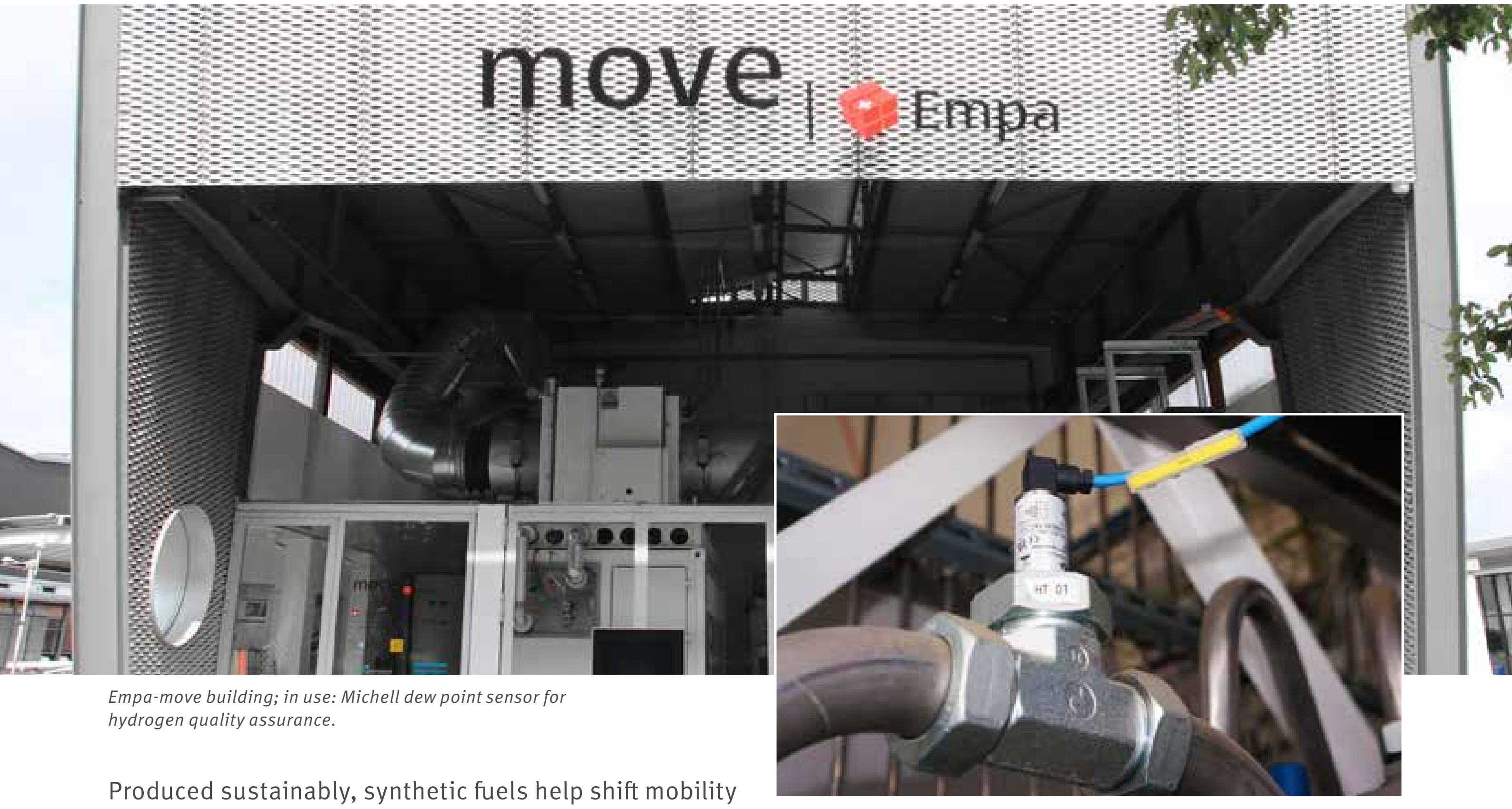
Empa Project: With Renewable Energies to Synthetic Fuels

How do we pack solar energy into a tank?
The mobility demonstrator "move", initiated by Empa and developed with other partners, addresses the subject of the future of mobility, which includes power-to-X technologies, in particular the production of synthetic methane.



