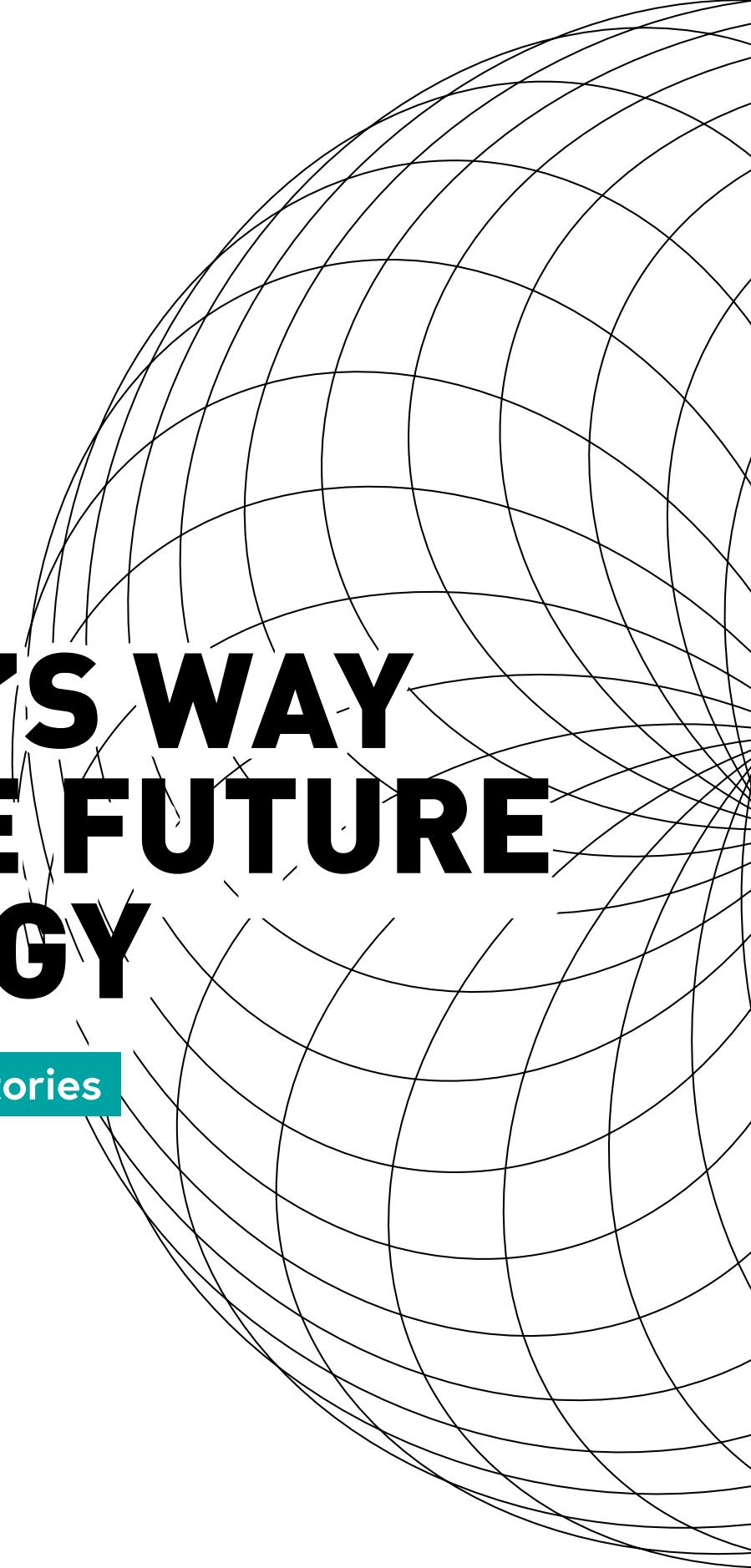
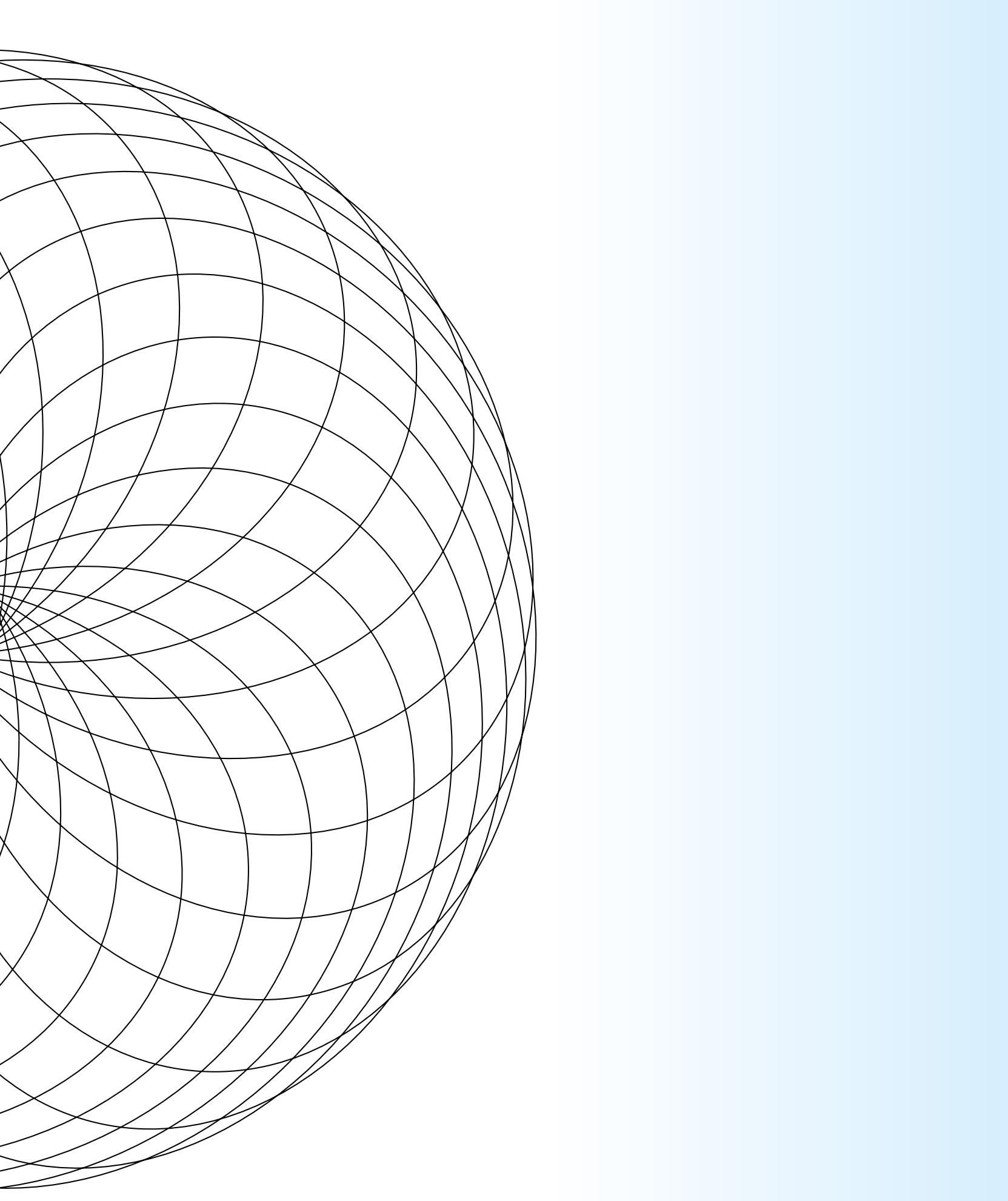


# AUSTRIA'S WAY INTO THE FUTURE OF ENERGY

Strategies and Success Stories





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*The research projects and initiatives presented in this brochure as well as presentations of innovative companies are examples of the large number of Austrian R&D activities in the area of future-oriented energy technologies.*



## FEDERAL MINISTRY FOR TRANSPORT, INNOVATION AND TECHNOLOGY

We are proud to be a part of the “Mission Innovation” network. Together with Austria, it comprises 23 countries and the European Union. The goal of this international initiative is to combat climate change in cooperation with private investors and to push the development of clean energy technologies forward. It is the cooperation between governments and private investors which makes Mission Innovation so powerful. The Austrian government stresses the importance of remaining on this path to success. That is why we are working together with Austrian companies to prioritise research and development on storage systems and batteries, smart buildings and smart cities, smart grids and industrial applications within the framework of the federal government’s energy research initiative.

**Norbert Hofer**  
**Federal Minister for Transport, Innovation and Technology**



## CLIMATE AND ENERGY FUND

The implementation of the energy transition poses many challenges – both for the Austrian economy as well as for Austria's inhabitants. Turning this transition into reality will entail drastic changes. However, Austria is well prepared in this regard: for eleven years now, the Climate and Energy Fund has been monitoring and supporting the transformation of energy and mobility systems. More than 130,000 innovative projects have been pushing developments in the areas of electricity, heating, industry and mobility since 2007. Thanks to our flagship regions in the Flagship Region Energy programme, a new chapter in the fostering of Austrian innovation has begun. We are developing and testing radical technological innovations "Made in Austria" in cooperation with a multitude of partners from business, research and politics. Furthermore, we are positioning Austrian companies as drivers of innovation on the global market.

**Theresia Vogel**  
**Managing Director of the Climate and Energy Fund**



## AUSTRIAN ECONOMIC CHAMBERS

Global trends such as the challenges associated with climate change, an ever-growing world population, increasing urbanisation or the growth of hundreds of new megacities are the drivers behind the demand for innovative energy and environmental technologies. Research and technological innovation must be clearly prioritised if we are to cope with these socio-political challenges.

Mission Innovation is an opportunity to intensify energy research in Austria and to acknowledge and develop Austrian companies' position as key players in the fields of energy and environmental technologies. Active participation in the Mission Innovation network makes it easier to connect with international consumers and potential partners, and is thus conducive to improving access to international markets.

**Harald Mahrer**  
**President of the Austrian Economic Chambers**





# **STRATEGIES & ACTIVITIES**

Leveraging potentials –  
stimulating innovations

# MISSION INNOVATION

## Clean energy technologies to combat climate change

Mission Innovation (MI) is a global research initiative founded on the occasion of the 2015 UN Climate Change Conference in Paris by countries who are leaders in energy technologies. Its goal is to combat climate change in cooperation with private investors and to push the development of clean energy technologies forward.

The network consists of 23 states\* and the European Union. Austria became a member of the Mission Innovation network during the 3rd Mission Innovation Ministerial in Malmö in May 2018. By joining this global initiative, Austria took an important step in terms of positioning itself as “a country of energy innovation”.

### Accelerating the clean energy revolution

In order to limit global warming to well below 2 °C, innovation in the fields of clean energy technologies and intelligent energy solutions have to be pushed forward on a large scale. The members of Mission Innovation are working on developing new, cutting-edge technologies as

well as reducing costs significantly. The countries involved, who account for more than 80% of the world's R&D budget for clean energy, are endeavouring to double the amount of R&D investments in the field within five years.

Sustainable energy technologies are an important international growth market. The funding provided by MI members should speed up the rate at which innovative developments occur and significantly increase the presence of clean, safe and affordable energy technologies and solutions. Austria wants to take advantage of this opportunity for its

businesses and actively shape the structural transformation of energy supplies, as well as develop new business segments. Through its participation in this international collaboration, Austria seeks to promote the visibility of its innovative solutions on a global scale and to reinforce the position of Austrian companies on the international market.

**[mission-innovation.net](http://mission-innovation.net)**



**Christoph Frei**

**Secretary General and CEO, World Energy Council  
Member of the Mission Innovation Austria Advisory Board**

\* Australia, Austria, Brazil, Canada, Chile, China, Denmark, Finland, France, Germany, India, Indonesia, Italy, Japan, Mexico, the Netherlands, Norway, the Republic of Korea, Saudi Arabia, Sweden, the United Arab Emirates, the United Kingdom, the United States



*Climate and Energy Model Region Freistadt,  
Photo: Climate and Energy Fund/Hans Ringhofer*

# #MISSION2030

## Austrian Climate and Energy Strategy

It will be necessary to completely restructure our current energy systems; both in terms of the supply as well as the use of energy in electricity, heating, mobility, and industry; if we are to meet the objectives of the Paris Climate Agreement. Austria has committed itself to meeting these objectives and to proactive environmental protection and energy policies.

#mission2030 – the Austrian Climate and Energy Strategy, which was drawn up by the federal government in 2018, has formulated basic goals and areas to be addressed on the path towards decarbonisation for the years 2030 and 2050. Austria's climate and energy policies seek to ensure a balance between ecological sustainability, competitiveness, affordability and security of energy supply. Austria's innovation potential should be used to develop forward-thinking technologies and solutions, based on objectives which

have been successfully put into effect, to implement these technologies and solutions and to make Austria an innovation leader.

### Sustainable, safe & competitive

The main goal of Austria's climate and energy policies is to reduce greenhouse emissions and to increase the share of renewable energy. Austria will have to reduce its CO<sub>2</sub> emissions by 36% by 2030, as compared to the year 2005. In 2018, the share of renewable energy in the gross final consumption of energy was approximately 33.5%. This share should go up to 45-50% by 2030. Approximately 72% of the electricity generated here currently comes from renewable energy sources. Austria has declared its intention to have domestic renewable sources of

energy cover 100% (national balance) of its total electricity consumption in 2030. Investments in measures related to energy efficiency as well as the development of renewable energy sources, infrastructure and storage systems will be necessary to meet this objective.

The transformation into an efficient and clean energy, mobility and economic system will have to include the entire energy value chain (generation, transport, conversion and consumption), including all the products and services in connection with it. Energy research and technological developments play a key role in this comprehensive process.

**mission2030.info**

# POSITIVE MARKET DEVELOPMENTS

## Energy technologies made in Austria

Sustainable energy technologies are not only essential for meeting both climate and energy objectives, they also ensure growth and added value, create new jobs and reduce our dependency on fossil fuel imports. Austrian research labs and development centres for energy technologies boast innovative products and system solutions characterised by efficiency and quality. Furthermore, they have established their reputation internationally. As an example, the export ratio of solar thermal collectors is approximately 84%, and four out of five biomass boilers produced in Austria are installed abroad.

Despite the falling prices of oil and gas in 2016 and 2017, the markets for products, systems and services in the most important energy technology industries continued to grow.

In 2017, Austrian companies dealing in biomass, photovoltaic, solar thermal energy, heat pumps and wind power generated a turnover of EUR 4.9 billion and employed more than 32,000 people. With 25,000 heat pumps installed in 2017, the industry recorded growth of 10.1%. The number of photovoltaic systems installed also increased by 11%, and the price of these systems continues to drop. Thanks to the use of innovative energy technologies, Austria was able to produce a total of 66.3 terawatt hours of renewable energy, and it prevented a total of 13.2 million tonnes of CO<sub>2</sub> from being produced.

Source:  
[nachhaltigwirtschaften.at/de/iea/publikationen/innovative-energietechnologien-in-oesterreich-marktentwicklung-2017.php](http://nachhaltigwirtschaften.at/de/iea/publikationen/innovative-energietechnologien-in-oesterreich-marktentwicklung-2017.php) (in German)

ADVANTAGE AUSTRIA, with its more than 100 offices in 70 countries, is the foreign trade promotion organisation of the Austrian economy and provides a broad range of intelligence and business development services for both Austrian companies and their international business partners. Under the auspices of the Austrian Federal Economic Chamber (Wirtschaftskammer Österreich - WKÖ), the experts from ADVANTAGE AUSTRIA around the world can assist you in finding Austrian suppliers and business partners.

Visit our international website [www.advantageaustria.org](http://www.advantageaustria.org) to learn more about the Austrian economy, its international presence and Austria as a business location. As experts in internationalisation, we will gladly support you in your search for the suitable Austrian technology, products and services.



Our international FRESH VIEW magazines offer an overview of specific Austrian business sectors:

[freshview.at](http://freshview.at)



### DESERT MOUNTAIN HIGH SCHOOL

In 2014, the Styrian company S.O.L.I.D. GmbH created the largest solar thermal cooling system in the world, installing it at Desert Mountain High School in Scottsdale, Arizona. This high school is located in one of the hottest parts of the U.S., with summer temperatures often exceeding 40 °C. A solar cooling system with a collector surface of 4,865 m<sup>2</sup> and a cooling capacity of 1,750 kilowatt (kW) was installed here. It provides air conditioning for the school with 2,600 pupils. The solar cooling system not only reduces energy consumption, it also relieves the power grid, especially during peak times. [www.solid.at](http://www.solid.at)



Desert Mountain High School - Scottsdale, Arizona. Photo: S.O.L.I.D. GmbH



## FLEXIBLE PV FILMS

The Austrian companies crystalsol GmbH and Forster Werbetechnik GmbH worked with partners in science to develop next-generation technology aimed at producing flexible PV films. The crystalsol concept is based on employing low-cost materials and ultra-efficient manufacturing technologies from the printing industry. Flexibility, low weight, easy assembly of the photovoltaic sheets and reduced costs can hence be achieved. [www.crystalsol.com](http://www.crystalsol.com)

# INNOVATION FOR THE FUTURE OF ENERGY

## Research & technological development in Austria

Energy research and innovation are key steps on the path towards the gradual decarbonisation of the energy system. Investments in research, technological development and innovation are crucial when it comes to the accelerated development of the energy and environmental technology market. Based on #mission2030 – the Austrian Climate and Energy Strategy – the technology-neutral Energy Research Initiative has the goal to support the transformation processes in the direction of clean, safe and affordable energy for the future through the development and testing of ground-breaking innovations in energy. All of the country's innovative forces – from clean tech start-ups and SMEs to international industry and research centres – play an active role in shaping these processes.

Over the past few years, many forward-thinking energy technologies and intelligent system solutions have been developed in Austria. To take advantage of Austria's innovation potential, it will be necessary to further develop these

strengths. Some of the most successful energy-related innovations include technological developments in the building sector, for example, with passive-house and plus-energy building technologies being tested in many demonstration buildings in Austria and receiving widespread recognition internationally.

### R&D priorities

In addition to the development of individual technologies, the focus of energy-related research in Austria lies on system integration and sector coupling in the fields of building and urban systems, energy conversion, distribution and storage, industrial energy systems and sustainable mobility systems. Essential to ensuring their success is large-scale testing of technologies and integrated solutions in real-life operation. Hence, this should push the development and implementation of innovative energy solutions forward and make it easier for new products and services to be introduced on the market.

In terms of implementation, two Flagship projects related to innovation have been developed as part of the Climate and Energy Strategy: Flagship 9 "Building Blocks for Energy Systems of the Future" and Flagship 10 "Programme Mission Innovation Austria".

Flagship 9 entails the pooling of resources from the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund into the following MI-related areas: plus-energy districts, integrated regional energy systems, break-through technologies for industry as well as energy-efficient mobility systems for the future. Flagship 10 concerns the continuation and expansion of the Austrian Flagship Region Initiative (see page 16 onwards).

