Project

Renewable fuels for electricity production

How all CO₂ emissions from cement production can be used appropriately

How all CO_2 emissions from cement production can be used appropriately

CO_2 can be used to produce methane gas, which in turn can be utilised for the generation of electricity or heat. Researchers from the Zurich University of Applied Sciences (ZHAW) investigated a value chain such as this as part of a joint project.

7 % of CO_2 emissions in Switzerland originate from cement production. *Source:* Shutterstock

At a glance

- During the production of cement, 2.5 million tonnes of CO2 are released in Switzerland every year.
- Researchers from the Zurich University of Applied Sciences (ZHAW), the Swiss Federal Laboratories for Materials Testing and Research (Empa) and the Swiss Federal Institute of Technology Lausanne (EPFL) have investigated how this CO_2 can be converted into renewable methane gas, which can in turn be used for the generation of electricity or heat, in as efficient a manner as possible.
- The conclusion of the analysis: all CO_2 released during Swiss cement production activities can be converted into methane. This could replace 33 % of fossil gas imports.
- However, the process is expensive: renewable methane currently costs around three times as much as fossil methane. In order for the renewable gas to become competitive, the technologies need to become more cost-efficient.

One of the most important objectives of Energy Strategy 2050 is to reduce emissions of carbon dioxide (CO_2). By signing the Paris Agreement, Switzerland has undertaken to reduce its CO_2 emissions by half relative to 1990.

At around 2.5 million tonnes of CO_2, cement production accounts for a considerable share of nationwide emissions: 7 % to be precise. The majority of these emissions are produced during lime burning which sees the CO_2 held in the lime released. It is not possible to reduce these CO_2 emissions from a chemical perspective. However, the gas could be used to reduce the consumption and importing of fossil fuels in Switzerland, as demonstrated by ZHAW researchers in a joint project. Together with renewable hydrogen, the CO_2 can be converted into renewable methane. This could then be fed into the existing natural gas grid and be utilised by fuel cell technologies which exhibit a high level of efficiency.

In four technical projects, the researchers developed new components, materials and processes in order to map the entire value chain. In a fifth, non-technical project, they analysed the sustainability of the process.

All of the CO_2 can be converted

The first project was about converting solar energy into renewable hydrogen (H_2). The process is referred to as photoelectrochemical water splitting (PEC). Unlike the case with photovoltaics, incoming sunlight is not initially converted into electricity, but rather used directly for water splitting. For this process, the EPFL researchers achieved an efficiency level of 8.8 % for the solar-to-hydrogen process.

Using the produced hydrogen, the CO_2 is then upgraded to methane gas. The subject of the second project. With a newly developed catalyst, it was possible to convert all of the introduced CO_2 into hydrogen. The researchers were also able to triple the operating time of the catalyst. This is key as it makes the conversion more effective and cost-efficient.

Next, the produced methane gas can be used to generate electricity or heat. This requires fuel cells – the third and fourth projects looked at the technologies involved. One focussed on stationary application, i.e. electricity and heating in buildings, while the other turned its attention to mobile utilisation, for example for use in vehicles. Here, the researchers developed new usage models and used a material that contributes to efficiency during the use of fuel cells.

All CO_2 from cement works could be turned into methane gas

However, can the process actually also be implemented in Switzerland? The answer is yes. The researchers conclude that all 2.5 million tonnes of CO_2 from Swiss cement production can be converted into renewable methane – and that this is even possible with existing technologies. This methane could replace 33 % of fossil gas imports.

But that's not all: with a heating system for private households that is primarily based on fuel cell technology, 50 % of CO_2 emissions could be saved relative to conventional heating systems. These fuel cells are incidentally already available on the market – consumers can now already make use of them to reduce their environmental footprint. However, not many are aware of this. According to the researchers, it would be desirable to increase people's awareness of them.

Nevertheless, there are still a few hurdles to overcome. Firstly, the process is expensive. Producing renewable methane in this way still costs 3.6 times as much as fossil gas. Accounting for around 90 % of the costs, the production of hydrogen is the most expensive production step in the value chain. In order to make renewable methane competitive, one or more of the processes therefore need to become more cost-efficient.

Photoelectrochemical water splitting, which produces hydrogen using solar energy, is also a young technology. According to the assessment of the researchers, it is unrealistic to expect that it will make a substantial contribution to the energy system in the next five to ten years. Subsequently, however, it could assume a major role. Among other reasons, this is because it could replace two technologies: photovoltaics for the conversion of sunlight into energy and electrolysis for the production of hydrogen.

Ten-figure investments required

Irrespective of whether methane gas is in future produced with this new technology or using the tried-and-tested method of photovoltaics plus electrolysis: a great deal of sunlight needs to be captured. Areas of around 100 square kilometres of solar cells would be required for just the 2.5 million tonnes of CO_2 produced by the cement industry. Theoretically, the 150 square kilometres of roof space available in Switzerland would suffice. However, the solar gas production would interfere with the private use of roofs.

One thing is for sure: in order to replace imported fossil fuels, ten-figure investments and statutory regulations will be required to guide developments in the greatly changing energy market. This is because the Swiss energy industry requires fixed framework conditions if it is also to be able to implement these technologies.

Produkte aus diesem Projekt

- A Cost Estimation for CO_2 Reduction and Reuse by Methanation from Cement Industry Sources in Switzerland,
  Date of publication: 28.02.18
- Renewable fuels for sustainable electricity production
  Date of publication: 01.01.16
- Das NFP70 Verbundprojekt "Reduction & Reuse of CO_2"
  Date of publication: 01.01.18
- Erneuerbare Energieträger zur Stromerzeugung
  Date of publication: 01.01.18
- Informationen zu Energieforschungs-, Pilot-, Demonstrations- und Leuchtturmprojekten'
  Date of publication: 01.01.18
- Puzzleteile eines neuen Energiesystems (NRP70)
  Date of publication: 01.01.18
- NRP70 - Reduction & reuse of CO_2: renewable fuels for efficient electricity production
  Date of publication: 01.01.18
- Erneuerbares Methan aus zementärem CO_2
  Date of publication: 01.01.18
- Neuartiger Katalysator für verbesserte CO_2-Methanisierung
  Date of publication: 21.03.17
- Sorption-Enhanced-Neutron-Scattering-II
  Date of publication: 21.03.17
- Interview mit Andre Heel
  Date of publication: 26.09.19
- CO_2 Reduction & Reuse – Renewable Fuels for Efficient Electricity Production
  Date of publication: 24.04.15

Contact & Team

Dr. Andre Heel
Forschungsbereich Prozesstechnik
ZHAW
Technikumstrasse 9
8400 Winterthur

+41 (0) 58 934 47 03
andre.heel@zhaw.ch

Andre Heel
Project director

Thomas Hocker
Projektleiter

Andreas Borgschulte

Vicente Carabias

Andreas Hagfeldt

Jürgen Schumacher

All information provided on these pages corresponds to the status of knowledge as of 10.05.2019.