IEA Bioenergy
Technology Collaboration Programme

Best Practices on flexible bioenergy

IEA Bioenergy: Task 44: 10 2022

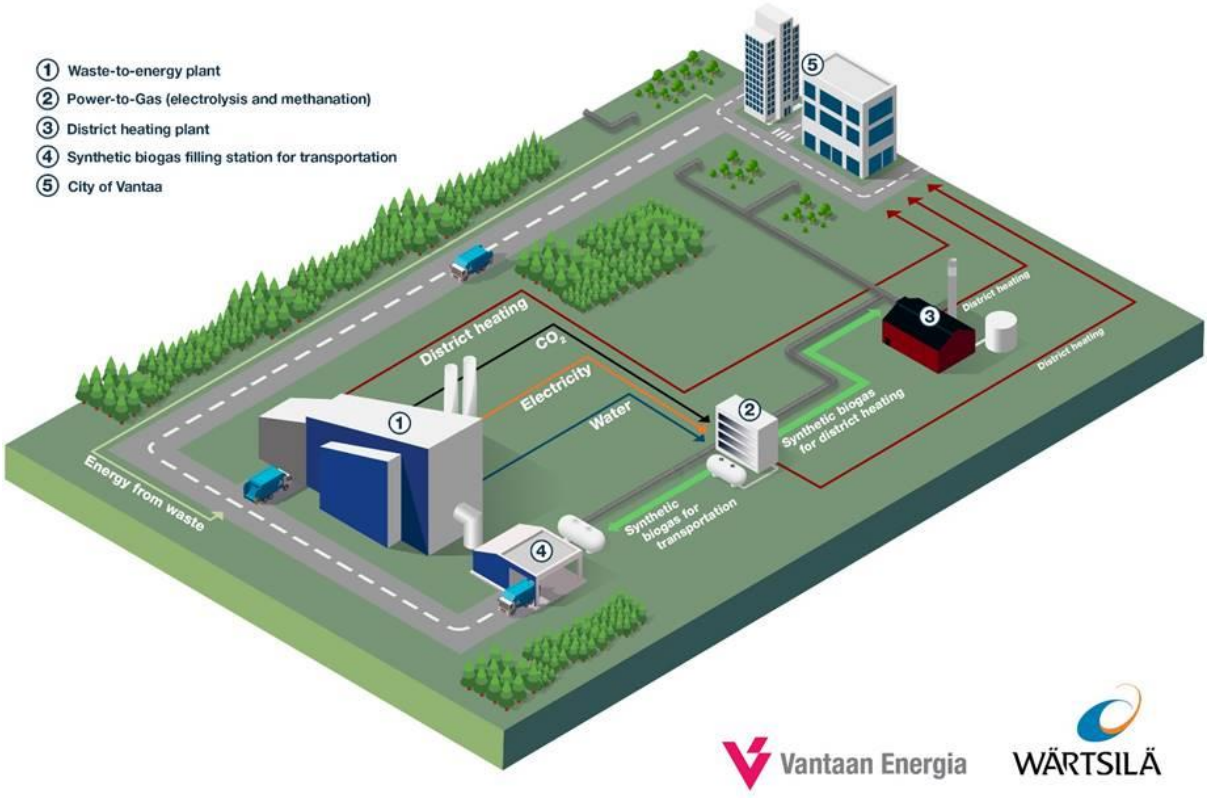
# Power-to-Gas integrated with Waste-to-Energy

Vantaa, Finland

## Project description

Vantaa Energy Ltd has initiatied planning of a Power-to-Gas (PtG) facility in its Waste-to-Energy (WtE) plant. PtG plant will produce synthetic natural gas (SNG) from green hydrogen and unavoidable carbon dioxide, captured from the WtE process. PtG facility will be connected to city's extensive district heating system. In addition to utilization for heating during peak loads, SNG will be utilized as transportation fuel either in compressed or liquefied form (CNG or LNG).

The concept is designed to fit on foreseen energy markets where supply from variable renewable energy sources (VRES) decreases electricity prices but increases volatility, and utilization of fossil fuels to cover peak load periods of local district heating system is not allowed anymore, or is very expensive due to tightening climate actions.