### THE VISION

The vision of Austria's ENERGY Research and Innovation Strategy (2017) is to make Austria a global innovation leader shaping our energy future. Its objectives include the following:

- energy research and innovation lead to economic growth, create new jobs and contribute to the decarbonisation of the energy system
- steady increase of energy research funding
- Austria becomes an innovation and technological leader in selected energy-related areas
- increased visibility of Austrian innovations on an international level and improved access to international markets



LISI, the plus-energy world champion house, was declared the best solar house in the world at the 2013 Solar Decathlon, an international competition in California. The building was developed and constructed as part of an interdisciplinary project at the TU Wien (Vienna University of Technology), under the direction of Karin Stieldorf from the Faculty of Architecture and Planning. [www.solardecathlon.at](http://www.solardecathlon.at). Photo: Blaue Lagune/Thomas M. Laimgruber, [blauelagune.at](http://blauelagune.at)

## HIGH PRESSURE HEAT STORAGE FACILITY IN VIENNA

In 2013, the world's first high-pressure, high-temperature storage facility started operation in Vienna Simmering. The new storage facility has made it possible to uncouple producing and consuming heat from each other. By storing surplus heat from nearby power plants (up to 980 Megawatt per hour/MWh), the peak-load boilers are needed less often when demand for heat is high. In the first four years of becoming operational, around 54,000 tonnes of CO<sub>2</sub> emissions have been saved. This innovative facility was planned and built in cooperation with leading scientists.

[www.wienenergie.at](http://www.wienenergie.at)



Photo: Wien Energie/Ian Ehm



## VIENNA GREEN CO<sub>2</sub>

In the energy research flagship project "ViennaGreen-CO<sub>2</sub>" researchers at TU Wien (Vienna University of Technology) and the University of Natural Resources and Life Sciences (BOKU) are collaborating with Shell and other partners on developing a new low-cost, energy-efficient CO<sub>2</sub> separation/capture technology for separating carbon dioxide. Its innovative fluidised bed process was tested during real-life operations at a pilot facility which is part of Wien Energie's biomass power plant. The researchers anticipate that, with the new technology, the costs of CO<sub>2</sub> separation per tonne of CO<sub>2</sub> can be lowered by up to 25%.

<https://vt.tuwien.ac.at>

Fluidised bed layer of the absorber, Photo: TU Wien/Julius Pirklbauer

# MI CHALLENGES

A total of eight MI challenges have been developed on an international scale within the framework of the Mission Innovation initiative. Each of the participating countries has been invited to take part in addressing them. The goal of international cooperation within the framework of these challenges is to intensify research efforts in the fight against climate change worldwide. These MI challenges cover the entire field of research and development, including demonstration projects.



**MISSION  
INNOVATION**

accelerating the clean energy revolution

## # Innovation Challenges

<p><b>#1 Smart Grids</b></p>  <p>Co-leads CHINA INDIA ITALY</p> <p>Enable future grids powered by affordable, reliable, decentralised renewable electricity systems.</p>	<p><b>#2 Off Grid Access to Electricity</b></p>  <p>Co-leads FRANCE INDIA</p> <p>Develop systems that enable off-grid households and communities to access affordable, reliable renewable electricity.</p>
<p><b>#3 Carbon Capture, Utilization, and Storage</b></p>  <p>Co-leads SAUDI ARABIA MEXICO UNITED KINGDOM</p> <p>Enable near zero CO<sub>2</sub> emissions from power plants and carbon-intensive industries.</p>	<p><b>#4 Sustainable Biofuels</b></p>  <p>Co-leads BRAZIL CANADA CHINA INDIA</p> <p>Develop ways to produce at-scale widely affordable, advanced biofuels for transportation and industrial applications.</p>
<p><b>#5 Converting Sunlight</b></p>  <p>Co-leads EUROPEAN COMMISSION GERMANY</p> <p>Discover affordable ways to convert sunlight into storable solar fuels.</p>	<p><b>#6 Clean Energy Materials</b></p>  <p>Co-leads CANADA MEXICO</p> <p>Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.</p>
<p><b>#7 Affordable Heating and Cooling of Buildings</b></p>  <p>Co-leads EUROPEAN COMMISSION UNITED ARAB EMIRATES UNITED KINGDOM</p> <p>Make low-carbon heating and cooling affordable for everyone.</p>	<p><b>#8 Hydrogen</b></p>  <p>Co-leads AUSTRALIA GERMANY EUROPEAN COMMISSION</p> <p>Accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale.</p>

Source: [mission-innovation.org/our-work/innovation-challenges/](http://mission-innovation.org/our-work/innovation-challenges/)

## MI CHALLENGES – THE WORKING GROUPS' OBJECTIVES

- to develop a common understanding of these challenges
- to identify and analyse key gaps
- to develop and promote cooperation between researchers, innovators and investors
- to increase the involvement of stakeholders from the government, research, the private sector and investors

## STEPS TOWARDS IMPLEMENTATION

- identification of sub-challenges and topics
- strengthening of ongoing collaborations and the creation of new ones
- development and consensus regarding monitoring methods
- increased engagement with private companies, industry and investors
- intensification of bilateral and multilateral collaboration
- further development of work programmes

# MISSION INNOVATION AUSTRIA

## R&D programmes and activities in Austria

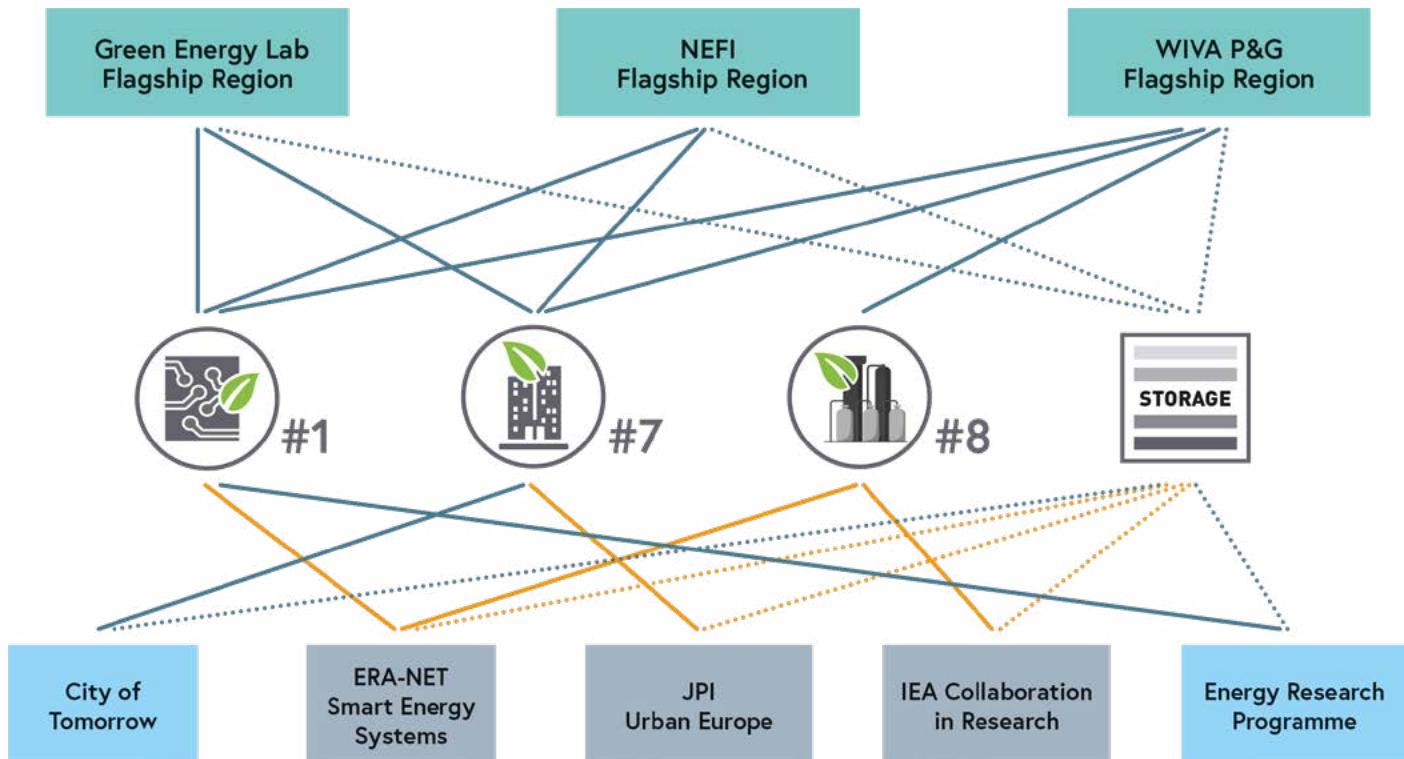
A multitude of national priorities, funding programmes and accompanying measures combined with participation in international research collaborations help to ensure that the development and implementation of innovative energy solutions both within and from Austria are being pushed forward. The Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund are using energy research and innovation programmes to support the development of and research on new products, systems and services, which makes them a key partner for companies and research centres. Austria's membership in the global

Mission Innovation initiative seeks to strengthen the country's research. Austria strives for active participation in this international collaboration as a pioneer in the development and implementation of key technologies for the future of energy.

### **Austria's involvement in Mission Innovation**

Local experts from science and economy came together to analyse the MI challenges. Taking account of Austria's research strengths, they determined that Austria would participate in the following MI challenges: #1 Smart Grids, #7 Affordable Heating and Cooling of Buildings, and #8 Renewable and Clean Hydrogen. In addition, the interdisciplinary topic of "energy storage and batteries" is particularly relevant.

An important characteristic of Austrian Mission Innovation activities is that they are strongly linked to the industry. One of the key factors to success in Austria is the close cooperation between entrepreneurs and the public sector. The objective is to use public funding to incentivise companies to invest in research.



Programmes and priorities of the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund, including international research collaborations and their relation to the MI Challenges #1 Smart Grids, #7 Affordable Heating and Cooling of Buildings, #8 Renewable and Clean Hydrogen as well as the interdisciplinary topic "Energy storage and batteries".



*“Over the past decade Austria quadrupled funding for public Clean Energy RD&D to accelerate innovation for climate change, energy and industrial transition challenges.*

*The focus has been exemplary: close cooperation between public research and the private sector, pilot projects on municipal, regional and national levels and an excellent track record as innovative partner for international collaborations with the IEA, SET Plan, ERA-Net and EERA. By joining Mission Innovation Austria’s government and industry is committed to forge ahead with new funding and global cooperation in priority areas such as Smart Grids, Heating and Cooling, Renewables, Clean Hydrogen, Smart Cities, Storage and Digitalization.”*

**Marianne Haug**

**University of Hohenheim, Stuttgart**

**Member of the Mission Innovation Austria Advisory Board**

## FLAGSHIP REGION ENERGY

### Innovative solutions in real-life operation

More than 200 project partners from business, science and research are working on the future of energy within the framework of the RTI (Research, Technology development and Innovation) initiative “Flagship Region Energy”. The goal is to make Austria an international innovation leader. Energy technologies and solutions “Made in Austria” are being developed in the flagship regions. Their use in real-life operations is being demonstrated on a large scale and made visible internationally. With funding from the Federal Ministry for Transport, Innovation and Technology (BMVIT), the Climate and Energy Fund will invest a total of EUR 120 million in three Austrian flagship regions until 2021. The initiative will last until 2025.

A variety of collaborations between companies and research centres (from start-ups and SMEs to international industrial players) ensure that innovative global solutions are being developed. Their focus lies on the reduction of emissions and the sustainable provision of affordable clean energy.

The RTI initiative combines instruments which stimulate research and environmental protection (technology readiness levels 5-9), thereby supporting companies in the testing and market introduction of innovative energy technologies.

#### **Exemplary solutions with up to 100% renewable energy**

Innovative Austrian energy technologies should prove that 100% renewable energy supply from largely regional sources is possible. In this context, an optimized system must be developed and implemented for all market participants. This system must ensure that production, consumption, system management and storage have all been perfectly aligned with one another. Sector coupling and system integration have an important role in this regard. These flagship regions should result in a forward-thinking, safe and affordable energy and transport system.

Austria wants to establish itself internationally as a leading market for innovative energy solutions. Austrian technology providers should thus maintain their leading position in an international competitive context and continue to develop further. In addition, new jobs should be created in industries with a promising future.

#### **Particularly beneficial to the public**

A crucial part of the RTI initiative is the involvement and active participation of users. The use of new energy technologies will be tested and demonstrated, simulating real-life conditions as much as possible. That way the public can experience first-hand the use of innovative energy solutions in large-scale projects. This should lead to a greater acceptance and confidence in Austria's leading technologies. The flagship regions will also resolve economic and administrative issues pertaining to technological issues.

# Flagship Regions 3

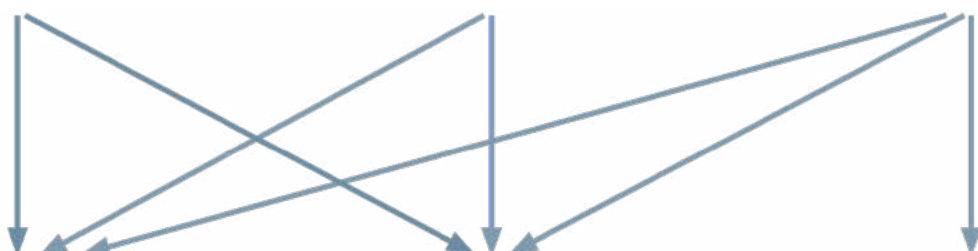
# 228 Partners

# Total Budget 395 € million

The **Green Energy Lab** flagship region in eastern Austria will be a living lab for the energy system of the future with a significant high share of renewables. This concept is based on flexibility and system integration through the digitalization of networks, infrastructures and end consumers (see page 38).

**NEFI – New Energy for Industry** demonstrates how Austrian manufacturing and energy-intensive industries can be decarbonised through 100% renewable energy supply. This flagship region is being implemented in selected locations in Lower Austria, Upper Austria, Salzburg and Styria. The focus lies on digitalization, which will allow a greater flexibility of energy systems and industrial processes (see page 48).

**WIVA P&G – Hydrogen Initiative Flagship Region Austria Power & Gas** entails research on how to find solutions for a hydrogen-based energy and mobility system. The focus of this research lies on the production, storage, distribution and use of renewable hydrogen for energy supply, industry and mobility (see page 58).



#1

Smart Grids



#7

Affordable Heating  
and Cooling of Buildings

#8

Renewable  
and Clean  
Hydrogen

# ENERGY RESEARCH

## New options for the energy transition

The Energy Research Initiative is central to research and innovation in the federal government's climate and energy policies. The Climate and Energy Fund's Energy Research Programme supports the implementation of Flagship 9, "Building Blocks for Energy Systems of the Future", which is part of the Energy Research Initiative of the Austrian Climate and Energy Strategy. It is pushing research and development of energy and mobility technologies for the future, with significant growth potential both domestically and abroad. Within this framework companies and research institutions are developing innovative energy solutions along the entire energy value chain. Their focus lies on energy systems and networks, industrial energy systems and transport and mobility systems in terms of optimized energy efficiency as well as conversion and storage technolo-

gies. New materials and innovative technologies, processes and system solutions are being tested and made ready for the market.

### **ICT as an enabler of energy innovation**

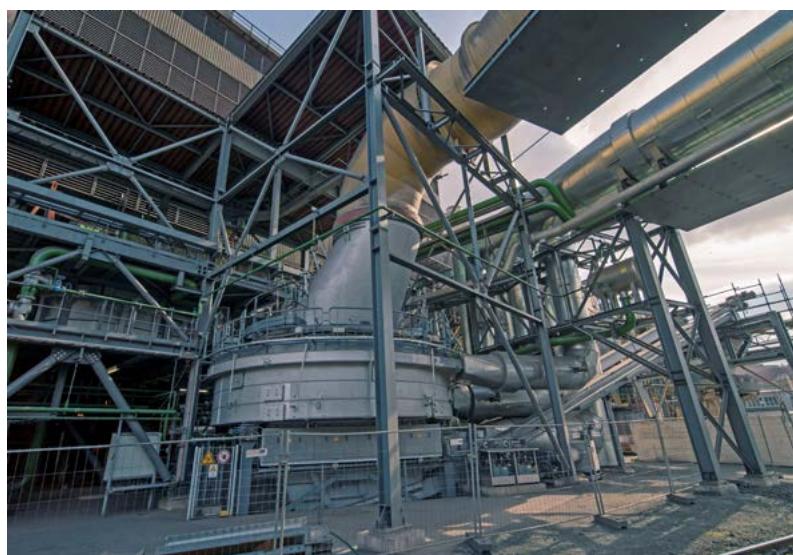
An important interdisciplinary topic in energy research is digitalization. Increased flexibility and sector coupling will play an important role in the supply of energy in future. As regards MI Challenge #1, innovative ICT-based technologies and their application in energy systems (networks, industry, production and storage) will be emphasised in particular. Research topics related to ICT solutions include, among others, how to integrate storage facilities into energy systems, determining industrial facilities' energy requirements or how

to supply energy using volatile renewable sources. Furthermore, digitalization is an enabler of new services, products and business models. The newly developed technologies will be validated in pilot projects (key word: "the local market as a test market"). Hence, this programme will help to make Austrian industry more visible on the global market.

**[www.energieforschung.at](http://www.energieforschung.at)**

The Climate and Energy Fund's Smart Cities Initiative has been supporting Austrian cities and municipalities on their way to becoming zero emission cities since 2010.

**[www.smartcities.at](http://www.smartcities.at)**



### **FORWÄRTS 2.0**

An innovative concept for dry granulation of blast-furnace slag has been developed by Primetals Technologies Austria GmbH, and this is currently being tested in a pilot facility at the voestalpine Stahl GmbH furnace in Linz. This innovative process makes it possible to recover the heat given off to the air and use it in further processes. With the newly developed dry slag granulation process, water consumption can be cut by up to 95%. In addition, no energy is needed to dry the slag sand. [www.primetals.com](http://www.primetals.com)

*Photo: Primetals Technologies Austria GmbH*

# CITY OF TOMORROW

## Solutions for urban living space

City of Tomorrow is a research and technology programme which focuses on R&D related to urban technologies, technological (sub-)systems as well as services. This programme is contributing to the modernisation and the sustainable development of cities. The "City of Tomorrow" should combine optimized energy and resource efficiency with attractiveness for residents and business.

The main focus lies on reducing energy consumption (electricity, heating and cooling) and the use of renewable energy in building compounds, housing schemes and districts in the city. These two criteria will be taken into account both when constructing new buildings and renovating existing ones. Another important aspect of the programme is the optimisation of building technology, new low-tech approaches and the development of new, energy-efficient construction materials that use resources sparingly.