Empa-move building; in use: Michell dew point sensor for hydrogen quality assurance.

Produced sustainably, synthetic fuels help shift mobility to renewable energies in order to meet climate targets for road transport, according to the Swiss "innovation engine" Empa. Synthetic fuels are suitable for use in heavy-duty as well as long-haul transport. Alongside electric and hydrogen mobility, these fuels, known as "synfuel" or "syngas", are one of the three possible technological paths to CO_2 reduction in the mobility demonstrator "move". The latest project here revolves around the production of synthetic methane from hydrogen and CO_2. According to Empa, these fuels "can be transported via conventional routes and made available through existing infrastructure, which is interesting for Switzerland, as well as globally, because it opens up enormous potential for renewable energy." The mobility demonstrator is expected to produce 3.6 kg of methane per hour. In comparison, the tank size of a passenger vehicle running on natural gas (CNG) is typically 80 liters, which is equivalent to 13.5 kg of CNG, or ~20 liters of gasoline. Depending on the type of vehicle, this is equivalent to a range of 50 to 200 kilometers. In 24-hour operation, the mobility demonstrator would produce fuel for approximately 2000 km. In the production of synthetic methane, the dew point sensor "Optidew401 from PST" plays a substantial role.

Conventional methanation

In the conventional process, methane (CH_4) and water (H_2O) are produced from carbon dioxide (CO_2) and hydrogen (H_2) by means of catalytic conversion. However, to achieve sufficient purity, this process requires several methanation stages in succession – with condensation areas in between and drying of the product.
The gaseous product of the methanation reaction contains mainly water and unreacted gases, which, according to the relevant regulation, prevents it from being fed directly into the gas grid; the product must first be purified.

Innovative "sorption-enhanced" methanation

The innovative methanation in "move", on the other hand, can even operate in a single stage and achieves the feed conditions without further purification of the product gas. The underlying idea: the reaction water is adsorbed during the methanation process on a porous catalyst support, namely a zeolite, i.e. it is removed from the reaction process. This continuous removal of water shifts the reaction equilibrium toward an almost 100 percent methane yield. According to Empa, the gaseous product can therefore be fed directly into the gas grid without additional purification and used, for example, to fuel gas-powered vehicles.

Marcel Jenny (Key Account Manager PST/Rotronic) in conversation with Dr.-Ing. Florian Kiefer (Automotive Powertrain Technologies Laboratory, Empa). In the background, the test facility.

Methane from solar energy

The CO_2 for methanation as well as the water for the production of hydrogen is extracted from the atmosphere directly on site using a CO_2 collector from the ETH spin-off Climeworks. The system draws in ambient air, leaving the CO_2 molecules attached to the filter material. Using heat – around 100 °C – the CO_2 molecules are then detached from the filter again. In addition to the CO_2, the Climeworks system also removes water from the air, which can be used via a condensate line for hydrogen production in the electrolysis system. This means that such plants are also conceivable for regions without a water supply.

System optimization with Optidew 401

In this methanation process, the dew point is determined at different points using Rotronic's "Optidew 401", according to Florian Kiefer of Empa's Vehicle Energy Technologies Group. "We also plan to use more robust dew point and CO_2 sensors for plant control and regulation of the methanation plant in our "move-MEGA" project." Florian Kiefer explains that the chilled mirror is currently being used in the preliminary tests due to its flexibility and accuracy. In the plant, this can and must be replaced by an industrial sensor (such as Michell Easidew I.S.). This sensor can be selected and optimized by the knowledge gained in the preliminary tests. In principle, there is also potential for other sensors in the plant, including CO_2 sensors for plant control or a gas chromatograph to monitor feed quality. So far, "Optidew401" has been used for the chilled mirror as a replacement for a defective device. Florian Kiefer emphasizes how uncomplicated it was to procure the device initially as a loan unit to bridge the delivery time.