Source: Vantaa Energy Ltd

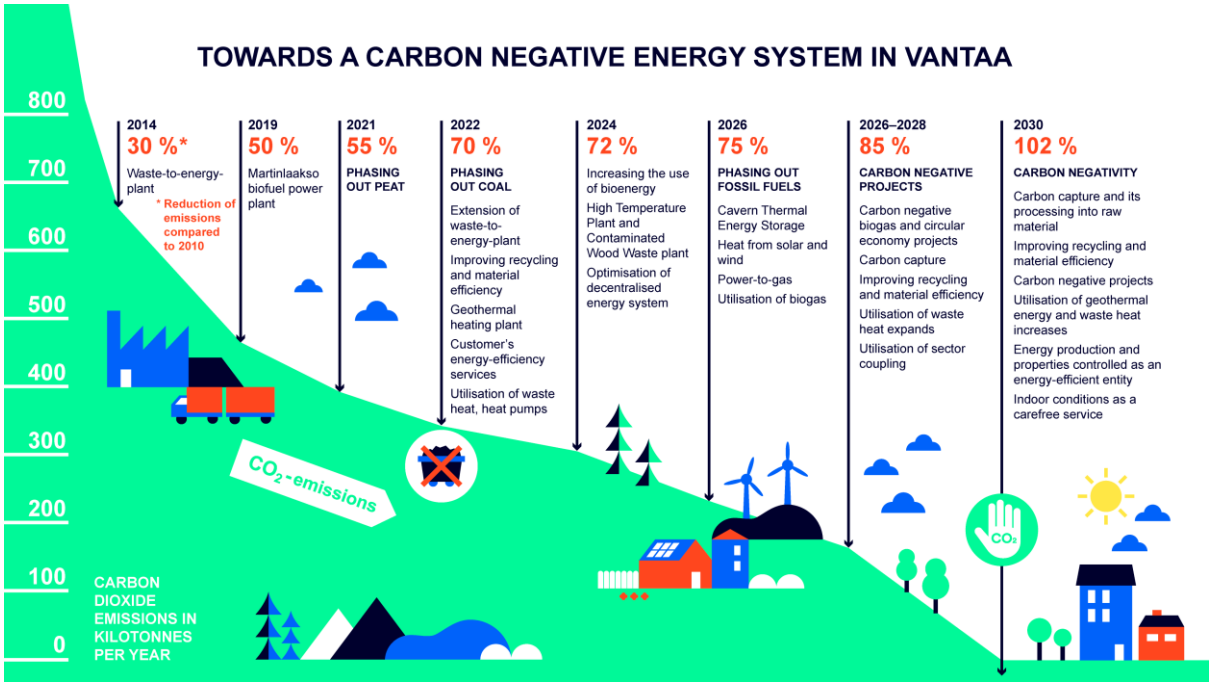
| Base information | |
|---|---|
| **Link for more information** | https://www.vantaanenergia.fi/en/fossil-free-2026/ |
| **Contact person, email** | Mr. Matias Siponen, matias.siponen@vantaanenergia.fi |
| **Location** | Vantaa, Finland |
| **Owner/Operator** | Vantaa Energy Ltd |
| **Technology supplier** | Wärtsilä Ltd |
| **Start of the project** | 2020 |
| **Construction year** | 2022-2025 |
| **Status** | 1st of a kind in the country |
| **Feedstock** | $CO_2$, water, electricity |
| **Products** | SNG, LNG, heat |
| **Size** | 20 $MW_e$, 10 $MW_{SNG}$, 10 $MW_{heat}$ |
| **Type of flexibility provided** | flexibility through storage, peak load heat, demand-side flexibility, link to $H_2$ |
| **Investment cost of the plant** | 80 M€ [2022] |

## Technical and commercial details

Vantaa is a city of ca. 213 000 habitants located in Southern Finland. Most of the buildings are heated by extensive district heating system. The system has been economic and reliable, as efficient combined heat and power (CHP) has been the core of heat production. However, the CHP plants have been based on coal and gas.