In terms of Mission Innovation Challenge #7, The City of Tomorrow programme focuses, in particular, on the following technological considerations:

### **On the path towards plus-energy districts**

Pilot projects should make the vision of plus-energy districts as an integral part of attractive and liveable urban areas and cities more visible.

### **Urban overheating and green cities**

In view of the climatic changes that are to be expected, the ecological functions of buildings and building complexes in an urban context will become increasingly important when addressing the issue of urban overheating. By focusing on urban greening technologies, this will be conducive to the development of innovations for green cities.

### **Digitalization in urban planning and construction**

Digitalization is a topic which increasingly affects all aspects of the economy. Furthermore, it will lead to a transformation of the construction industry as well as urban and building planning. Funding will be allocated towards projects dedicated to the implementation of digital technologies and processes in construction, in order to address this issue for the future.

[nachhaltigwirtschaften.at/de/sdz/](http://nachhaltigwirtschaften.at/de/sdz/)



Photo: AEE-INTEC

# **INTERNATIONAL PARTNERSHIPS**

## Austria's involvement in research networks

IEA Research Cooperation

Global solutions are required if we want to create a clean and sustainable energy future. In the next few years, new growth markets for sustainable energy technologies will appear across the globe. Austria is involved in several international research projects and has been a member of the International Energy Agency (IEA) since it was founded in 1974. Participation in this international energy technology network promotes the exchange of ideas and strategic, techno-political knowledge. At the same time, it is also an opportunity to show Austria's strengths worldwide.

Around 6,000 experts from 54 countries are working together in a total of 38 “Technology Collaboration Programmes” (TCPs). The national “IEA Research Co-operation” programme enables Austrian experts to participate actively in this network. Austria is currently involved in 21 TCPs with around 88 individual projects. These projects focus mostly on renewable energy sources and end-use technologies (energy efficiency, transmission and storage).

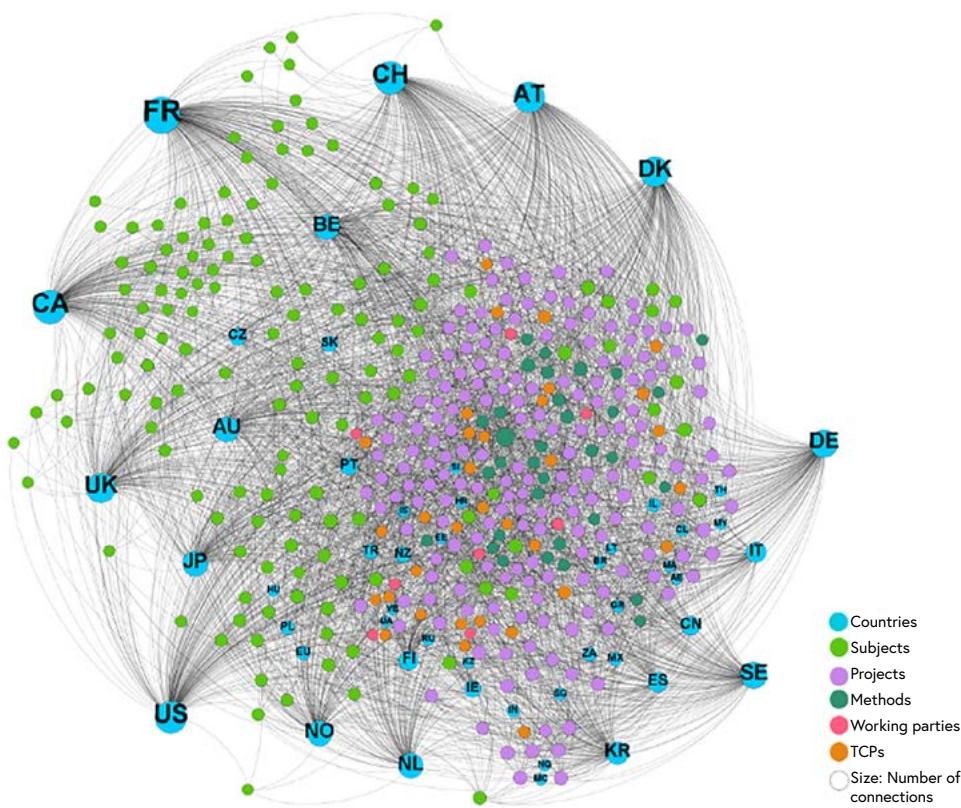
nachhaltigwirtschaften.at/de/iea/

## **Joint Programming Initiative Urban Europe**

**JPI Urban Europe** is a strategic research and innovation programme whose goal is to find European solutions creating forward-thinking, liveable and prosperous cities of the future through coordinated urban research and development.

Eight transnational tenders have come to fruition in this network of 20 European countries, chaired by Austria, since 2012. Under Austria's presidency, a programme has been developed as part of the SET-Plan: from 2018 to 2025, 100 European plus-energy districts are being planned and built. A key aspect of this activity is the possibility to draw on JPI Urban Europe's programme-management structures and experiences.

[ipi-urbaneurope.eu](http://ipi-urbaneurope.eu)



## *International collaboration within the framework of IEA TCPs*

**Source:** The Austrian Energy Agency, 2018

## SCIENCE TOWER – SMART CITY GRAZ

Countless innovative components have been tested and implemented into demonstration buildings in the Smart City Graz: new solar modules, solar cooling systems, urban solar power generators, integrated facade technologies, mini cogeneration plants, etc. The “Wagner Biro” model district’s centrepiece is a 60 metre research tower, owned by SFL Technologies GmbH. Part of the Science Tower’s facade is covered in dye-sensitized solar cells, which convert light into electricity. This innovative technology was realised on a large scale here for the first time. This forward-thinking building houses innovative companies and research centres which focus on urban and green technologies.

[www.smartcitygraz.at](http://www.smartcitygraz.at)

## Joint Programming Platform ERA-NET Smart Energy Systems

ERA-NET helps to support the coordination of national and regional funding programmes (within the framework of the EU’s Horizon 2020 programme), thereby fostering cross-border research and technological cooperation in Europe.

The joint programming platform **ERA-NET Smart Energy Systems** is an important instrument in terms of supporting transnational RTI collaborations related to smart energy system research. This platform makes a significant contribution on realising the objectives in connection with Action 4 of the European Strategic Energy Technology Plan (SET Plan): “Increase the resilience and security of the energy system”. Austria is head of the joint programming platform, which includes 30 funding partners from 23 countries. Its goal is to initiate and promote specific transnational RTI projects in cooperation with regional stakeholders and consumers from the participating countries.

[www.eranet-smartenergysystems.eu](http://www.eranet-smartenergysystems.eu)



Science Tower – Smart City Graz,  
Photo: Climate and Energy Fund/Gerhard Buchacher

Other ERA-NET platforms in which Austria is actively involved include **ERA-NET Bioenergy**, in charge of coordinating national bioenergy research programmes transnationally, and **SOLAR-ERA.NET**, a network dedicated to solar power technologies. Their goal is to help implementing the European Strategic Energy Technology (SET) Plan, through select cross-border tenders.

[www.eranetbioenergy.net](http://www.eranetbioenergy.net)

[www.solar-era.net](http://www.solar-era.net)



# SUCCESS STORIES

Innovative climate and energy solutions  
from Austria

A residential building in Vienna's Seestadt Aspern  
Photo: Projektfabrik Waldhör KG



**"The city of tomorrow  
combines climate protection  
with a high standard of living"**

# MAKE CITIES MORE LIVABLE

Urbanisation, globalisation, demographic growth and climate change all pose serious challenges for the cities of tomorrow. For cities to have a promising future, they must combine environmental protection, efficient use of resources, a high standard of living and attractive working conditions. At the same time, urban areas offer good opportunities to implement new solutions and concepts for a sustainable use of energy and material resources. The city of tomorrow is characterised by an intelligent system design which brings together new technologies and services for buildings and infrastructure, energy production and distribution, mobility, industrial production and small-scale manufacturing.

Buildings will take on a new role in future energy systems, both in connection with and through interaction with the infrastructures that provide energy. In addition to increased efficiency and a reduction of energy consumption in the building stock, new buildings must have increased flexibility, i.e. increased adaptability, to base energy consumption on

the levels of energy currently available. In future, buildings, housing schemes and entire city districts will move from being energy consumers to decentralised power plants. As plus-energy districts, they can be integrated into the energy system across sectors to ensure that production and consumption are balanced on a local level.

Due to their consumption of energy and resources as well as their high level of pollutant emissions, cities are speeding up climate change rapidly. At the same

time, they are also most affected by climate change. In addition to air pollution, smog and noise pollution, ever-rising temperatures and extreme weather phenomena pose a threat to the quality of life and the health of cities' inhabitants. Innovations for green cities, such as greening on buildings located in densely populated areas, can play an important role in increasing urban systems' ability to adapt to climate change and in sustainably improving the quality of life in cities.



*Photo: Andrei Merkulov/stock.adobe.com*



Photo: pawel-czerwinski/unplash

# INNOVATIONS FOR GREEN URBAN OASES

Building density, a very high percentage of impermeable surfaces and limited vegetation lead to rising temperatures and an unhealthy microclimate in cities. Extreme weather events such as heat waves, strong winds, storms and torrential rain occur more often due to global warming. They exacerbate the situation and have a negative impact on the health and quality of life of many of the city's inhabitants.

Green and open spaces such as greening on buildings, parks, green corridors, functional tree-planting, rain gardens and community gardens can make an important contribution to improving cities'

microclimate and hydro-logical balance, mitigating the heat-island effect and coping with extreme weather events. In addition, green infrastructures in cities help to diminish air pollution, noise, dust and carbon dioxide emissions, and they lower the costs of energy and air-conditioning for buildings. Green open spaces are also important for social interactions. They are places where people come together and engage in common activities, thereby improving the quality of life for cities' inhabitants.

## Smart concepts for green infrastructure and against urban overheating



### MUGLI

MUGLI is a former shipping container that has been greened. It was transformed into a mobile exhibition space servicing destinations in Austria and abroad. Visitors can experience building greening first hand; MUGLI also offers information and knowledge targeted to the broad public. In addition, MUGLI serves as a modular space where network partners can experiment on existing and new technologies. It generates measurement data on local weather conditions, water and energy consumption in real time.

MUGLI, Photo: GRÜNSTATTGRAU



*Greenery on a roof through urban gardening, Sargfabrik, Vienna; Photo: GRÜNSTATTGRAU*

## The innovation laboratory GRÜNSTATTGRAU

GRÜNSTATTGRAU is a holistic competence centre for greening on buildings and develops and coordinates innovations for the green, smart city of tomorrow. It was launched within the framework of the City of Tomorrow programme to promote collaboration and synergies in the research sector "Green City" and to support the implementation of cutting-edge projects. GRÜNSTATTGRAU is run by the Austrian Association for Greening Buildings (Verband für Bauwerksbegrünung/ [www.gruenstattgrau.org](http://www.gruenstattgrau.org)).

This innovation laboratory serves as the interface between network partners from the public sector, business and research. GRÜNSTATTGRAU promotes the sharing of best practices and provides an impetus for existing and new technologies, skills and services.

In order to take increased advantage of synergies between rooftop greening and photovoltaic systems, GRÜNSTATTGRAU works in collaboration with the innovation laboratory act.4.energy (see page 41). [www.act4.energy](http://www.act4.energy)

Its goal is to support a sustainable market development of technologies for green cities as well as to make these technologies affordable and their use widespread. After being launched with over 300 partners in 2017, this interdisciplinary network continues to grow. In addition to detailed information on how to green roofs and facades, visitors to the web platform [www.gruenstattgrau.at](http://www.gruenstattgrau.at) will also find a new digital database for companies, experts, products and construction and research projects.

This will make networking, finding collaboration partners and the implementation of greening initiatives through high-quality systems easier and more targeted.

## INNOVATION LABORATORIES

With this funding instrument, the Federal Ministry for Transport, Innovation and Technology (BMVIT) supports long-term testing and innovation processes. Innovation laboratories initiate, coordinate and accompany various RTI projects and ensure their long-term effectiveness. Within the innovation laboratories, the goals, strategies and measures in a specific thematic field are developed and the dissemination of the research results (in the national and international environment) is promoted.



*PV and greenery on a roof, Photo: GRÜNSTATTGRAU/Dusty Gedge*

# THE PLUS-ENERGY HIGH-RISE OFFICE BUILDING OF TU WIEN

The plus-energy high-rise office building of the TU Wien (Vienna University of Technology), located in the city centre and completed in 2014, is a pioneering example of the sustainable construction and renovation of office buildings. Originally built in the 1970s, the building was completely renovated as part of a research project. An interdisciplinary team of experts developed innovative strategies and technologies for extremely high energy efficiency in office buildings in an integrated planning process. The multitude of pioneering solutions that came about are being showcased in Austria's largest plus-energy office building.

This research and construction project is an example of successful interdisciplinary networking and integrated planning. More than 20 partners from research and industry\* collaborated on the project from its inception to its practical imple-

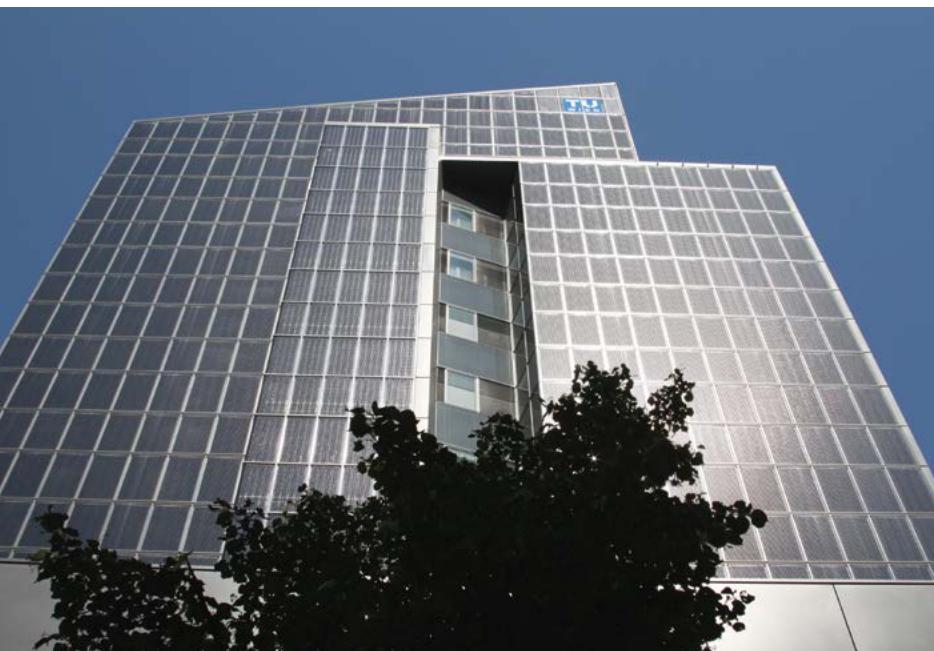
mentation. The entire building has a net floor area of 13,500 m<sup>2</sup> on 11 floors, and provides high-quality work stations for around 800 of the university's employees and students. In 2014 it was the first

were improved and a large number of pioneering solutions integrated into a comprehensive strategy. It was important for the team that the new developments will be scalable.

## Innovative building put into practice

high-rise office building worldwide designed to produce more energy than is needed to operate and use the building.

In terms of energy use, office buildings are very different from residential buildings; offices have a higher occupancy and are equipped with many devices that emit heat as a by-product of their operation. Lighting, indoor temperature and air quality must comply with special requirements and be aligned with the office's work-related needs. During the planning process, more than 9,000 components



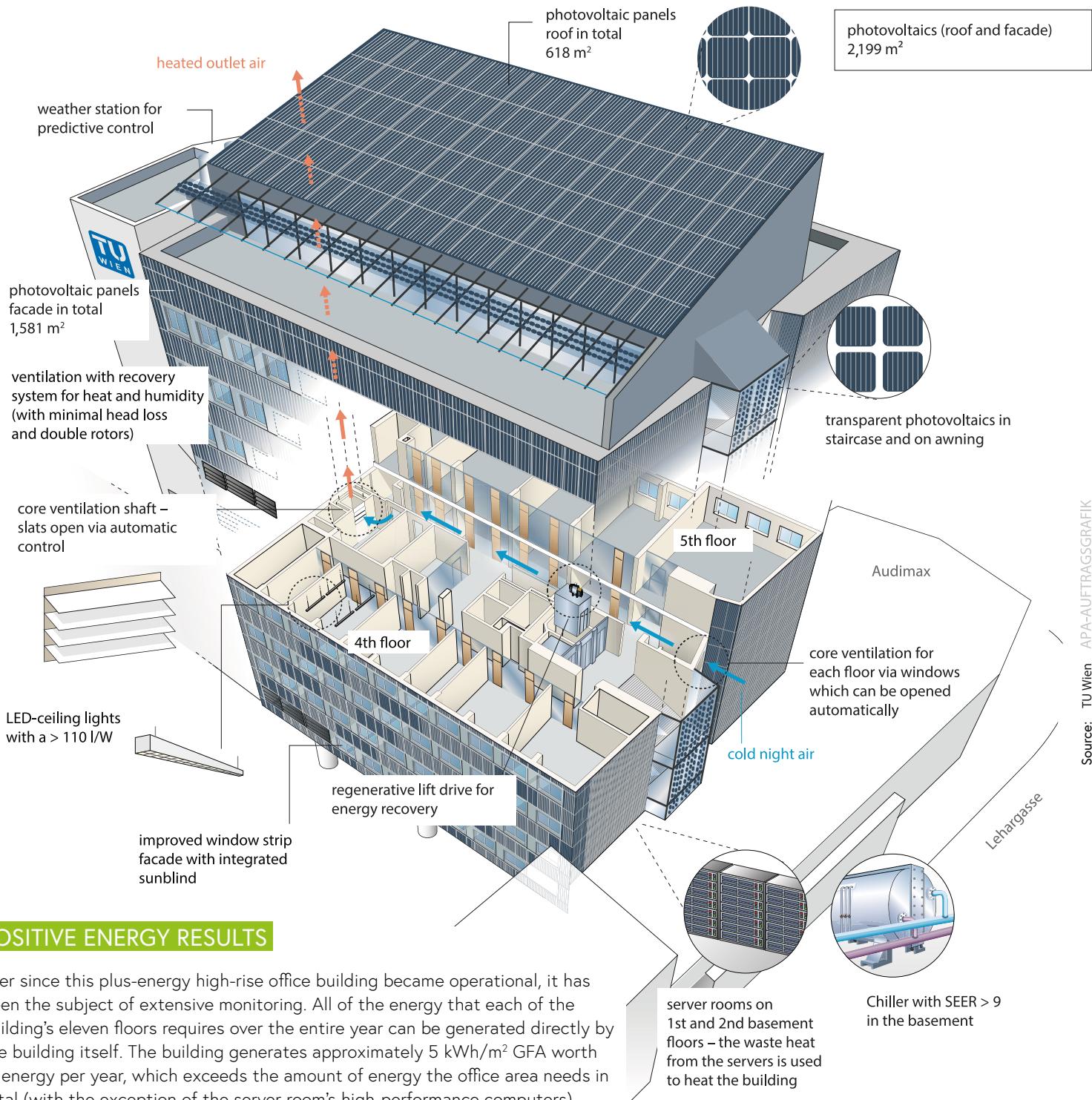
TU plus-energy high-rise office building after being renovated, Photo: TU Wien



Entrance area (above), cooling machine (below),  
Photos: Projektfabrik Waldhör KG

\* General planning: ARGE Architects Hiesmayr-Gallister-Kratochwil; scientific support in the processes of planning, construction and becoming operational: TU Wien experts (Research group for Building Physics and Sound Protection, Thomas Bednar), Building Physics planners from Schöberl & Pöll GmbH; Project realisation: TU Wien in cooperation with the Federal Ministry of Science, Research and Economy (bmwf) and BIG Bundesimmobilien gesellschaft mbH; Funding for research and technologies provided by: the Federal Ministry for Transport, Innovation and Technology (BMVIT); additional funding provided by the Austrian Research Promotion Agency (FFG), Kommunal kredit Public Consulting (KPC), The City of Vienna (Municipal Department MA 20 - Energy Planning).

