Impact Objectives

- Demonstrate three innovative power-to-gas concepts at sites in Falkenhagen, Germany; Solothurn, Switzerland; and Troia, Italy
- Facilitate the integration of power-to-gas technologies into the future European energy system

Innovating power-to-gas technology

__Dr Frank Graf__ explains how the __STORE&GO__ consortium is advancing energy storage technology and why this is crucial to safeguarding the security of supply in the future energy system

Why is it important for energy storage technology to be progressed?

Since energy from wind and sun is not always available in the exact moment when we need it, it is necessary to have a buffer for this kind of energy – especially once we rely mainly on wind and sun as energy sources. For small amounts and short-term storage of energy, batteries will be the solution of choice. However, when we think about seasonal storage, for example shifting energy from summer to winter, only a chemical energy carrier like gas provides the required storage capacity.

Storage units that cover the European Union (EU)'s energy needs for months already exist in underground caverns and the natural gas pipeline network itself. Furthermore, an all-electrical world seems neither viable nor robust, since various applications in the mobility, industrial and residential sector will, for technical reasons, rely on fuels or gases. Therefore, power-to-gas (PtG) will be an important technology to transfer electricity into other energy sectors.

What are the main targets of the STORE&GO (Innovative Large Scale Energy STORagE Technologies & Power-to-Gas Concepts after Optimisation) project?

We want to operate each of our three plants for about two years in daily business. This alone will be our first measure of success. By analysing and evaluating the operation, we will find out which technological component is best used for which application. In the next step, we will identify business cases for PtG on the short- and on the long-term, and cast this knowledge into the first European PtG roadmap, which will be our second big measure of success.

Can you explain the PtG technologies that STORE&GO is aiming to integrate into the daily operation of European energy grids?

The first step at each of our three demonstration sites is an electrolyser, which provides hydrogen. This hydrogen is then fed into a so-called methanation reactor together with CO_2, where both substances react to methane. The produced gas is basically the same as natural gas. Since the electricity for the whole process comes from renewable sources, and since the CO_2 that we use stems from non-fossil sources, the resulting methane may be called 'green'. We implement quite a few highly innovative components, such as CO_2 capture from air, liquefaction of the green methane to liquefied natural gas (LNG), and biological and catalytic methanation in honeycomb and micro reactors. As we demonstrate three innovative methanation technologies at three demo sites located in different European regions displaying representative grid situations, various probable future use cases are covered in the project.

Do you have expectations for the wider impact of this project?

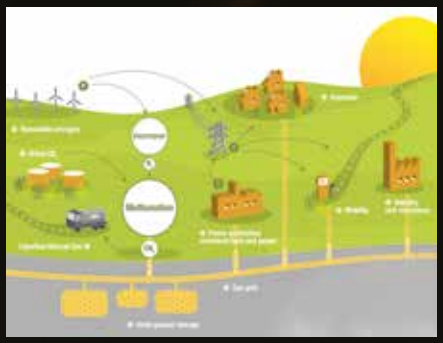
We want to raise awareness at the European level that this kind of energy storage and transformation/conversion is already available today, and that it is an indispensable component to safeguard the security of supply in our future energy system. Our upcoming recommendations on how to spread PtG will hopefully give additional insights to policymakers. PtG is an excellent instrument to bring renewable energy into applications that are otherwise hard to de-fossilise. Think about long-range transport on roads and especially on sea. Think about heating, I cannot imagine the gas heaters in millions of flats throughout Europe's old cities being replaced solely by electric heat pumps and immersion heaters. This poses both extreme technical and financial difficulties. Instead, PtG offers a way to keep the existing devices, and to exchange the fossil gas used in these devices with green gas. With this approach, the energy turnaround may be achieved a lot faster and more cost-efficiently than going the all-electric way.

The future of energy supply

__STORE&GO__, a project underway at the __DVGW Research Centre__ at Engler-Bunte-Institute, Germany, is demonstrating that large-scale energy storage by power-to-gas is possible and highlighting that it is necessary

In order for the European Union (EU) to meet the assigned target of reducing CO_2 emissions by at least 40 per cent by 2030 compared to 1990 and by 80–95 per cent by the year 2050, the majority of fossil and nuclear energy must be replaced with renewable energy. As renewable sources tend to be volatile and generate energy intermittently, long-term storage is required.

An EU Horizon 2020 Research and Innovation programme project coordinated by the DVGW Research Centre at Engler-Bunte-Institute, Germany, is striving to integrate power-to-gas (PtG) technology into Europe's future energy system. The project, 'Innovative Large Scale Energy STORagE Technologies & Power-to-Gas Concepts after Optimisation' (STORE&GO), involves the demonstration of three different PtG concepts in: Falkenhagen, Germany; Solothurn, Switzerland; and Troia, Italy. The work builds on previous research that has demonstrated the technical feasibility of PtG technologies, and seeks to further enhance the technology's ability in order that it can be integrated into the daily operation of European energy grids.