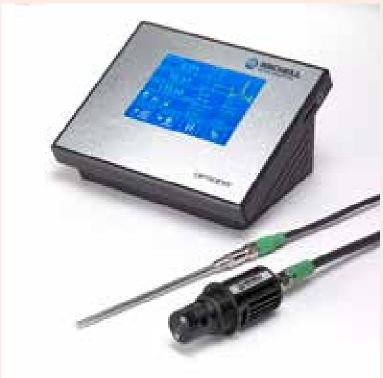
In the coming years, Florian Kiefer sees the development of solutions in the field of power-to-gas or liquids together with industrial partners as an important focus of the research group. In addition, the group is already involved in the development of technologies for the realization of negative emissions, always with a "focus on industrial applications, scalability and flexible operation in conjunction with renewable energies."

Project-related PST products

Product	Type	Application
Michell Optidew 401	Chilled mirror hygrometer (-40…120 °C)	Determination of moisture in hydrogen, methane or CO_2
Michell Easidew	Dew point transmitter	Determination of trace moisture in hydrogen, methane or CO_2
Possible future use		
Michell Easidew I.S.	Intrinsically safe dew point transmitter	Determination of trace moisture in hydrogen, methane or CO_2
Michell XTC601	Thermal conductivity analyzer	Determination of, for example, residual CO_2 in methane
Rotronic HF5 with HC2-LDP110-EX	Humidity and temperature transmitter with dew point sensor	Determination of dew point in, for example, methane
Rotronic CCA-S-CO_2-X5-SET	NDIR sensor. 0…5% CO_2	Determination of CO_2 in methane
Michell S8000	Chilled mirror …-60 °C	Determination of residual moisture in hydrogen, methane or CO_2

Already used

Michell Optidew 401



The Optidew 401 and Optidew 501 are fast-response chilled mirror hygrometers that take advantage of the latest developments in chilled mirror technology. Ideal for use in industrial humidity control or precise measurements in laboratories. The hygrometers can be configured as a bench-top or wall-mounted unit, or as a transmitter version of the Optidew 501 (without display). Accuracy is ±0.15 °C over a dew point measurement range of -40 to +120 °C, which withstands the higher stress of H_2O_2.

Michell Easidew EA2

The Easidew sensor is a moisture meter that measures both dew point and moisture content. It is simple to install as it is available with a wide range of process and electrical connections. All Easidew dew point measuring instruments are available with a service replacement program that reduces the costs and time of maintenance. Reconfiguration of the transmitters is easy with the self-contained Easidew and Pura communication kit. Michell's ceramic metal oxide humidity sensor-based hygrometers are calibrated to international standards and come with a traceable calibration certificate.

Empa
Materials Science and Technology

About Empa

As the ETH Domain's interdisciplinary research institute for materials science and technology, Empa sees itself as a bridge between research and practical application. The researchers develop innovative solutions for the priority challenges of industry and society in the areas of nanostructured, "smart" materials and surfaces, energy, construction and environmental technologies, resource efficiency as well as medical technologies and personalized medicine. Through the most efficient and direct technology transfer possible, its aim is to transform research results from Empa laboratories into marketable innovations together with industrial partners. In this way, Empa makes a significant contribution to further boosting the innovative strength and capabilities of the Swiss economy in an increasingly competitive global environment.

About Dr.-Ing. Florian Kiefer

Florian Kiefer holds a degree in mechanical engineering with majors in energy and process technology from the Technical University of Munich and a PhD from the Chair of Thermodynamics. He is currently responsible for the industrialization of a power-to-gas system within the Empa Future Mobility Demonstrator project "move". He gained experience in energy and process engineering at Fraunhofer ISE and Fichtner Consulting as well as in various engineering projects at TU Munich and Empa. These include thermal power plant technology, renewable energies, water treatment and catalytic reactor systems.

About Process Sensing Technologies

Process Sensing Technologies (PST) provides an unmatched suite of instruments, analyzers and sensors for precision measurements and monitoring in highly demanding end markets. These range from pharma/life sciences, specialty gases, semiconductors, O&G, petrochemicals and energy to gas detection, the food and beverage industry and building automation.
PST brings together established brands that excel in the precision and reliability of their products, are strong in innovation and focus on customer service. With a history of development and innovation that began in 1965 and continues today, we look forward to many more milestones in the future.

Rotronic is a member of the Process Sensing Technologies (PST) Group

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