## AN INNOVATIVE ENERGY CONCEPT AND HIGHEST ENERGY EFFICIENCY



## POSITIVE ENERGY RESULTS

Ever since this plus-energy high-rise office building became operational, it has been the subject of extensive monitoring. All of the energy that each of the building's eleven floors requires over the entire year can be generated directly by the building itself. The building generates approximately 5 kWh/m<sup>2</sup> GFA worth of energy per year, which exceeds the amount of energy the office area needs in total (with the exception of the server room's high-performance computers).

[www.univercity.at/plusenergiehochhaus](http://www.univercity.at/plusenergiehochhaus)



## SMART URBAN DEVELOPMENT ASPERN – VIENNA'S URBAN LAKESIDE

aspern, Vienna's Urban Lakeside, is one of Europe's largest urban development areas. A new sustainable city district, which combines a high standard of living with dynamic economic power, will be created in north-eastern Vienna by 2028. High-grade housing will be built for more than 20,000 people, and nearly as many jobs will be created there; these projects will be implemented in several steps.

At the same time, the Urban Lakeside serves as a testing ground for innovative energy technologies and solutions in

urban spaces. Within the framework of numerous R&D projects, new developments for smart and energy-efficient urban development involving users will be tested and demonstrated in practice. Aspern Smart City Research GmbH & Co KG (ASCR) is a research centre focusing on all aspects of the future energy system: smart grids, smart buildings, smart ICT and smart users.

[www.ascr.at](http://www.ascr.at)

### SMART CITY DEMO ASPERN

The Climate and Energy Fund\* has created a testing area in aspern within the framework of its three-year Smart City Demo Aspern lead project. This testing area comprises a kindergarten/primary school, a student residence and a residential building, with research being conducted on how to find solutions that increase energy efficiency. Using real data, it is possible to find out how buildings or entire building complexes can use locally produced PV power surpluses and supply them on the market for electricity at a profit. Testing was conducted on the active control of a low-voltage network, intelligent connection of buildings and the low-voltage network, using innovative information and communication technologies, and maximising the flexible use of buildings. Users and residents were actively involved so that conclusions could be drawn about the functionality, strengths and weaknesses of the technologies and regulating systems used.



aspern Campus – Vienna's Urban Lakeside, Photo: ASCR

\* Project partners: Siemens AG Austria, Wien Energie GmbH, Wiener Netze GmbH, AIT Austrian Institute of Technology GmbH, MD-Stadtbaudirektion project coordination Vienna's Urban Lakeside aspern, MA 18 Urban Development and Planning, Moosmoar Energies OG, Käferhaus GmbH, SERA energy & resources e.U.

## LOCAL STORAGE SYSTEMS – NEW OPTIONS FOR NETWORK SERVICES

The FACDS (Flexible AC Distribution Systems) research project, headed by Wiener Netze GmbH\*, is investigating how network storage systems can be used to improve distribution networks. Local network storage systems are a new facility for distribution network operators; they can be put to work flexibly and actively, and regulated dynamically. These network storage systems result in a variety of options for network services. The project's goal was to find out what requirements a local storage system has to fulfil within a classic distribution network. These requirements relate to network stability and quality and to ensure a reliable power supply as more power is generated and fed in locally and a large number of new consumers (e.g. electric vehicles) appear on the scene.



FACDS inverter, Photo: Wiener Netze GmbH

\* Project partners: Wien Energie GmbH, Siemens AG Austria, AIT Austrian Institute of Technology GmbH, Energy Institute at Johannes Kepler University Linz, ASCR, Research Burgenland GmbH

### Testing in aspern

This innovative concept was tested under real-life conditions in Vienna's Urban Lakeside aspern. These conditions included simulations, laboratory operation and the implementation of a full-scale network storage system. This system boasts five battery storage units, which were installed in ASCR's (Aspern Smart City Research) smart transformer stations. It consists of a lithium iron phosphate battery with a power rating of 100 kW and a capacity of 120 kWh, plus an inverter. Testing was conducted on dimensioning storage capacity and various operating modes in the distribution network.

### Cost-effective operation thanks to multiple utilisation

The project also investigated how various different stakeholders can use network storage systems jointly. The goal was to improve the cost-effectiveness of operating electrochemical storage systems. Apart from utilisation by the distribution network operator, the network storage system could also help operators of local facilities to improve their own energy consumption. Another option is to allow energy providers to store electricity in the network storage system when wholesale prices are low, and supply it to customers later at the market price. The research team prioritised the use of storage capacity and inverter power for network services; only residual potential should be employed to improve cost-benefit ratios.

[www.ascr.at](http://www.ascr.at)

## GEOTIEF WIEN – USING HEAT FROM THE DEPTHS OF THE EARTH

Hydro-geothermal energy is a source of thermal energy that is available 365 days of the year, generated locally, renewable and environmentally friendly. It is highly probable that there are large hot springs located underground in the eastern part of Vienna. The heat could be used and fed into Vienna's district heating network. "GeoTief Wien" is a research project being conducted by Wien Energie in cooperation with partners from research institutes and industry. It is an in-depth investigation of how hydro-geothermal energy in eastern Vienna could be used. The project's goal is to provide extensive knowledge of the hot springs and their occurrence in the depths of the earth.

A large-scale, 3D geological model of the designated zone's underground surfaces is being developed to that end. In addition, detailed analyses are being conducted on how to integrate geothermal energy into Vienna's existing district heating network. The project's outcome should be an optimal strategy on how to successfully integrate environmentally friendly geothermal energy into Vienna's existing network based on an understanding of the entire system and taking technical, economic and regulatory aspects into account. This would allow Vienna to establish itself as a model region for a sustainable and economically viable heating supply based on geothermal energy and to pave the way for intensive use of this type of energy in Austria.

[www.geotiefwien.at](http://www.geotiefwien.at)



Photo: Wien Energie GmbH

# THERMALLY ACTIVATED BUILDING SYSTEMS

Thermally activated building systems (TABS) are an innovative approach to the energy-efficient heating and cooling of buildings. When constructing a building, pipes that register thermal activity are built into large components; these pipes then serve as a conduit for warm or cold water, depending on the time of year. These thermally activated concrete components are surface collectors used to regulate the building's temperature. The components release heat uniformly in the winter, and in the summer they absorb energy surpluses, which results in a building with optimal thermal comfort.

## Building masses as storage systems for renewable energy

These pipes that register thermal activity can be incorporated into the concrete components quickly, easily and affordably. The reinforced concrete that makes up the top level of a ceiling is particularly well-suited to the use of TABS. Owing to its high material density, concrete is an excellent heat accumulator and a very good thermal conductor. Because of concrete's high thermal conductivity, the thermally activated components can absorb heat quickly and release it gradually and uniformly throughout the entire building.



Thanks to its low surface temperature, the radiant heat emitted by the components warms rooms to a comfortable temperature.

### **Use renewable energy sources**

Even on extremely cold winter days, the water circulating through the pipes only needs to be around 30 °C to create a pleasant room temperature. This only works when the building envelope is well insulated.

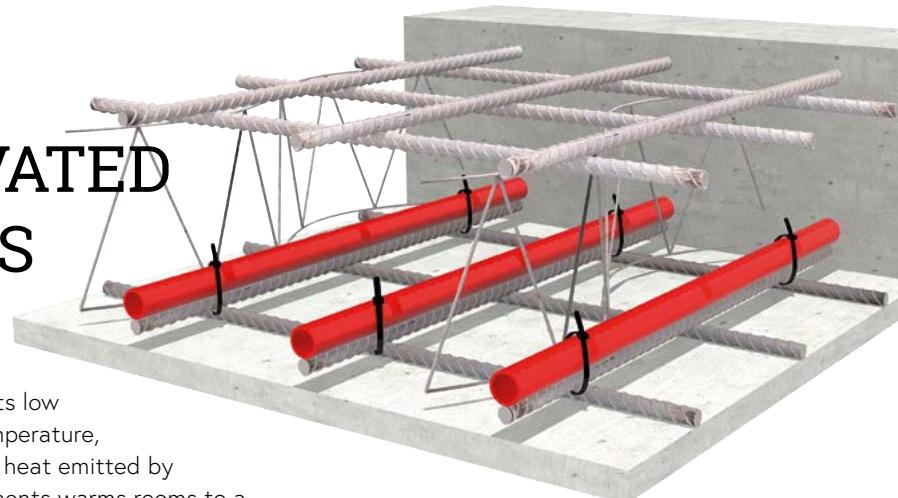


Chart: Z+B, Schwabl

heat waves in the middle of the summer can be counteracted effectively through relatively high coolant temperatures (around 20 °C). Ideally, a building with air conditioning from a TABS will only require the energy needed to run a circulation pump.

### **Surplus energy storage**

Energy storage systems will become more important in view of increased use of volatile renewable energy sources. As concrete is an excellent heat accumulator, combined with a thermally activated building system it is possible to take advantage of its potential as a highly efficient energy storage unit. For example, surplus energy from renewable sources can be converted to heat and stored temporarily in layers of concrete. Loading the storage system, for example, in the form of a thermally activated layer, is also possible in sporadic intervals and does not result in unpleasantly cold temperatures in the room being heated. When there are several buildings with TABS, peak electricity generated through renewable energy sources can help to alleviate grids during peak times and, conversely, reduce the demand for energy during periods where supply is limited.

Consequently, the use of energy is significantly lower as compared to traditional methods of heating. Due to its low flow temperatures, TABS are highly suitable for use with renewable energy sources, such as solar thermal energy, geothermal energy and heat pumps, which are mostly powered by electricity from wind turbines or photovoltaic systems.

### **Energy-efficient cooling**

In view of climate change, the demand for energy-efficient solutions for air conditioning in office buildings and residential complexes will increase. Thermally activated building systems are also suitable for air conditioning in buildings. Thanks to their large thermally active surfaces, the overheating which occurs during

*Installing a thermally activated building system in the top level of a ceiling,*  
Photo: Aichinger Hoch- und Tiefbau GmbH



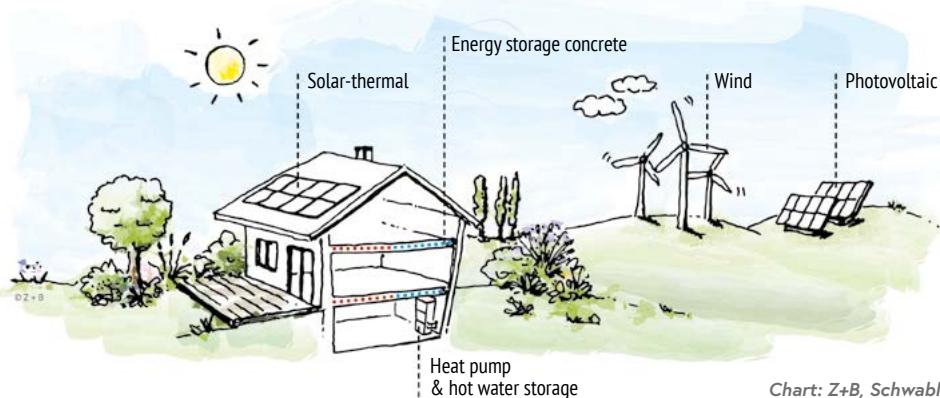
Mühlgrundgasse construction project, 1220 Vienna, both photos: MA 20, A. Kromus

## PROJECT MGG22 – SUBSIDISED HOUSING WITH A CUTTING-EDGE ENERGY CONCEPT

Funded by the City of Vienna and the Federal Ministry for Transport, Innovation and Technology (BMVIT), an innovative construction project has been brought to life in Mühlgrundgasse, in Vienna's 22<sup>nd</sup> district. For the first time ever, a combination of TABS and wind power is being used for a subsidised housing complex's heating and cooling systems. The housing complex with 155 flats is being built by the non-profit housing association Neues Leben in cooperation with the real estate developer M2plus Immobilien GmbH.

The energy needed for heating and warm water will be generated by a combination of 9 brine-water heat pumps and 30 geothermal ground probes. The temperature of the geothermal energy collected from the earth can be increased when heating is required using a heat pump. When the building needs to be cooled down in summer, heat can be transferred underground.

A wind power load management system ensures that most of the power needed to operate the heat pumps comes from surplus wind power. The energy which has been converted into heat can be stored temporarily in the layers of concrete in the building complex. Only around one quarter of the energy needed to heat the building year-round has to be provided through additional sources of conventionally generated electricity.



## PLANNING GUIDELINES

The planning guideline "Thermische Bauteilaktivierung" (VÖZ on behalf of the Federal Ministry for Transport, Innovation and Technology, in German) summarises all knowledge on thermally activated building systems that has been gathered until now. Additionally, it provides planners and builders with detailed instructions as well as basic information on additional training options. The guideline addresses questions related to building physics, building planning, the underlying building systems and their regulatory aspects as well as the sustainable supply of energy.

[nachhaltigwirtschaften.at/resources/sdz\\_pdf/schriftenreihe-2016-9-energie-speicher-beton.pdf](http://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe-2016-9-energie-speicher-beton.pdf)

# INNOVATIVE COMPANIES FROM AUSTRIA

## S.O.L.I.D. GESELLSCHAFT FÜR SOLARINSTALLATION UND DESIGN MBH



**Collector test of various collector types with 3,123 m<sup>2</sup> for solar district heating feed-in at the district heating plant Puchstrasse in Graz, Austria; Photo: S.O.L.I.D. GmbH**

Founded in 1992, the Graz-based solar technology company S.O.L.I.D. has developed from a regional specialist into one of the world's leading suppliers of large solar heating and cooling systems. S.O.L.I.D. sees itself as a competent partner for the planning, construction and operation of large-scale solar thermal systems worldwide with more than 300 reference projects. The areas of application range from hot water preparation, room heating and cooling, to process heating and cooling as well as solar district heating.

S.O.L.I.D. is manufacturer-independent and uses only state-of-the-art products. Research & development is a central element of the firm philosophy and indispensable for the advancement of the enterprise. Thus, new holistic and innovative system approaches can be developed, which on the one hand further advance the energy transition and on the other hand receive the own pioneer position at the market.

### S.O.L.I.D. Gesellschaft für Solarinstallation und Design mbH

Puchstrasse 85, 8020 Graz, Austria

[office@solid.at](mailto:office@solid.at)

[www.solid.at](http://www.solid.at)



The Pink GmbH has many years of experience in the field of steel and stainless-steel processing and welding technology, with the main focus on the design and manufacture of storage tanks made of steel and stainless steel for various applications. The Pink GmbH is also successful in the field of thermal solar technology, whereby all components for thermal solar systems including the planning and control of such plants can be offered. In addition, the company has extensive experience in the design and the implementation of refrigeration systems with thermally driven chillers, whereby external chillers are used as well as the self-developed and self-made product "PinkChiller". In the business area of "energy engineering", in addition to the development of energy concepts the simulation software "simplex" is developed and used exclusively, which allows the detailed calculation and optimization as well as the control of district heating systems.

**Pink GmbH**  
Bahnhofstrasse 22, 8665 Langenwang, Austria  
[info@pink.co.at](mailto:info@pink.co.at)  
[www.pink.co.at](http://www.pink.co.at)

### PINK GMBH



*Fig.: Pink GmbH*



*Photo: Wien Energie/Ian Ehm*

*“Innovations provide the decisive leading edge in the highly competitive energy sector. By pushing for solar energy, Wien Energie is moving forward. Consumers’ interest in clean energy produced in your own home has risen significantly over the past few years. After having evaluated the options available, such as the creation of new, local energy communities, solar power will become more and more important. The goal is to generate a large part of the power entire districts need through self-sufficiency.”*

*The power that has been generated in a district will be distributed among inhabitants according to their needs. If no one uses the power, it will be sold to others or even used for charging stations in the district. By using new technologies, such as Blockchain, this could all take place in future automatically and according to economic criteria. Linking various sectors, like mobility and energy, or also using the option of new energy communities make the market for energy accessible to completely new competitors.”*

**Michael Strebl**

**Managing Director, Wien Energie GmbH**

**Member of the Mission Innovation Austria Advisory Board**



**GREENONETEC SOLARINDUSTRIE GMBH**

As the world's leading thermal flat-plate collector manufacturer, GREENoneTEC is one of the enablers for an emission-free heat supply. A key element of the energy transition and an important business activity of GREENoneTEC is the solarisation of district heating. Regarding the high area efficiency, solar district heating is the way to go to achieving a CO<sub>2</sub>-neutral heat supply in urban areas. The series GK3003 large-size collector – specially developed for this application – is technologically advanced and has proved its efficiency in many different pilot projects worldwide.