Power-to-gas couples various elements of the energy system

Honeycomb cylinders, the core of the Falkenhagen reactor

The project is led by Dr Frank Graf and involves the participation of 27 partner organisations and companies from across Europe, specifically Austria, France, Germany, Italy, the Netherlands and Switzerland. Project activities are spread over nine work packages. To ensure smooth coordination and collaboration between the project partners, the STORE&GO consortium utilises an online project management platform, which enables the researchers to continuously exchange their progress and findings with each other.

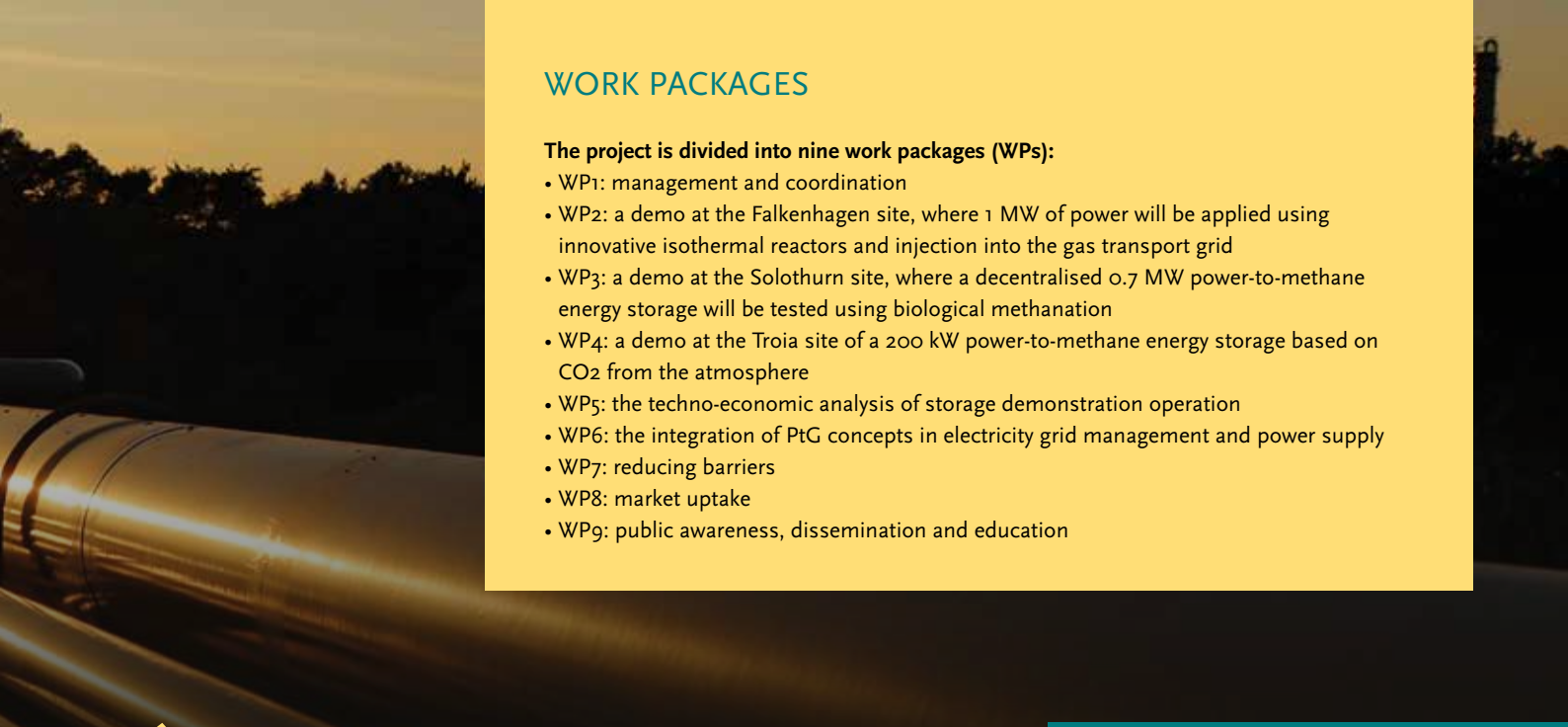
EXPERT EXPLORATIONS

The team feels this level of collaboration is required due to the extent of the expertise required for such an undertaking. 'We are convinced that it is not sufficient to simply serve the public a powerful new technology,' Graf highlights. 'Instead, we need to analyse the strengths of PtG so that we can give precise recommendations regarding how and where to roll out this technology. Policy makers and investors need to be told how, when and where they can apply this technology to generate a business case, or to safeguard the security of supply, or to protect the environment.' For this reason, the STORE&GO consortium benefits from the involvement of large industrial players, innovative small companies, and research institutes with a focus on reactor concepts, electricity grids, techno-economical studies, business development and law. These partners provide the experience and knowledge necessary to ensure that STORE&GO's activities result in real-world change.