Vantaa Energy Ltd will be fossil free by the end on 2026. The company has phased out peat and coal in 2021 and 2022, respectively. After this, the next challenge is to phase out large part of natural gas, which is still used during the winter months for heat production. This will be achieved by constructing the largest seasonal heat storage in the world in order to increase flexibility and store low-emission and low-cost energy in the summer to be utilized in the winter. However, small amounts of natural gas will still be needed for ramping up power plants and during exceptionally cold winters for heating.

Seasonal variation in heat demand is a major challenge for drastic emission reductions in Nordic countries. To tackle this hardest to decarbonise issue before declaring fossil free, the company has initiated planning of a Power-to-Gas facility, which will produce synthetic natural gas from clean hydrogen and carbon dioxide to be used during coldest winter days. In addition to utilization for heating, the product is used as transportation fuel.




Source: Vantaa Energy Ltd

PtG process consists of three process steps, first hydrogen production via electrolysis, second $CO_2$ separation from the flue gas, and third step is a methanation step to produce renewable synthetic methane.

Electrolysis

In first process step, electricity is used to break water into hydrogen via electrolysis. Oxygen can be utilized as side product. Clean water is available from Waste-to-Energy plant, and is utilized (approximately 3 $m^3$/hour) in electrolysis of water to produce hydrogen. Excess heat in the process will be led to heat pump to be utilized in district heating system.

$CO_2$ separation

For the second process step, $CO_2$ is captured from the flue gases of the WtE plant. Flue gases will be led through $CO_2$ capturing equipment to capture the $CO_2$ emissions from the process. $CO_2$ will be further processed to required purity by removing harmful residue before methanation.

Methanation

In the third part of the process, hydrogen and $CO_2$ is synthesized in bio or catalytic methanation process. Water is formed as a side product. Excess heat in the process will be led into the district heating system to improve process efficiency. After methanation, synthetic methane is further polished to meet requirements set by the Finnish natural gas grid company (Gasgrid).

Based on the project concept evaluation, including budgetary proposals from equipment suppliers, the preliminary total investment cost for 10 MW Power-to-Gas facility is expected to total 80 million euros. The total investment cost is subject to change and further detailing as the project concept and full feasibility studies are finalized. The total investment consists of the following main elements:

- Process equipment for water electrolysis, $CO_2$ capture and bio methanation
- Erection, piping, instrumentation & control, electrical work
- Steel structures, civil works, interconnections
- Design, engineering, project management
- Transportation of equipment

– Commissioning, permits, financing fees

The cost excludes additional infrastructure needs for synthetic methane utilization as transportation fuel (investment into fuel filling station, compression etc).

The investment support is applied from Ministry of Economic Affairs and Employment of Finland (TEM) funding for large-scale demonstration projects. Despite the investment support, production cost for SNG is estimated to be significantly higher than cost of natural gas. Higher production cost can be partly covered by SNG sold to transportation. As transportation fuel, SNG is accounted as carbon neutral because $CO_2$ is already accounted as an emission from WtE plant. In Finland, distribution obligation is applied for transportation fuel distributors, which increases demand and prices of carbon neutral fuels.

## Market opportunities

Combining PtG with WtE and district heating has four remarkable benefits in terms of system level flexibility, efficiency, emissions and economics:

1) Utilization of unavoidable $CO_2$ emissions. There is an extensive sorting of wastes at Vantaa applied by households, industries and waste operators. Sorted streams are recycled according to waste hierarchy and the fractions which cannot be recycled are utilized as energy.
2) Co-locating WtE plant and electrolyzer enables benefits, such as lower transmission costs and reduced need to strengthen the existing high voltage grid.
3) Heat from the PtG process can be recovered and utilised as district heat, valuable form of energy in Nordic countries. Vantaa Energy Ltd will also invest in world's largest cavern heat storage.[1]
4) Through PtG, cheap electricity is converted to SNG, which can be seasonally stored to be used during peak load hours during coldest winter days.

## Lessons to Industry

- It is already possible to find economically feasible PtG cases in the locations where low cost electricity is available and by-product oxygen and heat can be utilized.
- Extensive district heating network is one important enabler for this kind of energy intensive project.
- It is neccessary to assess different sectors together to realize the multiple benefits of the concept.

[1] https://www.vantaanenergia.fi/en/fossil-free-2026/vectes/