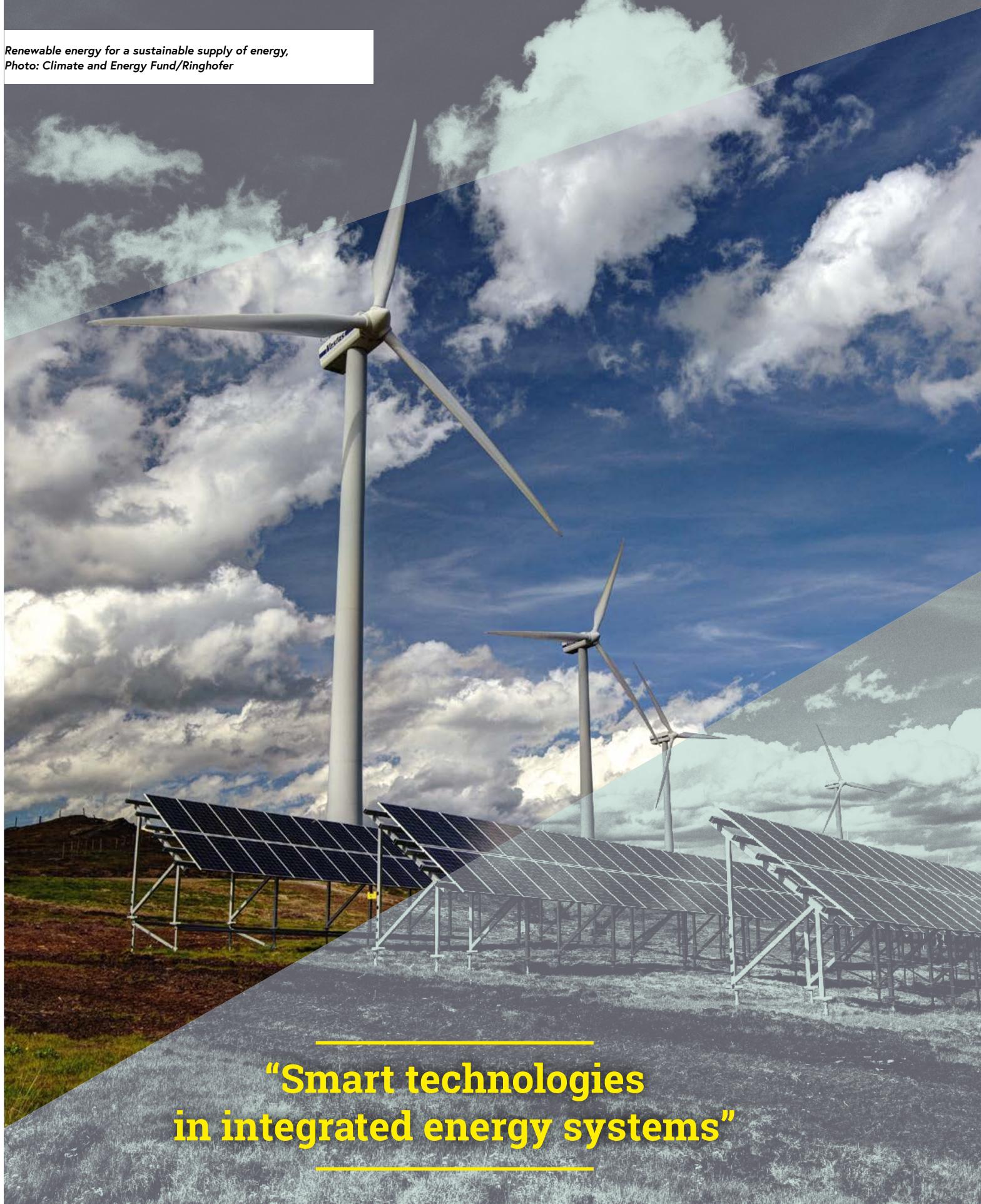
As a collector manufacturer from Austria with considerable project experience GREENoneTEC is a reliable partner for the implementation of a cost-optimized solar heat supply. Further business units of GREENoneTEC are solar thermal collectors in customized OEM versions and system solutions for decentralized solar heat (Thermosiphon CLASSIC, Sunpad).

**GREENoneTEC Solarindustrie GmbH**  
**Industriepark St. Veit, Energieplatz 1, 9300 St. Veit/Glan, Austria**  
**sebastian.schramm@greenonetec.com**  
**www.greenonetec.com**



*The beginning of a sustainable heat supply,  
 Source: GREENoneTEC*

*Renewable energy for a sustainable supply of energy,  
Photo: Climate and Energy Fund/Ringhofer*



A composite photograph illustrating renewable energy. The upper portion shows several white wind turbines with three blades each, set against a backdrop of a blue sky filled with large, white, billowing clouds. The lower portion shows a field of solar panels, which are dark rectangular panels mounted on metal frames, angled towards the sun. The entire image is framed by a diagonal grey band at the bottom.

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**“Smart technologies  
in integrated energy systems”**

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# INTELLIGENT ENERGY SUPPLIES OF TOMORROW

The growing number of renewable energy sources and the increased decentralisation of energy generation mean that our energy networks need to be adapted. In addition to a large number of local producers such as photovoltaic, wind and biomass systems, in future new "consumers" (e.g. e-bikes or heat pumps) and storage systems will have to be integrated into the energy system.

To ensure a smooth transition in terms of the energy supply's structural changes, various aspects of and sectors involved in the system must work together harmoniously. Sector coupling, i.e. the inter-relationship between power, heating and mobility, is a key concept for the optimal use and integration of renewable energy sources. The energy networks of the future will require smart components that communicate with each other in order to ensure secure, stable and sustainable network operations.

Digitalization will be a key skill here. New energy management systems based on ICT technologies will enable links to be created within the infrastructure, across multiple sectors between networks and with all energy stakeholders.

Energy research and technological development in Austria are being conducted and taking place in a systematic manner, with all aspects of the energy value chain being taken into account. The goal is to create solutions for an integrated system based on renewable resources by merging different conversion and storage technologies in hybrid systems in buildings, industry, networks, as well as in traffic and mobility systems. This should result in the creation of sustainable solutions for an integrated system based on renewable energy sources.

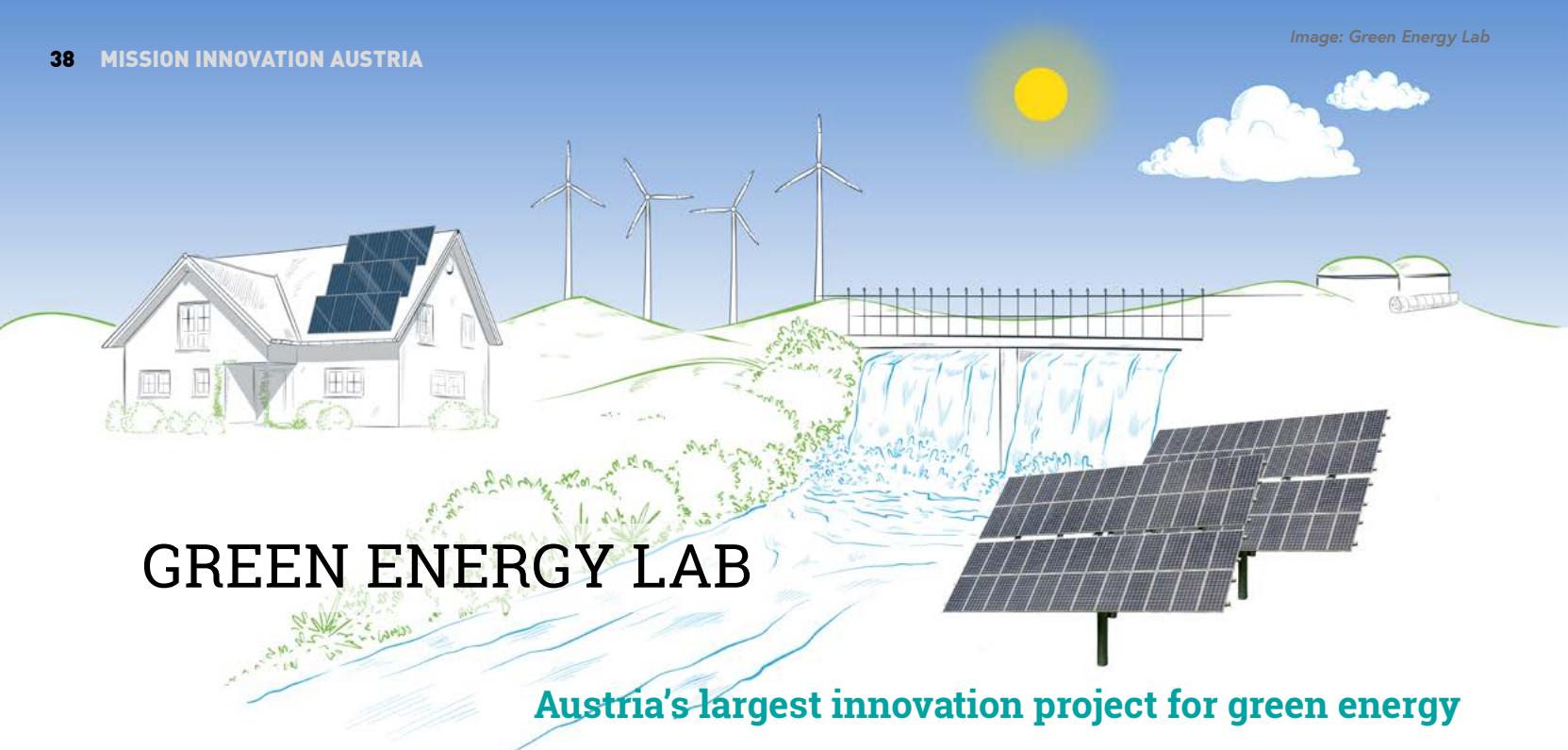


## TECHNOLOGY ROADMAPS

Technology roadmaps for energy storage systems, heat pumps and photovoltaic highlight the technological and economic potential of these technologies in the energy networks of the future. Additionally, they serve as a guideline for national research, technological and innovation policies as well as for market launches.\*

\* Download the technology road maps (in German):

[www.klimafonds.gv.at/wp-content/uploads/sites/6/Technologieroadmap\\_Energiespeichersysteme2018.pdf](http://www.klimafonds.gv.at/wp-content/uploads/sites/6/Technologieroadmap_Energiespeichersysteme2018.pdf)  
[nachhaltigwirtschaften.at/resources/nw\\_pdf/1608\\_endbericht\\_oesterreichische\\_technologieroadmap\\_fuer\\_waermepumpen.pdf?m=1469661515](http://nachhaltigwirtschaften.at/resources/nw_pdf/1608_endbericht_oesterreichische_technologieroadmap_fuer_waermepumpen.pdf?m=1469661515)  
[nachhaltigwirtschaften.at/resources/edz\\_pdf/1615\\_technologie\\_roadmap\\_photovoltaik.pdf](http://nachhaltigwirtschaften.at/resources/edz_pdf/1615_technologie_roadmap_photovoltaik.pdf)



# GREEN ENERGY LAB

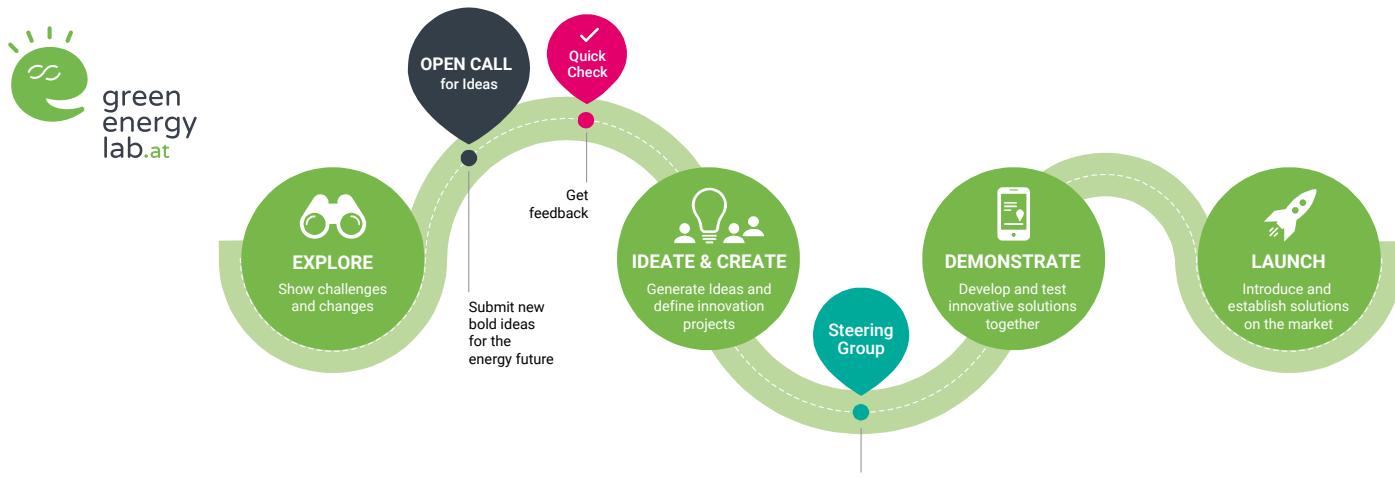
**Austria's largest innovation project for green energy**

Green Energy Lab is a research initiative for sustainable energy solutions, and it is part of the "Flagship Region Energy". The Green Energy Lab flagship region in eastern Austria will be a living lab for the energy system of the future, with a significantly high share of renewable energy sources. More than 100 partners from science, business and the public sector will collaborate with energy providers from four federal provinces: Energie Burgenland, Energie Steiermark, EVN and Wien Energie. They will work together to develop solutions that are geared towards customers, based on actual requirements and scalable – from the prototype phase to their market launch.

They will implement several cutting-edge projects that focus on five key aspects of innovation – flexibility, digitalization, integrated systems, customer integration and business models – and the projects will entail user participation. Green Energy Lab is Austria's largest lab for innovative green-energy solutions, with test markets in the federal provinces Burgenland, Lower Austria, Styria and Vienna, and approximately five million end consumers. An open innovation process is central to the Green Energy Lab and it provides quick access to knowledge and technology.

Some current projects are, for example, ThermaFlex, SecondLife Batteries, Blockchain Grid, Spatial Energy Planning, Open Data Platform, Heat Water Storage Pooling and Hybrid DH Demo. The topics addressed in these projects include everything from a reduction of CO<sub>2</sub> emissions in the district heating sector to the utilisation of e-car batteries as storage modules and the optimized distribution of network resources.

**[www.greenenergylab.at](http://www.greenenergylab.at)**





## **Blockchain Grid**

The European Commission's "Clean Energy Package for all Europeans" (CEP) was created to ensure that, in future, locally generated energy is also consumed locally. It stipulates that Citizens Energy Communities be implemented to that end. Citizens and municipalities should be able to participate actively in the energy systems as prosumers, i.e. as both energy producers and consumers. In Blockchain Grid\* a platform which allows users to distribute available network resources and renewable energy among each other autonomously is being developed.

A variety of concepts based on blockchain technologies will be realised for Energy Communities with active participation of their citizens: (1) P2P (peer-to-peer) trading for the local exchange of PV power surpluses among customers, (2) a community storage system for the Energy Community as well as (3) dynamic distribution of the network's capacity. This will create options and incentives for those involved to offer available network capacities and surplus renewable energy autonomously and to use them optimally. The grid operator will act as a market facilitator. These new developments will be tested in a real-life setting: in a low-voltage network in Heimschuh/Styria.

\* Project partners: Energienetze Steiermark GmbH, Energie Burgenland AG, Siemens AG Austria, AIT Austrian Institute of Technology GmbH

## **ThermaFlex**

There are currently more than 2,000 local and district heating systems operating in Austria. They supply approximately 25% of the heating needed for buildings. During the course of the energy transition, large thermal networks will become increasingly important, especially in cities. This is because they can directly absorb industrial waste heat or solar thermal energy, for example, store it and transport it, thereby ensuring a balance between energy production and consumption. The systems of the future have to be highly flexible and operate intelligently so that renewable energy sources can be successfully integrated. At the same time, they have to provide end consumers with secure and affordable energy.

The ThermaFlex\*\* flagship project is dedicated to increasing energy flexibility in the district heating sector.

An interdisciplinary team of 27 project partners (utilities, technology providers and research institutes) will implement and evaluate specific measures to increase flexibility in seven large-scale demonstration sites (Salzburg, Styria and Vienna). Additionally, this will illustrate options for the scalability and exchange of best-practice measures.

The approach to increase the entire system's flexibility is unique: it combines the use of technical components (CHP biomass, solar thermal energy, heat pumps) and systemic integration (sector coupling, smart control, low-exergy networks) with measures that are not of a technical nature (user and stakeholder integration, innovative business models). The initial implementation is expected to take place in some of the demonstration sites by the end of 2019.

\*\* Project partners: AEE - Institute for Sustainable Technologies (Project coordinator), FH JOANNEUM GmbH, BIOENERGY 2020+ GmbH, StadtLABOR Innovationen für urbane Lebensqualität GmbH, TU Graz University of Technology – Institute for Heating Technology, Stadtwerke Gleisdorf GmbH, S.O.L.I.D. Gesellschaft für Solarinstillation und Design m.b.H., WIEN ENERGIE GmbH, TU Wien – Institute for Energy Systems and Electrical Motors, Feistritzwerke-STEWEAG GmbH, JOANNEUM RESEARCH Forschungsgesellschaft mbH, AIT Austrian Institute of Technology GmbH, Salzburg AG für Energie, Verkehr und Telekommunikation, Rotreat Abwasserreinigung GmbH, SIR – Salzburger Institut für Raumordnung und Wohnen, Alois Haselbacher GmbH, Energie Steiermark AG, Horn Consult, ENAS Energietechnik und Anlagenbau GmbH, Pink GmbH, GREENoneTEC Solarindustrie GmbH, STM Schweißtechnik Meitz e.U., Green Tech Cluster Styria GmbH, FRIGOPOL Kälteanlagen GmbH, Abwasserverband Gleisdorfer Becken, Schneid GmbH, Nahwärme Tillmitsch GmbH & Co KG



*Photo: Energienetze Steiermark/Krug*

## **Technologies for Citizens Energy Communities**



*Large-scale storage systems compensate fluctuating network feed-in, Photo: AEE INTEC*

# GIGA\_TES

District heating networks that are supplied entirely through renewable energy sources require very large storage systems so they can store large quantities of renewable heat and waste heat over a whole season. In turn, this provides the heating network with a great deal of flexibility. Compared to the heat accumulators of today, large-scale storage systems in the energy networks of the future will have to be ten times larger in terms of volume. These giga-scale storage systems will have to be built subsurface in cities. These storage systems will put the materials and construction methods used to the test, as their volume is exceptionally large and they are constructed vertically.



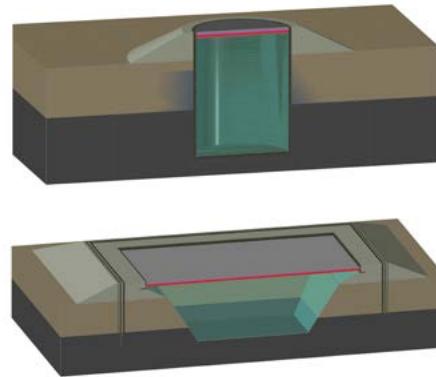
*The first experiments using novel formulas for concrete that result in better heating insulation have already been conducted,*  
Photo: Smart Minerals GmbH

## Giga-scale storage systems for heating entire districts

### Flagship project for giga-scale thermal energy storage

The Austrian flagship project Giga\_TES (Giga-Scale Thermal Energy Storage for Renewable Districts) is being conducted by AEE INTEC in cooperation with a large number of research and business partners\*. Their research relates to concepts for giga-scale energy storage that supply districts with renewable heating. Leading Austrian producers of materials and components, energy providers and stakeholders in the construction industry are collaborating with national and international research centres. The goal is to develop materials, components and system technologies that are suitable for giga-scale thermal energy storage.

