IEA Bioenergy
Technology Collaboration Programme

Best Practices on flexible bioenergy

Siemens Energy on the path to decarbonization through gas turbines

Finspång, Sweden

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Project description

Siemens Energy is developing a pioneer technology, turbines that can be fuelled with natural gas, biogas and hydrogen, in the city of Finspång. The company works on the development, manufacture and services related to gas turbines as well as on the construction of the entire power plants. The main characteristics of these turbines are high efficiency and low environmental impact as well as low emissions. The integration of hydrogen fuelled gas turbines in future energy systems is demonstrated in the Zero Emission Hydrogen Turbine Center (ZEHTC)[1].

Base information	
Link for more information	http://www.zehtc.org/ http://www.siemens-energy.com/zehtc
Contact person, email	Markus Jöcker - Technology Innovation Manager markus.jocker@siemens-energy.com
Location	Finspång, Sweden
Technology supplier	Siemens Energy and international partners within the research project Zero Emission Hydrogen Turbine Center (ZEHTC)[2]
Project Period	From October 2019 to April 2023
Demonstration plant start-up year	2021
Status	Demonstration system
Feedstock	Locally produced hydrogen, natural gas and biogas
Products	Power and heat
Gas turbines manufactured per year **Capacity**	40-60 15-66 MW
Type of flexibility provided	Feedstock flexibility, energy storage

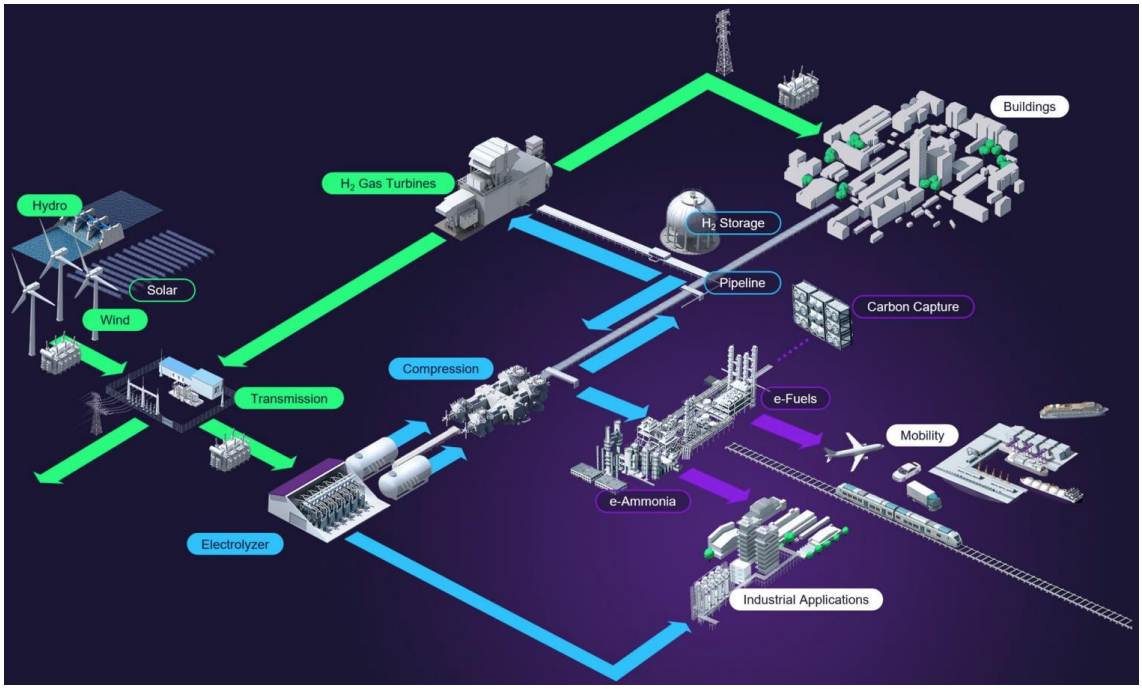
[1] This project has received funding in the framework of the joint programming initiative ERA-Net Smart Energy Systems' focus initiative Integrated, Regional Energy Systems, with support from the European Union's Horizon 2020 research and innovation programme under grant agreement No 775970.
[2] The consortium is composed of six partners from private and public spheres, including two international universities.