The researchers are working to reduce the energy losses and costs associated with existing methods of converting energy. In addition, the team has identified that there is currently no place for PtG in the legislative framework. At present, regulations exist for either electricity or for gas, but not both, meaning that interfaces between the two networks are not accounted for. This state of affairs presents a range of problems, as it creates uncertainty regarding who may operate a PtG plant (i.e. a system operator or a gas producer), there are no clear approval procedures, and plants run the risk of being liable for double fees. This is something that the STORE&GO consortium wishes to change. 'We dearly hope that PtG will be considered in the ongoing revision of the EU's energy legislation,' Graf explains.

NOVEL TECHNOLOGIES

Each of the three concepts being demonstrated in STORE&GO involves novel methanation technologies, and each has been adapted for the respective



WORK PACKAGES

The project is divided into nine work packages (WPs):

- WP1: management and coordination
- WP2: a demo at the Falkenhagen site, where 1 MW of power will be applied using innovative isothermal reactors and injection into the gas transport grid
- WP3: a demo at the Solothurn site, where a decentralised 0.7 MW power-to-methane energy storage will be tested using biological methanation
- WP4: a demo at the Troia site of a 200 kW power-to-methane energy storage based on CO_2 from the atmosphere
- WP5: the techno-economic analysis of storage demonstration operation
- WP6: the integration of PtG concepts in electricity grid management and power supply
- WP7: reducing barriers
- WP8: market uptake
- WP9: public awareness, dissemination and education

"We dearly hope that power-to-gas will be considered in the ongoing revision of the EU's energy legislation"

demonstration site. These PtG plants will be integrated into the power, heat and gas grids for further transport and integration. The idea is that this will enable the researchers to feed renewable methane into the existing natural gas grid in a climate-neutral way without any restrictions, which means it can be made available for a wide range of customer applications. 'The demo sites provide highly diverse testbeds: different climates; grid types and topologies, like transmission or distribution; different combination of solar, wind and hydro energy; and different CO_2 sources, including bioethanol, waste water and directly from air,' Graf elaborates. 'This way, we can analyse and compare the advantages of PtG in various environments.'

Two of the sites use thermo-catalytic methanation, with reactors designed specifically to improve the heat management of the exothermic methanation reaction that is needed to ensure high conversion rates of hydrogen and CO_2 to methane. In addition, the researchers expect that these reactors will have constructive advantages that will result in cost reductions. At the third site, a biological methanation reactor is used. This involves microorganisms called Archaea breathing in hydrogen and CO_2 and exhaling methane. 'This concept seems to be feasible, especially in context with biogas plants in rural areas,' underlines Graf.

A EUROPEAN ROADMAP

In addition, the team is analysing the existing regulatory and legislative framework, in order to identify where PtG fits in. As such, the researchers are involved in the BRIDGE initiative – a cooperation group involving to date 32 low carbon energy (LCE) smart-grid and energy storage projects funded under Horizon 2020. The researchers are also conducting a multi-country survey in order to identify acceptance or resistance in relation to PtG. The team hopes to accelerate market uptake by identifying business models; creating a European PtG map displaying the most promising locations to install facilities; and developing a European PtG roadmap that contains recommendations regarding which applications PtG may serve in the short-, mid- and long-term. 'This European PtG roadmap will be a central outcome of the project,' reveals Graf.

The team hopes that the STORE&GO project will benefit end users across Europe by ensuring a sustainable supply of energy and therefore guaranteeing security. 'Furthermore, the gas generated by PtG can replace fossil gas in any application, like heating and transport,' states Graf. 'It thus helps to free the heating and transport sector from fossil CO_2 emissions.' The team is pleased with the progress STORE&GO has made to date and is confident it is on target to achieve project objectives and, ultimately, enhance the future of energy storage and provision, benefitting humankind.

Project Insights

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BIO
Dr Frank Graf graduated in Process Engineering at the Karlsruhe Institute of Technology (KIT) in 2001, and received his PhD in 2007. From 2005 to 2010 he headed the Department of Gas Technology Consulting at DVGW Research Centre at Engler-Bunte-Institute. Graf has been responsible for the Gas Technology division since 2010, and is also the group manager of 'Physical-chemical fuel processing technologies' at Engler-Bunte-Institute. His current R&D work at KIT and DVGW is focused on the development of innovative processes for gases from renewable sources and the future role of the gas infrastructure in the energy system.

STORE&GO

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