One of the project's outcomes should be a set of guidelines on how to plan and realise the construction of these storage systems in Austria. The results can be utilised in real-life projects, including the "BIG SOLAR" district heating project in Graz, amongst others.



*Storage system shapes, Fig.: Ingenieurbüro ste.p*

### Case studies and simulations

The studies will address questions related to the construction of storage systems, geology and geophysics, materials, how to combine giga-scale storage and the district heating network, operational behaviour, economic aspects and acceptance by the public and for three locations in Austria designs of giga-scale storages will be made as test cases.

A variety of shapes, construction techniques, concrete mixtures and storage components for the tanks' walls, floors

and cover plates will be analysed for tanks in three different sizes (100,000; 500,000 and 2,000,000 m<sup>3</sup> volume). Important considerations in this regard are density, water resistance and vapour density as well as thermal insulation. This also includes estimates of the costs of materials and construction. Another aspect of the project will be the continued development of cutting-edge materials for sealing, e.g. polymers, which last for a long time and are particularly resistant to changes in temperature. Elaborate simulations will provide insight into the energy efficiency of the storage systems.

[www.gigates.at/index.php/en/](http://www.gigates.at/index.php/en/)

\* Project partners: agru Kunststofftechnik GmbH, Bilfinger VAM Anlagentechnik GmbH, Gabriel-Chemie GmbH, Geologie und Grundwasser GmbH, GVT Verfahrenstechnik GmbH, Ingenieurbüro ste.p ZT-GmbH, Lenzing Plastics GmbH & Co KG, Metawell GmbH, PORR Bau GmbH, S.O.L.I.D. Gesellschaft für Solarinstallation und Design m.b.H., Salzburg AG für Energie, Verkehr und Telekommunikation, Smart Minerals GmbH, WIEN ENERGIE GmbH, University of Innsbruck, Johannes Kepler University Linz, SOLITES, PlanEnergi

# ACT4ENERGY INNOVATION LABORATORY

## Integrated regional energy solutions

The act4energy innovation laboratory focuses on the development of innovative, intersectoral system solutions for integrated energy infrastructure. act4energy comprises ten communities in the federal province Burgenland who are working together with several companies and research partners in the Oberwart-Stegersbach region. They are pooling their resources to create pioneering projects and activities for sustainable, regional systems which will then be put into practice. act4energy creates and runs experimental set-ups that lay the foundation for innovative solutions. This exemplary open-innovation process has brought together representatives from research institutes, politics, companies and municipalities as well as involved citizens.

### **Use renewable energy sources more effectively**

The initiative supports research and innovation projects on the development and testing of new products, solutions and services as well as on improving the use of renewable energy sources. The region boasts highly developed infrastructure for renewable energy sources: the "Sonnenkraftwerk Burgenland" photovoltaic initiative (with a wide variety of PV systems such as those in private homes, municipal and agricultural settings, PV systems at company locations and, in particular, those which are part of citi-

zens' initiatives), biomass and biogas facilities as well as geothermal energy applications. These pioneering projects and activities can build on this infrastructure.

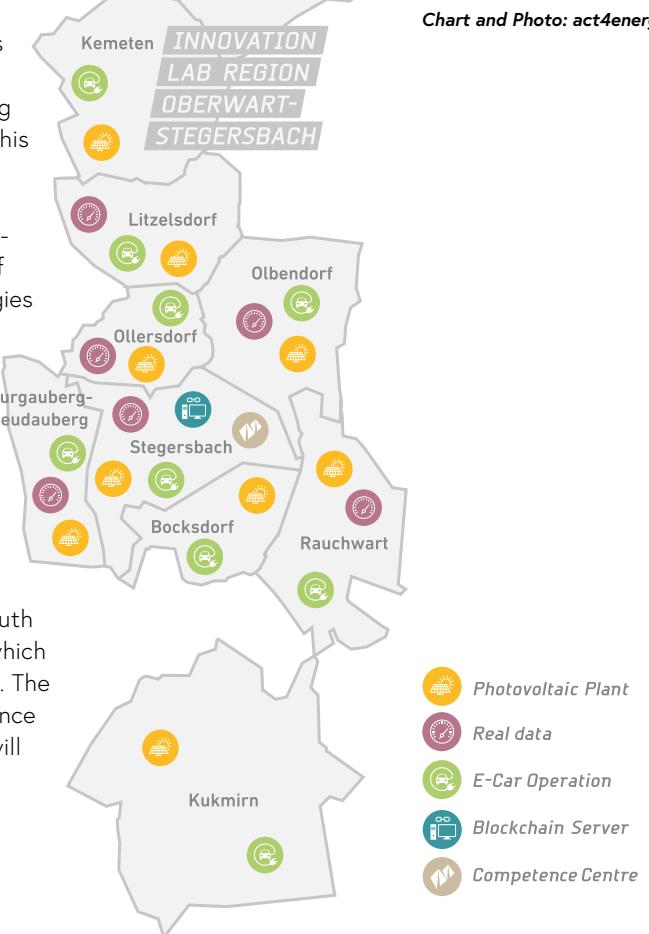
One of their focuses is on the optimisation of the region's consumption of PV power. The goal of new technologies and system solutions is to have end consumers of locally produced PV power use it optimally in future, to feed energy surpluses into the network, and to be able to benefit from renewable energy communities and flexible tariff models.

The concepts and solutions for the future of energy developed in the south of Burgenland will serve as models which can then be applied to other regions. The creation of an international competence centre for regional energy systems will be conducive to networking and the exchange of knowledge in future.

**[www.act4.energy](http://www.act4.energy)**



Chart and Photo: act4energy



act4energy strategy team:

AIT Austrian Institute of Technology GmbH, BlueSky Energy GmbH (Greenrock), Fronius International GmbH, Kapsch BusinessCom AG, Kioto Photovoltaics GmbH, Rabmer Greentech GmbH, Siblik Elektrik GmbH & Co. KG, Siemens AG Österreich

# FLEXIBILITY THROUGH LOCAL STORAGE SYSTEMS AND LOADS

## Field trials in Austrian municipalities

Today, visible changes can be observed in distribution networks. On the one hand an increasing amount of small-scale generation units, especially PV, are deployed also leading to a raising number of PV-storage systems being installed. On the other hand an increased electrification of the demand side can be seen, including electric vehicles, heat pumps and other components.

First products exist to use the flexibility of both those storage systems and loads for providing additional services to the electricity market. A certain penetration of those components might lead to equipment overloading or voltage band violations in distribution grids due to increased simultaneity caused by a common control signal.

### PROJECT LEAFS\*

In this energy research flagship project, led by the AIT Austrian Institute of Technology new technologies and operating strategies for active, network- and market-driven control of local storage systems and flexible loads were developed in collaboration with industrial and research partners\*\*. Team members were conducting research on various control mechanisms for these components as well as monetary incentives for customers to act in a grid-friendly way. These innovative concepts are being tested in field trials in three Austrian municipalities. To give a comprehensive picture legal, economic, socio-economic and regulatory assessments were carried out along with the field trials.



\* LEAFS – Integration of Loads and Electric Storage Systems into Advanced Flexibility Schemes for LV Networks

\*\* Project partners: Fronius International GmbH, Siemens AG Austria, Salzburg Netz GmbH, Netz Oberösterreich GmbH, Energienetze Steiermark GmbH, TU Wien – Energy Economics Group, Energy Institute at Johannes Kepler University Linz, Moosmar Energies OG

## FIELD TRIALS IN SALZBURG, UPPER AUSTRIA AND STYRIA

In **Köstendorf** (Salzburg Netz GmbH), residential PV storage systems have been installed in five households with PV facilities, and integrated into a local energy management consisting of a building energy agent (BEA), an onload tap changer, a central grid controller and the local electric vehicles. The storage systems and electric vehicles are controlled indirectly via the BEA. The grid operator acts as an aggregator, transmitting market signals. He does not act as a market participant but instead provides the communication and control infrastructure.

Three residential PV storage systems were installed in **Eberstalzell/Littring** (Energie AG/Netz Oberösterreich GmbH). Based on weather forecasts, the grid operator transmits network constraints that the storage system must comply with each day. An aggregator (in this case Fronius International GmbH) transmits a market signal directly to the device via the internet. In the second field trial "Sonnenbonus", monetary incentives to activate flexibility are tested with more than 200 households. The aim is to motivate households to consume more electricity when there is a high generation of PV in the local grid.



*Residential PV storage system and onload tap changer Köstendorf,  
both photos: Salzburg Netz GmbH*



*Energy monitor Eberstalzell (left) and residential PV storage system (right),  
Chart and Photo: Netz Oberösterreich GmbH*

In **Heimschuh** (Energenetze Steiermark GmbH), a municipality in the south of Styria, nine households with PV systems share a central storage system. Excess PG generation of the single household is stored in the central storage system and fed back when needed. For the field trial a battery energy storage system with a storage capacity of 100 kWh has been installed – this equals approximately the capacity of 20 residential PV storage systems. With that size the system can be used by all participating customers at the same time. The expectation is that costs for the network customers will decrease, while energy consumption will be reduced and the power grid will be relieved and stabilised.

# INNOVATIVE COMPANIES FROM AUSTRIA

## TCG UNITECH GMBH



TCG UNITECH is part of an international family business with full focus on the automotive sector.

As such, the company develops and produces complex components for the international automotive industry in the areas of high pressure die casting, injection moulding, oil and coolant pumps.

The TCG UNITECH Group sees itself as an economically valuable company. The premise is to achieve success in harmony with environmental and social values.

Together with research institutes and industrial partners, the use of energy is continuously optimized, system improvements in the manufacturing process are developed and, with energy recovery systems, control systems for better energy distribution and the optimization of tools, the use of resources is minimized.

**TCG UNITECH GmbH**  
**Steiermärker Strasse 49, 4560 Kirchdorf an der Krems, Austria**  
[www.tcgunitech.com](http://www.tcgunitech.com)



*Plant 1 – Kirchdorf/Krems, Photo: TCG UNITECH GmbH*

## KREMSMÜLLER INDUSTRIEANLAGENBAU KG

Since 1961 Kremsmüller conducts business in industrial plant construction. Especially in the last few years the company built up a very comprehensive know-how in the field of process and environmental technology. This expertise is perfectly reflected through an in-house developed thin-film dryer, with which the drying of sewage sludge is most feasible.

The use of sludge as a fertilizer in agriculture has been prohibited in Germany since 2018, as it also releases large amounts of toxic substances into the soil. The thin-film dryer from Kremsmüller enables an economical and environmentally friendly drying of sludge. What remains is an odourless granulate, which is then incinerated to generate electricity and extract phosphorus from the ash. With this development Kremsmüller offers a highly effective, clean and economical solution for sludge disposal, applicable for municipalities, communities and waste disposal companies.

**Kremsmüller Industrieanlagenbau KG**  
**Kremsmüllerstrasse 1, 4641 Steinhaus, Austria**  
[office@kremsmueller.com](mailto:office@kremsmueller.com)  
[www.kremsmueller.com](http://www.kremsmueller.com)

*United Skills of  
**KREMSMÜLLER***



*Kremsmüller thin-film dryer, Photo: Kremsmüller*



*Photo: Siemens AG Austria*

*“Energy consumption is increasing, particularly in urban areas. Therefore, one of the most urgent tasks of our time is to provide people and industries with power that has been generated efficiently. In that respect, research, technology and innovation are key to ensuring a safe, affordable and clean energy supply.*

*The cooperation between companies, research institutes and the public sector is the basis for developing innovative energy solutions and establishing Austria as a technological leader on an international level. The ‘Mission Innovation Austria’ initiative is also playing an important role in this regard. Siemens Austria is participating in several national and international research and demonstration projects, such as the one in Seestadt Aspern. The aim of these projects is to combine individual solutions so that they translate into efficient energy systems and thus push the energy transition forward.”*

**Wolfgang Hesoun**

**Chairman of the Executive Board - CEO, Siemens AG Austria**

**Chairman of the Mission Innovation Austria Advisory Board**

## INFINEON TECHNOLOGIES AUSTRIA AG

Infineon Austria is a group subsidiary of Infineon Technologies AG, a leading global supplier of semiconductor solutions that make life easier, safer and greener. The biggest source of energy is its efficient utilization; that is why ever more efficient chip technologies like the ones developed and produced at Infineon Austria play a key role. Seeing that the importance of energy efficiency will grow in the future, the company is investing EUR 1.6 billion in a new chip factory for power electronics.

Infineon Austria chips are applied where energy has to be generated, transmitted and utilized efficiently. The focus is on increasing energy efficiency and system miniaturization. The purpose of our chips and system solutions is to ensure as little energy wastage as possible during the whole energy circle. Our solutions ensure CO<sub>2</sub> savings of 56 million tons across the group during their various product life-cycles (numbers for fiscal year 2018).

**Infineon Technologies Austria AG**  
**Siemensstrasse 2, 9500 Villach, Austria**  
**communications.austria@infineon.com**  
**www.infineon.com/austria**

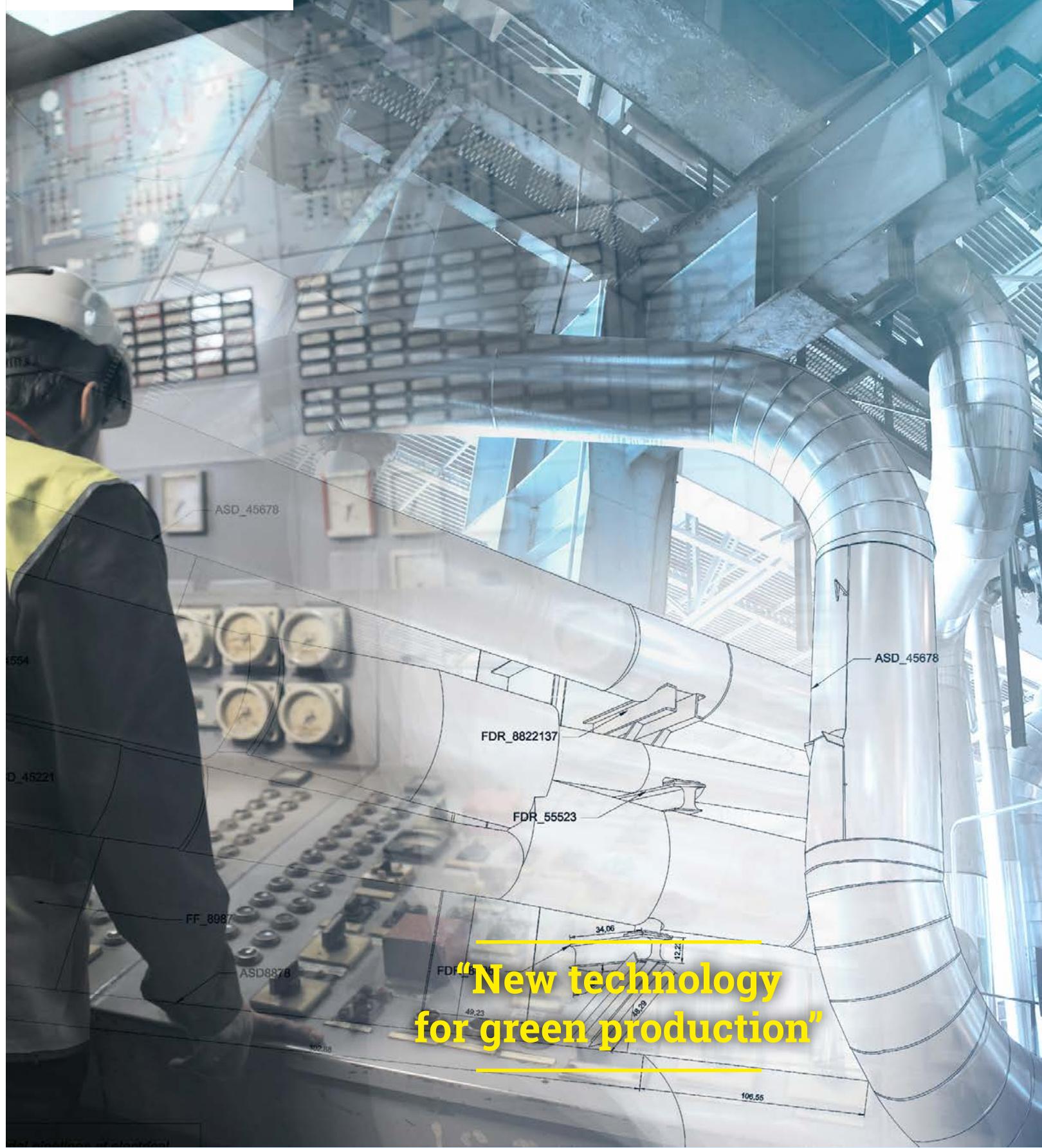


*Wafer made out of silicon carbide, a new semiconductor material: Infineon Villach serves as the global competence center of the group – not only for power electronics, but also for new semiconductor materials. These energy saving chips enable the reduction of energy losses of up to 80% during current conversion.*

*Photo: Infineon Austria*



Innovation ensures the technological lead and competitiveness of the Austrian industry  
Photo: Andrei Merkulov/stock.adobe.com



# DECARBONISATION OF INDUSTRY

Austrian industry is characterised by a high degree of productivity and creates growth and stable employment opportunities throughout the country. At the same time, industrial companies are important for supporting research and development and for driving the innovation needed to restructure the energy system. In terms of the sustainability of certain sectors, such as the iron and steel industries or the pulp industry, on a global scale Austrian companies are considered to be trailblazers. Innovation is key to the ongoing development of Austrian companies' competitive and technological edge and to ensuring its success in the long term.

Final energy consumption in Austrian industry accounts for around 30% of total energy consumption in Austria. Energy-intensive industry sectors include iron and steel production, chemicals and petrochemicals, the stone, earth and glass industries, and the paper and printing industries. Austrian industry continues to develop energy-optimized processes and methods that are not only used in the country's manufacturing plants, but also transferred to countries around the world by Austrian plant engineering.

The focus of research and development lies on the decarbonisation of industrial production. The aim is to reduce the amount of raw materials and energy used, to have fewer emissions and to optimise and intensify processes which result in a smaller CO<sub>2</sub> footprint per manufactured product.

In many industrial processes the potential for energy efficiency has already largely been exhausted, and in some cases the thermodynamic limits have been reached. The time has come to integrate more and more renewable energy sources into industrial processes and to align the energy requirements for industrial facilities with available fluctuating renewable energy sources.

In order to reduce CO<sub>2</sub> emissions significantly whilst still achieving the same output, it will be necessary to use breakthrough technologies. These new technologies and processes are being researched thoroughly and tested in Austrian companies.



