce gases (power-to-gas = MAN PtG) such as hydrogen (H₂) or methane, or liquids (power-to-liquid = MAN PtL) such as methanol, gasoline or kerosene.

Along with the decarbonization benefit, using synthetic fuels provides many other benefits for the environment. Due to the purity of synthetic fuels, particle and NO_x emissions are diminished.



Power-to-gas 50 MW reference case

- 1 Amine gas treatment/CO₂ separation
- 2 Main plant media interface (gas grid, water, O₂, etc.)
- 3 Methanation unit incl. SNG treatment
- 4 Control air unit
- 5 Cooling system
- 6 Electrolysis building (AEL or PEM)
- 7 Step-down transformer (optional)
- 8 Water treatment and storage tanks

System solutions

MAN power-to-gas (MAN PtG)

MAN Energy Solutions drives forward large-scale industrial electrolyzers based on the polymer-electrolyte membrane (PEM) process together with H-TEC SYSTEMS (member of the MAN group) to cover the H₂ demand for power generation and industries. For this purpose, renewable electricity is used to run the electrolyzer that splits water into green hydrogen and oxygen.

Converting green hydrogen and carbon dioxide in its MAN DWE® reactors to synthetic natural gas (SNG) or e-gas, MAN Energy Solutions is a market-leading provider of methanation technology. Starting in 2013 with the 6.3 MW e-gas demo factory in Werlte, Germany (kiwi AG) MAN Energy Solutions has developed solutions for a wide range of plant capacities beginning with skid-based solutions up to large scale production plants.

In addition, we offer full engineering, procurement and construction (EPC) services for SNG-plants anywhere in the world.

MAN power-to-liquid (MAN PtL)

MAN Energy Solutions is involved in both main routes to synthetic fuels, either starting from methanol synthesis or by Fischer-Tropsch.

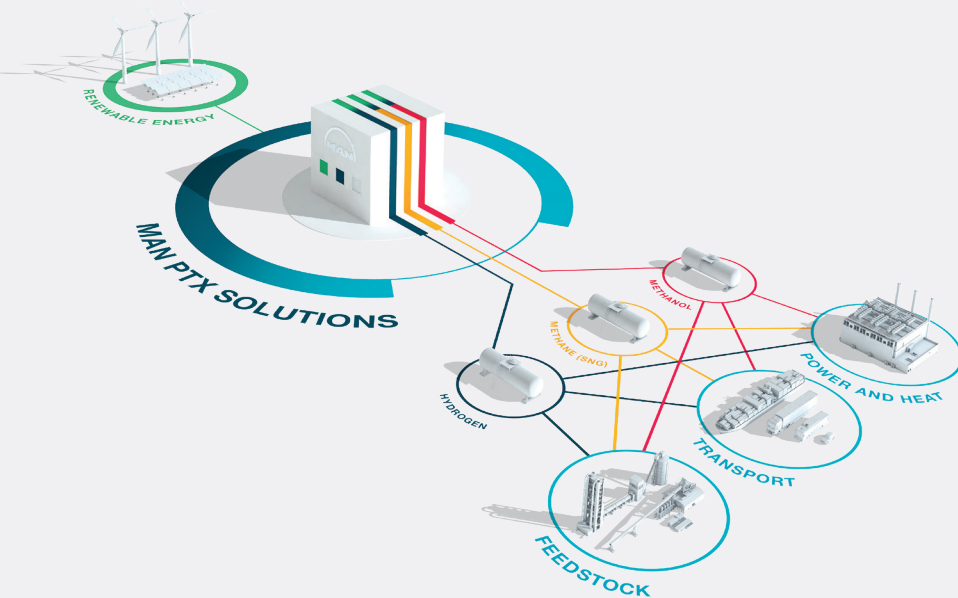
The Fischer-Tropsch route to synthetic fuels is already a mature process based on a catalytic chemical reaction in which carbon monoxide (CO) and H₂ are converted into hydrocarbons.

Having manufactured several world-scale methanol converters based on fossil energy sources in the past, in 2018 MAN Energy Solutions started to operate pilot reactors converting CO₂ and green hydrogen to methanol. Based on this experience, MAN Energy Solutions and its partners provide modular synthesis skids for the production of green methanol. These skids can easily be combined with each other to increase the capacity and availability.

As an alternative to the direct use of green methanol e.g. as a bunker fuel in the maritime sector, it can also be used as a building block to gain carbon-neutral synthetic aviation fuels (SAF) or carbon-neutral synthetic gasoline. MAN Energy Solutions and its partners are able to provide this technology in a large scale greater than 100,000 tonnes per year.

Key components

- **Renewable energy**
Wind, solar or other renewable energy sources provide the power for a PtX plant.
- **Electrolysis**
The electrolysis plant, which is powered by green energy, splits water into oxygen and hydrogen.
- **CO₂ source**
A broad variety of gases containing CO₂ can be used as a source, e.g. biogas, flue gases or waste gas streams from industry.
- **Methanation**
In a methanation plant, the hydrogen reacts with carbon dioxide. The result is synthetic natural gas (SNG).
- **Methanol synthesis**
Reactors convert CO₂ and green hydrogen to green methanol.
- **Fischer-Tropsch synthesis**
CO (or CO₂ by reverse water gas shift (RWGS) reaction) and green hydrogen are converted into hydrocarbons based on a catalytic chemical reaction.
- **Storage and transportation infrastructure**
The synthetic fuels can be stored on site, fed into the gas grid or transported via trucks or ships to the destination of use.



MAN Energy Solutions

86224 Augsburg, Germany

P + 49 821 322-0

F + 49 821 322-3382

info@man-es.com

www.man-es.com

All data provided in this document is non-binding. This data serves informational purposes only and is not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

Copyright © MAN Energy Solutions.
D2366611-N1 | GKM-AUG-22100