Flexibility characteristics at ZEHTC	
Gas turbine range	15—66 MW
PEM Electrolyzer 225 kW	47 Nm^3/h hydrogen production capacity at nominal operation, which would give about 100 kg per day in full time operation
Diaphragm compressor 15.5 kW	Compress the hydrogen from 30 bar to 200 bar
Hydrogen Storage	24,000 liter at 200 bar (about 360 kg)
Battery	75 kW/76 kWh - enables island operation of the system
Solar Panels	133 kW peak (DC); 100 kW (AC); about 1,500 m^2 ground area
Gas turbine operation at 15% vol hydrogen	One hour of full load test operation consumes 150 kg hydrogen and saves 360 kg fuel gas and about 1 ton CO_2 emissions[3]
Total project cost	About € 3.2 million for the Swedish part of the project

Technical and commercial details

- At the Siemens Energy gas turbine manufacturing plant, there is a gas turbine testing centre in order to test gas turbines prior to delivering them to final consumers. These turbines are supplied with natural gas and biogas and also tested with hydrogen.
- The tests produce a huge peak of electricity, which is partly fuelled into the electrical grid. Some excess power is not utilized and the company is working on that in order to utilize it. This facility has become the nucleus of the ZEHTC demonstrator plant.
- They started by the installation of solar panels. Afterwards, the electrolyzer to generate hydrogen from solar energy and waste energy was added. Finally, the tests are executed from the surplus power of the gas turbine.
- Siemens Energy can therefore store the hydrogen produced from waste energy and solar power and supply it back towards the plant as gas turbine fuel when they need it for the next test.
- Also, for the purpose to improve the reliability of the energy system, batteries are included for supplementary storage. Then, a final solution is a smart micro grid, which is able to indicate how a future energy system can work, for a sustainable society.
- The plant has operated since 2021, helping Siemens Energy's goals to make available 100% hydrogen-driven turbines by 2030. This plant is also important to demonstrate that the concept can be used on a larger scale.
- The following schema sums up the described demonstration system as it could be integrated in a large-scale energy grid of the future.

[3] Considering a typical medium size gas turbine (30-35 MW_{el}) fuel consumption - SGT-700



Schema of the targeted sustainable energy system (Source: Siemens Energy, 2022)

Market opportunities

- Customers in diverse markets (e.g. China, Japan and Europe) have already manifested a high interest in green hydrogen. Siemens Energy therefore has been working to develop this new request for them. In addition to that, the changeover from natural gas to biogas is taking place gradually.
- Taking into account general goals, Siemens Energy wants to inspire other customers to switch towards the same direction, as well as to influence industry and society, boosting global efforts to decarbonize.
- The gas turbines are built from pre-machined components. They can operate in heat and power plants under immense pressures and temperatures to produce electricity. This can be done in a sustainable way with little or no GHG emissions, for example by using green hydrogen, liquid biofuels or biogas. In a future energy system, these plants are needed to support the electricity production from renewables like wind and solar power. Today, these gas turbines can operate with up to 75% (vol) hydrogen and are further developed to operate with up to 100% hydrogen latest by 2030.
- Due to 3D printing, for which Siemens Energy has a dedicated task force, some key elements are built with an impressive configuration, such as cooling channels needed to deal with the intense heat released when burning hydrogen.

Lessons learned

- Siemens Energy is enabling energy producers to initiate the changeover from fossil to carbon-free energy production. Through its turbines that can be fuelled by a mix of natural gas, hydrogen and/or biogas, they are provided with a new development that allows (i) economic feasibility, (ii) eco-friendliness and (iii) a high level of availability and reliability.

- Recently, detailed academic model results have been published as part of this work highlighting the role of biogas and hydrogen fuelled gas turbines in the future. https://www.sciencedirect.com/science/article/pii/S0360319921039768?via%3Dihub
- Regarding the development of this technology, it would be good to have more specific case studies, in order to assess reasonable sizes of the components, among others.

Picture of technology

Source: Siemens, 2021