## TECHNOLOGY ROADMAPS

The R&D roadmap "Energy efficiency in energy-intensive industry" identifies RTI areas for action in different energy-intensive industrial sectors with the prospect of 2030 to 2050. The roadmap illustrates RTI requirements for a substantial raise of energy efficiency in internal industrial production processes.

The technology roadmap "Renewables4Industry – Matching energy demand of industrial plants and supply of energy from fluctuating renewable sources" addresses appropriate renewable energy technologies for key processes in industry and describes supporting RTI policy instruments.

[www.energieforschung.at/informationen/  
publikationen/](http://www.energieforschung.at/informationen/publikationen/)  
(available only in German)

# FLAGSHIP REGION NEFI – NEW ENERGY FOR INDUSTRY

NEFI is a unique innovation cooperative between Austrian technology providers, industry, research institutes, politics and the public. These partners are paving the way for the complete decarbonisation of industry. This includes the development of key technologies "Made in Austria" and their implementation in Austrian industrial companies. Headed by the AIT Austrian Institute of Technology, Montan University Leoben, OÖ Energiesparverband and the Upper Austrian government's location agency Business Upper Austria

several leading companies in Austria and innovative SMEs from every sector are collaborating with partners from research centres and institutes. Upper Austria and Styria, two states with a strong industrial base, are supporting the programme and its development.

The transition towards renewable energy sources poses serious challenges for industrial production. At the same time, this is an opportunity for Austrian technology producers to expand their position

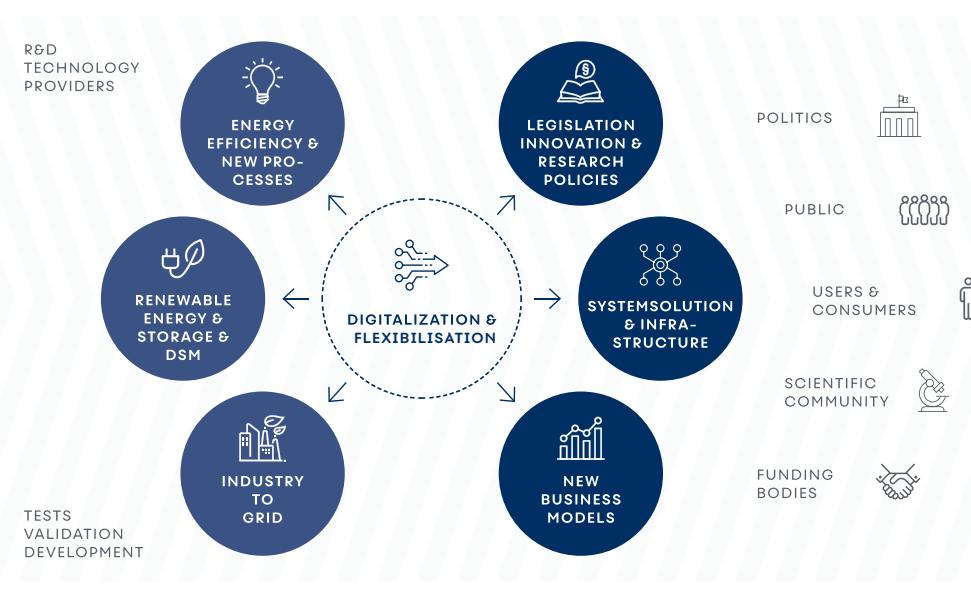
as global market leaders. The NEFI flagship region is helping to increase Austrian clean-tech innovations' visibility on an international level and to create "light-houses" for decarbonisation. The initiative promotes Austrian technology producers' competitiveness and, in doing so, ensures that Austria maintains its position as a sustainable location for industry.

The digitalization, which gives rise to new opportunities for making the energy system and industrial processes more flexible, plays a central role in research and innovation. NEFI takes a systematic approach, focusing on six fields of innovation and actively involving companies as part of an integrated energy network. This also results in the creation of several new business activities.

NEFI has started with ten projects. They are both the starting point and the foundation for the technological developments required to provide industry with energy that is 100% from renewable sources. By working on these developments with industrial partners, they become widely accepted and more willing to switch to renewable energy sources. Examples of two NEFI projects will be presented on the next page.

[www.nefi.at](http://www.nefi.at)

## FIELDS OF INNOVATION



## GREEN FOUNDRY 4.0

The production of light alloys is one of the most energy-intensive industrial processes. A process that is typically used is casting. In view of the technology currently available, production takes place in several steps (melting, casting, tempering and mechanical processing). Each step in production is conducted on an individual island. This results in significant energy losses. By taking a holistic approach that takes both material and the flow of energy into account, foundries were able to significantly improve their energy efficiency and to reduce their CO<sub>2</sub> emissions.

Project partners AIT Austrian Institute of Technology, TCG UNITECH, HOFMANN Wärmetechnik and LKR Leichtmetallkompetenzzentrum Ranshofen are conducting research and developing technologies for Green Casting 4.0. This includes improved energy recovery and the reuse of energy, faster production cycles and the use of renewable energy sources, among others. LKR Leichtmetallkompetenzzentrum is testing new technologies and components such as a cutting-edge bi-directional high-temperature heat distribution system; energy-optimized, long-lived casting forms and a completely integrated oven heated with waste heat. TCG UNITECH is planning to operate a real Green Foundry 4.0 at its new production facility.



Fig.: AIT Austrian Institute of Technology

## Environmentally friendly production processes for foundries



## GMUNDEN HIGH-TEMPERATURE HEAT LINK R&D

### Use waste heat from a cement factory

A consortium headed by the Institute for Energy Technology and Thermodynamics at the TU Wien\* is developing a concept for a high-temperature heat extraction system with a heat conduction rate of 10 MW<sub>th</sub> (thermal megawatts) at the Gmunden cement factory in Upper Austria. The factory's waste heat potential is 10 MW<sub>th</sub> at 400 °C. They want to use the heat year-round in future. In terms of the necessary technology, a ceramic hot-gas filtration system combined with fluids such as liquid salt or CO<sub>2</sub> will be used for the cement gas. Installing a ceramic hot-gas filter will make highly efficient heat extraction from the waste heat possible for the first time. In turn, this will provide in a wide range of options for affordable heat accumulators and the resulting use of heat. A long-term heat accumulator with capacities ranging from 24 hours to 60 days will combined

with a high-temperature power line that is 1.5 km long, supplying steam to large customers in the city of Gmunden. This innovative concept, developed within the framework of this project, should also be available for use in other locations.

#### Project goals:

- A ceramic hot-gas filtration system for the cement oven's waste heat
- Installation of a heat extractor with ribbed pipe heat exchangers and innovative fluids
- Cost-efficient heat accumulators
- High-temperature district heating transport over 1.5 km of public property

\* Project partners: Energie AG OÖ Wärme, Energie AG OÖ Power Solutions, Zementwerk Hatschek GmbH, Energy Institute at Johannes Kepler University Linz, Kremsmüller Industrieanlagenbau KG, PORR Bau GmbH, Ingenieurbüro ste.p ZT-GmbH



Photo: Rohrdorf Zement

# ENERGY-EFFICIENT DRYING PROCESSES USING HEAT PUMPS



Drying is one of the most energy-intensive industrial processes. It accounts for up to 25% of total energy consumption in industry around the world. Energy-intensive drying processes are particularly common in the paper industry, but also occur in the timber, sugar, paint, textile and brick industries. The vast majority of all drying processes (approximately 85%) use air dryers powered with fossil fuels. Usually, the water vapour produced in drying is simply expelled with the exhaust air and no use is made of its energy content.

In the national DryPump project AIT Austrian Institute of Technology has investigated how compression heat pumps can be used to recover the energy content of the water vapour from the exhaust air and reuse it in the production process. Industrial drying requires very high temperatures of up to 170 °C. In compression heat pumps, waste heat is used to evaporate a working fluid, it is compressed and condensed to deliver heat at a higher temperature level.

## New technologies for increased energy efficiency and CO<sub>2</sub> reduction

Within the framework of DryPump, technically feasible concepts were developed and economically evaluated for selected processes in cooperation with project partners from science and industry\*. The researchers expect that in the mid-term the new technology will enable energy savings of up to 80% and savings of CO<sub>2</sub> emission up to 68%.

\* Project partners: Wienerberger AG, AGRANA Beteiligungs-AG, Bitzer Kühlmaschinen Bau GmbH, AMT Kältetechnik GmbH, TU Wien – Institute for Energy Systems and Thermodynamics, IZF – Institut für Ziegelforschung Essen e.V.

## Heat pump technologies for industrial drying

### Demonstrations in Austrian companies

In view of these promising results heat pumps for industrial drying will continue to be further developed in the EU "DryFiciency" project (H2020 grant agreement no. 723576). The use of this new technology is being demonstrated at two Austrian industrial companies. The heat pump system will be installed for the drying process at AGRANA's starch production facility; it will provide approximately 10% of the heat required for drying. The technology will also be used for drying bricks at Wienerberger.

[www.dryficiency.eu](http://www.dryficiency.eu)



Drying bricks at Wienerberger,  
Photos: Zinner/Wienerberger AG

# RENEWABLE STEEL GASES

The potential to increase energy efficiency in the production of steel using conventional process optimization methods has already been exhausted for the most part. Innovative concepts that are completely new will be required to make the production of steel less energy- and resource-intensive and, by extension, to ensure that Europe remains competitive as a location for production. The steel production of today is the same around the world: it takes place in integrated steel mills with blast furnaces. Gases rich in energy are released during the production process, and these gases

account for most of the steelworks' CO<sub>2</sub> emissions. The aim of the Renewable Steel Gases project is to utilise these gases through the use of renewable energy sources.

## Renewable energy sources in the production of steel

The focus of the project, which is being conducted by the Chair of Process Engineering in Industrial Environmental Protection at Montanuniversitaet Leoben

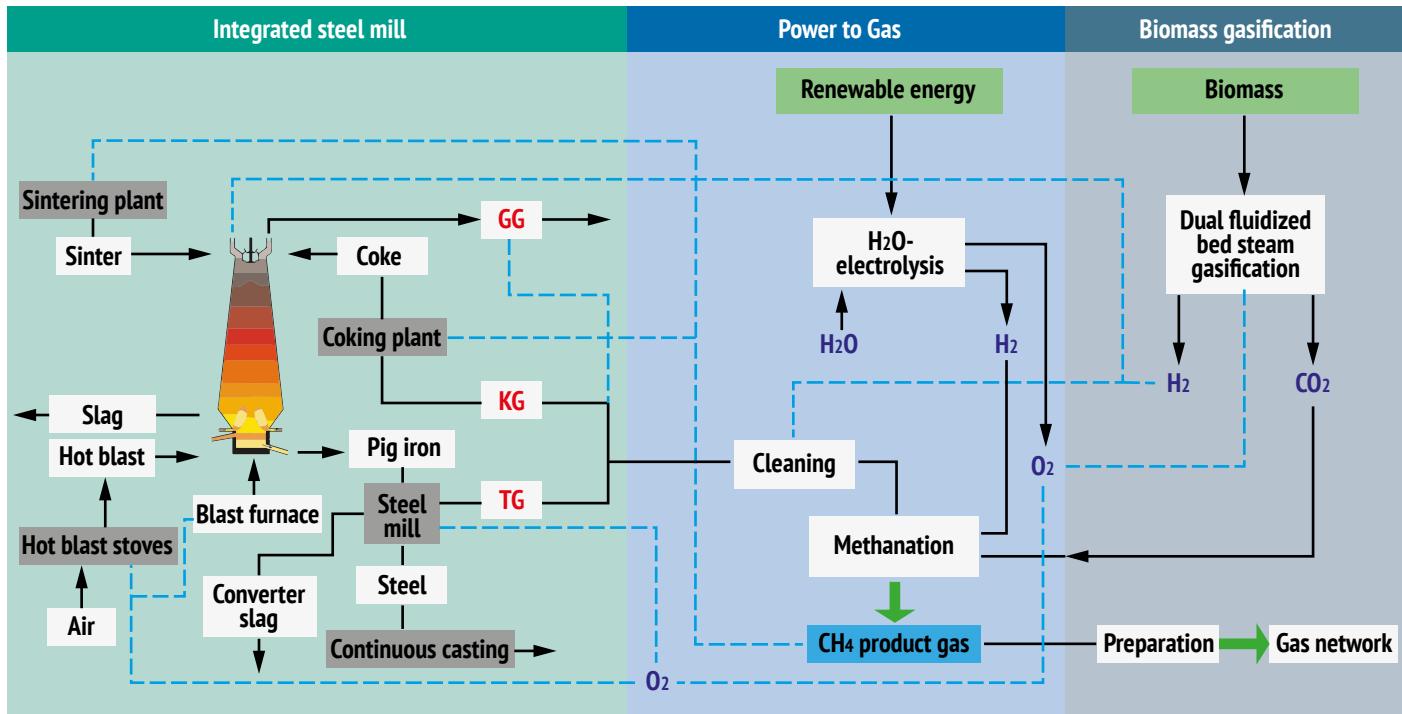
in cooperation with partners in research and industry\*, is to analyse concepts for the wiring of a power-to-gas facility and a biomass gasification system that provides H<sub>2</sub> and CO<sub>2</sub> within an integrated steel mill.

By incorporating renewable energy sources into steel production, it will become much more energy-efficient and will reduce CO<sub>2</sub> emissions significantly. Furthermore, the goal is to create a chemical storage system for energy surpluses that can be used both within as well as outside of the steel mill.



*Laboratory for methanation at Montanuniversitaet Leoben,*

*Source: Montan University Leoben/Chair of Process Engineering in Industrial Environmental Protection, Photo: Croce & Wir*



Concept for incorporating a power-to-gas facility and biomass gasification into an integrated steel mill,

Chart: Montanuniversitaet Leoben

## Turn gases released during production into a source of energy

Renewable energy sources will be used to produce hydrogen (H<sub>2</sub>) through electrolysis. In addition, biogenically created H<sub>2</sub> will be released in a dual fluidized bed steam gasification process. The renewable hydrogen will then be used for methanation of the gases released during production, i.e. the gases' carbon molecules will be converted into renewable methane.

The synthetic methane can be used as a substitute for natural gas, which will significantly reduce the amount of fossil fuels needed for production. Oxygen, one of the by-products of electrolysis, can also be used in the steel mill, for example, in the Linz-Donawitz (LD) converter. This will make the production process even more energy-efficient.

## Analysis of possible process chains

The project team's goal is to identify those process chains which result in the greatest reduction of CO<sub>2</sub> emissions from a large number of possible wiring options for power to gas, biomass gasification and the integrated steel mill. The project also entails preparing the construction of a demonstrative facility for this innovative process.



Photo: makspogonii/stock.adobe.com

\* Project partners: K1-MET GmbH, TU Wien – Institute for Process Engineering, Environmental Engineering and Technical Life Sciences, Energy Institute at Johannes Kepler University Linz, voestalpine Stahl GmbH, voestalpine Stahl Donawitz GmbH

# INNOVATIVE COMPANIES FROM AUSTRIA



## AVL LIST GMBH



*Photo: AVL List GmbH*

Research and development are the basis of the business model of AVL, the world's largest independent company for the development, simulation and testing of powertrain systems (hybrid, combustion engine, transmission, e-drive, batteries, fuel cells and software) for passenger cars, commercial vehicles and large engines. AVL employs over 9,500 people worldwide. The turnover in 2017 was EUR 1,55 billion.

AVL's research focuses on improving efficiency, reducing emissions as well as the necessary development and test systems and methods. Research activities cover the whole powertrain incl. hybrids and electric drives, combustion engines, all kinds of transmissions, power electrics and electronics as well as batteries and fuel cells for all applications ranging from two-wheelers to stationary power generation.

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## RAG AUSTRIA AG

RAG Austria AG is the largest gas storage and energy storage company in Austria and one of the leading technical storage operators in Europe. As a partner of renewable energies, the company develops innovative and future-oriented energy technologies. The exploration, supply and trading of gas as well as the use of gas as fuel complete the portfolio. Thus, RAG Austria AG makes an indispensable contribution to the sustainable energy supply of Central Europe.

In addition to the classic natural gas, in future green gas – gas produced from renewable energies (wind and sun) – will make an essential contribution to the energy supply. The demands of a decarbonised future require massive energy storage capacities: large-volume, seasonally versatile. All this offers RAG.



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*RAG – Storage Puchkirchen, Photo: RAG Austria AG*



*Photo: FRONIUS International GmbH*

*"FRONIUS is convinced that by 2030 hydrogen will play an important role in many areas of our lives. Energy sector integration will be leading the way. This entails the production of green hydrogen, which will be a vital energy source for mobility and industry. Hydrogen will be a natural addition to other forms of electro-mobility around the world, in particular, for vehicles that consume large amounts of energy, such as trucks or communal vehicles. Many municipalities and small-scale manufacturers will produce green hydrogen themselves and use this hydrogen for their fuel cell-powered vehicles.*

*In 2030, hydrogen will be a seasonal storage solution for renewable energy. FRONIUS will make significant contributions in many of the above mentioned areas by providing solutions for the production, storage, distribution and consumption of affordable and smart solar energy, in line with the vision of 24 hours of sun. It will focus mostly on local hydrogen production through electrolysis, the use of hydrogen for mobility, seasonal storage systems and reconversion of hydrogen with stationary fuel cells."*

**Klaus Fronius**

**Owner of FRONIUS International GmbH**

**Member of the Mission Innovation Austria Advisory Board**

## VOESTALPINE AG

voestalpine is a globally active technology and capital goods group focused on product and system solutions based on steel and other metals in technology-intensive industries. Current production technologies are inevitably energy- and thus CO<sub>2</sub>-intensive. Energy consumption and emissions were halved in the past 50 years, however, further potential of existing production routes is limited.

voestalpine therefore is conducting intensive research activities to develop entirely new technologies in the long term. Within the scope of the EU flagship project H2FUTURE, the currently largest PEM electrolysis plant for production and utilization of green hydrogen will be operated at the Linz location.

In Leoben-Donawitz, the project Sustainable Steelmaking (SuSteel) investigates the direct production of steel from iron oxides without any intermediate steps. It entails using hydrogen plasma to both reduce oxides and serve as a source of energy for smelting.

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*voestalpine is seen as a pioneer in its industry with regard to environmentally friendly products and processes, Photo: voestalpine*

**voestalpine**  
ONE STEP AHEAD.

*Large quantities of hydrogen can be produced using green power,  
Photo: malp/stock.adobe.com*



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***"In the future, hydrogen can connect the power, heating and transport sectors"***

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# GREEN HYDROGEN – ENERGY SOURCE OF THE FUTURE

Hydrogen is a multipurpose source of energy that can be produced through the use of renewable energy sources and is characterised by its ease of storage and transport.

$H_2$  can be produced either through electrolysis with power from renewable energy sources or through reforming biogenic by-products. Hydrogen is the only source of energy that has the potential to store large quantities of energy over a longer period of time in chemical form.

Converting renewable energy sources with hydrogen technology is sustainable, pollution-free and offers many options for the energy systems of the future. Hydrogen technology has the potential to enable sector coupling between power, heating and transport and to incorporate a large number of renewable energy sources into existing energy systems.

Power-to-gas technology converts surpluses from the production of wind and solar power into hydrogen and/or methane which can be transported and stored in existing gas infrastructure.

Both energy sources can be used in industry, in mobility and to generate heat and electricity. For example, hydrogen is used for reconversion into stationary fuel cells and in gas engines or serves as the link to emission-free mobility by using it as fuel for fuel cell vehicles.



Photos: Climate- und Energyfund/Hans Ringhofer

# HYDROGEN INITIATIVE AUSTRIA POWER & GAS FLAGSHIP REGION

Renewable hydrogen is central to the energy system's restructuring process on the path towards decarbonisation. The hydrogen initiative Austria Power & Gas Flagship Region is dedicated to researching, developing and demonstrating innovative technologies and intelligent system solutions for the supply and use of energy that is hydrogen-based. WIVA P&G is the research association that is in charge of coordinating and implementing the initiative throughout Austria. The goal is to make innovative Austrian energy solutions using hydrogen technology visible nationally and internationally.

WIVA P&G boasts experience resulting from more than 30 research, development and demonstration projects which have either been completed or are ongoing. Additionally, the implementation of at least 25 subprojects have been initiated. It is also planned to integrate additional, new R&D projects on hydrogen into the initiative. These innovation strategies pertain to the energy, industry and mobility sectors. The focus lies on the entire hydrogen value chain. The production and storage of hydrogen, chemical conversion to methane or other hydrocarbons as well as burning and reconversion will be

analysed, developed and demonstrated in various applications and processes.

The initiative brings internationally outstanding research projects together and helps to establish hydrogen technologies from Austria on the international market.

[www.wiva.at](http://www.wiva.at)

**WIVAP&G**  
Energy Model Region

**"Austria is the perfect region for the transition to an energy system with green hydrogen."**



*Energy infrastructure based on hydrogen and on renewable gas in the energy system of the future, Source: WIVA P&G*

## RENEWABLE GASFIELD

The key to integrating fluctuating renewable energy sources into the energy system is to include long-term storage systems based on hydrogen and synthetically produced natural gas. In cooperation with business and research partners\*, Energie Steiermark's Renewable Gasfield project demonstrates the wide range of uses for hydrogen and how it can be incorporated into the energy system. An integrated power-to-gas concept combines the production of green hydrogen through electrolysis with newly developed load-flexible methanation technology.

The power generated by PV facilities is converted into hydrogen and fed into a trailer for later use in industrial applications. Alternatively, it is used as fuel which is available to the public at a 350 bar hydrogen refuelling station. Additionally, this green hydrogen will be used for the methanation of biogas which will be subsequently fed into the gas grid. These multiuse facilities will be developed in such a way that the focus will remain on the region's specificities. The project site is located south of Graz. A 1 MW<sub>el</sub> (electrical megawatts) biogas plant, which is currently being operated only at half capacity, will be integrated into the hydrogen production process. The modularity of the facility's concept is key to its innovativeness. This makes it possible to enhance and adjust every part of the facility so that it is equipped for the demands of the future.



**Electrolysis machine,**  
Photo: Uniper Energy Storage GmbH

\* Project partners: HyCentA Research GmbH, Energy Institute at Johannes Kepler University Linz, Energie Agentur Steiermark GmbH, Uniper Energy Storage GmbH, Energienetze Steiermark GmbH, Montan University Leoben, WIVA P&G, Assoc. Partner: Department 15 Energy, Housing, Technology (Provincial Government of Styria)

## UPHY I & II

The UpHy project (headed by OMV)\*\* pertains to the development of technologies for the production and distribution of green hydrogen as well as the options available for calibrated measurements of the quality and quantity of hydrogen required at tanking stations. UpHy I is examining the modern analytical methods available to determine the necessary quality parameters (in accordance with ISO 14687-2\*\*\*) with the goal of developing a mobile measurement system for the mass and quality of hydrogen gas. This will make it possible to calibrate the measurements directly at H<sub>2</sub> tanking stations.

Additionally, researchers are investigating various options for green hydrogen production and the underlying H<sub>2</sub> logistics. They are also developing new business models for the use of renewable energy sources in mobility and in industry. UpHy II will continue this research and also create a form of green H<sub>2</sub> production as well as a modular hydrogen value chain, consisting of a 300-bar trailer-cum-filling station and a 350-bar tanking station for buses and trucks; they will be built in accordance with the most modern standards.

\*\* Project partners: Energy Institute at Johannes Kepler University Linz, HyCentA Research GmbH, VERBUND Solutions GmbH, VF Services GmbH, WIVA P&G

\*\*\* ISO 14687-2: Hydrogen fuel – Product specification – Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles

# UNDERGROUND SUN CONVERSION

**Natural gas produced from hydrogen and environmentally friendly storage systems**



A RAG facility in Pilsbach/Upper Austria, Photo: RAG Austria AG

Within the scope of Underground Sun Conversion, an Austrian consortium headed by RAG Austria AG\* is conducting research on a process unlike any other in the world: a targeted microbiological mechanism will be used to create green natural gas from hydrogen directly in a (porous) gas storage facility.

## **Storage systems for wind and solar power**

The research project builds on the energy research flagship project “Underground Sun Storage”, which was concerned with developing and testing technology for storing wind and solar energy in natural gas storage facilities. By converting electrical energy into hydrogen, the existing natural gas infrastructure could be used as seasonal storage for surplus energy from renewable energy sources.

The Underground Sun Storage project examined the hydrogen compatibility of underground gas storage facilities and for the first time also implemented a field trial on an industrial scale at a depleted natural gas reservoir in Pilsbach in Upper Austria.

\* Project partners: Montan University Leoben, University of Natural Resources and Life Sciences, Vienna (BOKU/IFA Tulln Department), acib GmbH (Austrian Centre of Industrial Biotechnology), Energy Institute at Johannes Kepler University Linz, Axiom Angewandte Prozesstechnik GmbH



RAG facility in Pilsbach/Upper Austria, Photos: RAG Austria AG/Karin Lohberger Photography

## Renewable production of natural gas

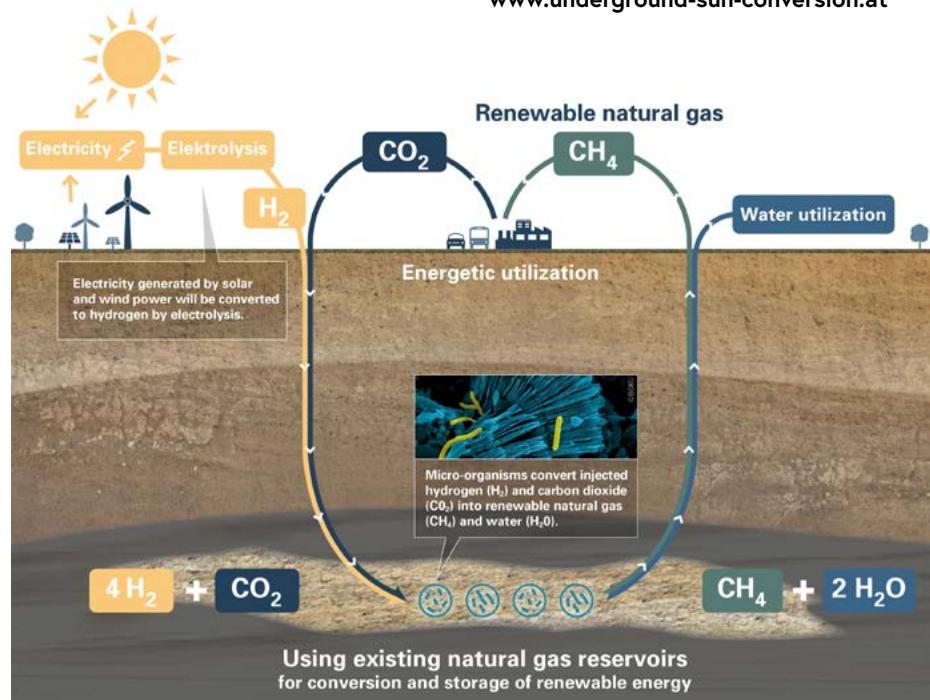
The aim of Underground Sun Conversion is to emulate the natural process in which natural gas occurs and to create a sustainable carbon cycle. The first step is to produce hydrogen in an above-ground facility using wind and solar power. Together with CO<sub>2</sub> (e.g. from biomass combustion) it is then pumped down to an existing gas reservoir more than 1,000 metres below ground. Laboratory experiments have shown that hydrogen which has been introduced into the storage facility can be converted into methane relatively quickly through a microbiological process involving CO<sub>2</sub>. Methanisation thus takes place naturally in underground rock formations, but it is accelerated by millions of years. The renewable natural gas produced in the depths can be stored right there, tapped into as the need arises and transported to consumers via the existing grids.

## Applicability of the research results in practice

Laboratory experiments, simulations and a scientific field trial will be carried out in an existing RAG storage facility in Pilsbach over the course of the project. The idea is to apply the research results to many other subterranean natural-gas reservoirs around the world.

This will lay the foundation for the future: to produce large quantities of renewable natural gas in a way that binds CO<sub>2</sub> and to store the energy seasonally and in an environmentally friendly manner in natural storage facilities so it can be utilised flexibly at any time.

[www.underground-sun-conversion.at](http://www.underground-sun-conversion.at)



Source: RAG Austria AG

# FRONIUS SOLH<sub>2</sub>UB

The use of hydrogen in the energy system of the future is a topic that is being investigated intensively in Austria. In 2018 the Austrian company FRONIUS International GmbH began to operate the first in-plant green hydrogen tanking facility in Austria at its plant in Thalheim.

Known as SOLH<sub>2</sub>UB, it is a local hub for solar power that can produce and store green hydrogen which can be used for mobile applications or can be reconverted into electricity and heat. This high-tech Austrian company developed the necessary components itself: those needed

to convert solar energy surpluses into hydrogen with electrolysis as well as the stationary fuel cells.

## Using H<sub>2</sub> in many ways

Companies and municipalities benefit from using hydrogen in several ways: green hydrogen is very easy to store, and it can be used to operate fuel cell-powered vehicles in the vicinity. Hydrogen has a great deal of potential for vehicles that consume large quantities of energy, such as municipal vehicles, transporters, buses or lorries, among

others. In addition, drivers can go for long distances without needing to refill the vehicles, and when they do, they are refilled quickly. If necessary, the vehicle's hydrogen can be reconverted into electricity in a stationary fuel cell. The heat that is generated from production and reconversion can also be used locally.

[www.fronius.com](http://www.fronius.com)



The first in-plant green hydrogen tanking facility in Austria, Photo: FRONIUS International GmbH



*Wind2Hydrogen pilot facility at OMV site in Auersthal, Lower Austria, photo: OMV*

## Pilot facility generates green hydrogen from solar power

### Wind2Hydrogen – Feeding green hydrogen into the natural gas grid

The project Wind2Hydrogen has already resulted in valuable experience with regard to the hydrogen value chain as a whole. The Wind2Hydrogen project, led by OMV\* and in cooperation with research and corporate partners\*, investigated the production of green hydrogen and the feeding of hydrogen into the natural gas grid. Also the filling and possible use of hydrogen in mobility was tested.

A novel high-pressure PEM electrolyser developed by FRONIUS International GmbH was used, which generates high-purity hydrogen at 163 bar. The electrolyser's modular design makes it suited to ultra-dynamic operation, with no risk of shutdowns in connection with fluctuating levels of wind or PV-generated power.

The primary aim of the research work was to identify how well the gas infrastructure (transit and distribution grid) copes with hydrogen, and how much green hydrogen can be stored in the Austrian natural gas grid.

A pilot facility was built and hydrogen was supplied to one of OMV's natural gas pipes in Auersthal (Lower Austria) between September 2015 and May 2017. The pilot facility was running for a total of 40,400 operating hours with 12 electrolysis modules. During this period, 4,610 kg of hydrogen were produced and either successfully supplied to the natural gas grid or bottled.

The knowledge generated through this project – about everything from operative planning to beginning operations – could be applied to the Hydrogen Initiative Austria Power & Gas Flagship Region, among others.

\* Project partners: EVN AG, FRONIUS International GmbH, HyCentA Research GmbH, Energy Institute at Johannes Kepler University Linz



*Wind2Hydrogen pilot facility, Photos: Nick Waldhör*

# HYDROMETHA

Conventional power-to-gas systems use electrolysis to convert water into hydrogen with the option of subsequent methanation. The HYDROMETHA lead project, under the direction of AVL List GmbH\*, is developing a cutting-edge, fully integrated system of  $\text{CO}_2 + \text{H}_2\text{O}$  high-temperature co-electrolysis (Co-SOEC) with catalytic methanation.

The interconnection and optimisation of these processes will allow a significant increase in conversion efficiencies that are  $> 90\%_{\text{el}}$ . The core system will be built and characterised in the form of a 10kW<sub>el</sub> function carrier, with testing in the long term.

The key targets of this carrier are as follows:

- $\text{CO}_2 + \text{H}_2\text{O}$  Co-electrolysis with an overall system efficiency  $> 90\%$ , providing a highly efficient  $\text{CO}_2$  sink through the conversion of  $\text{CO}_2 + \text{H}_2\text{O}$  in the fuel cell developed for Co-SOEC
- Increasing the overall electrical Co-SOEC plus methanation efficiency compared to systems using low-temperature PEM electrolysis  $> 30\%$
- Increasing power densities on the Co-SOEC cells  $> 100\%$
- Dynamic operation of the methanation in a load range between 20% and 120%
- Significantly improving heat management compared to systems without Co-SOEC, leading to a reduction of heat energy losses  $> 50\%$

By simplifying the system, increasing its useable life and durability as well as optimising the process chain, researchers anticipate that costs will fall significantly and hence the system will become more marketable.

The aim is to establish a national and international value chain for Co-SOEC technologies.

\* Project partners: Fraunhofer – Institute for Ceramic Technologies and Systems, Energy Institute at Johannes Kepler University Linz, Montan University Leoben/Faculty of Physical Chemistry and the Faculty of Process Engineering in Industrial Environmental Protection, Prozess Optimal CAP GmbH

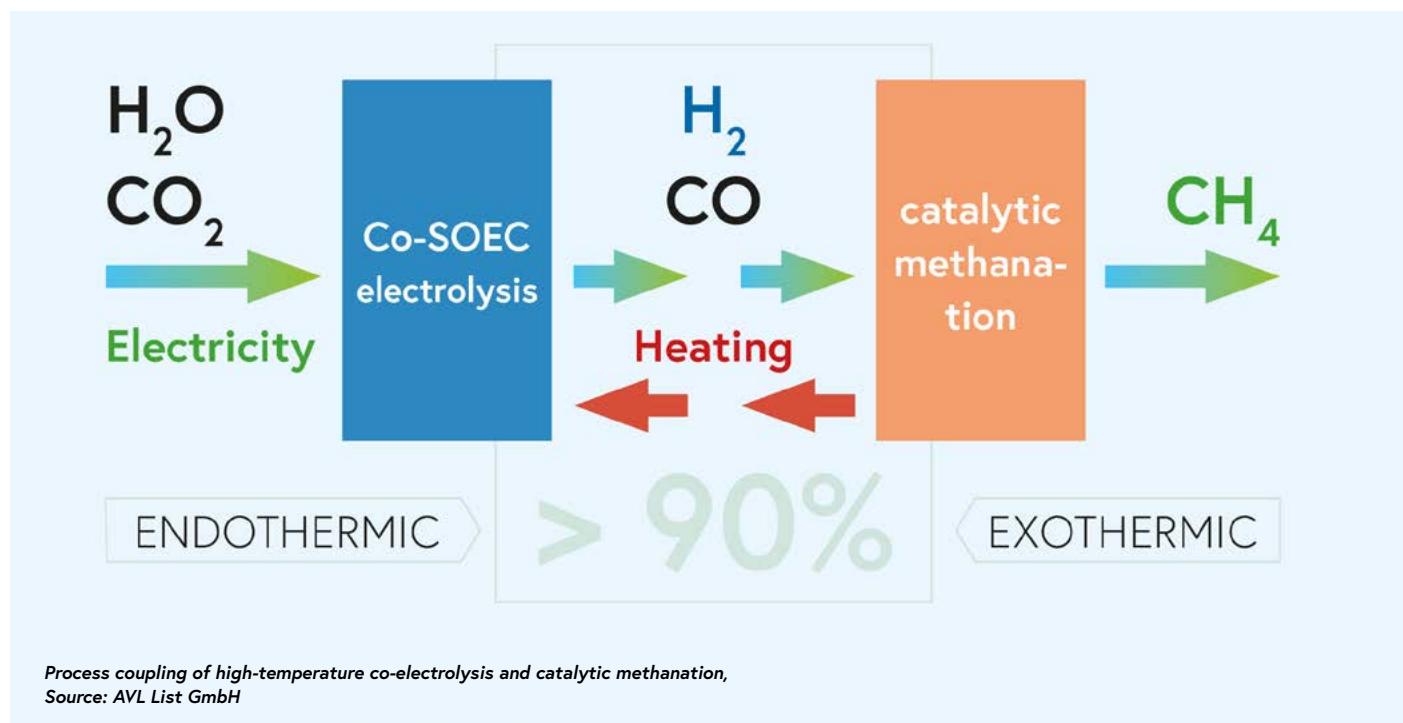
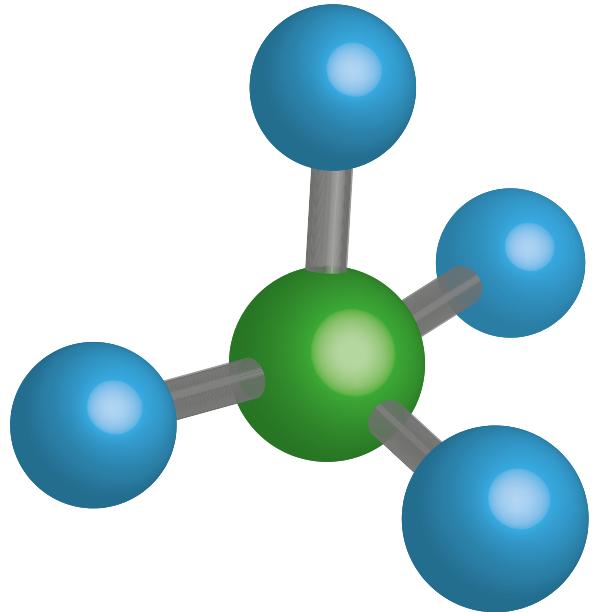




Fig.: AVL List GmbH

**Integrated power storage system  
based on high-temperature co-electrolysis  
and catalytic methanation**



# IMPRINT

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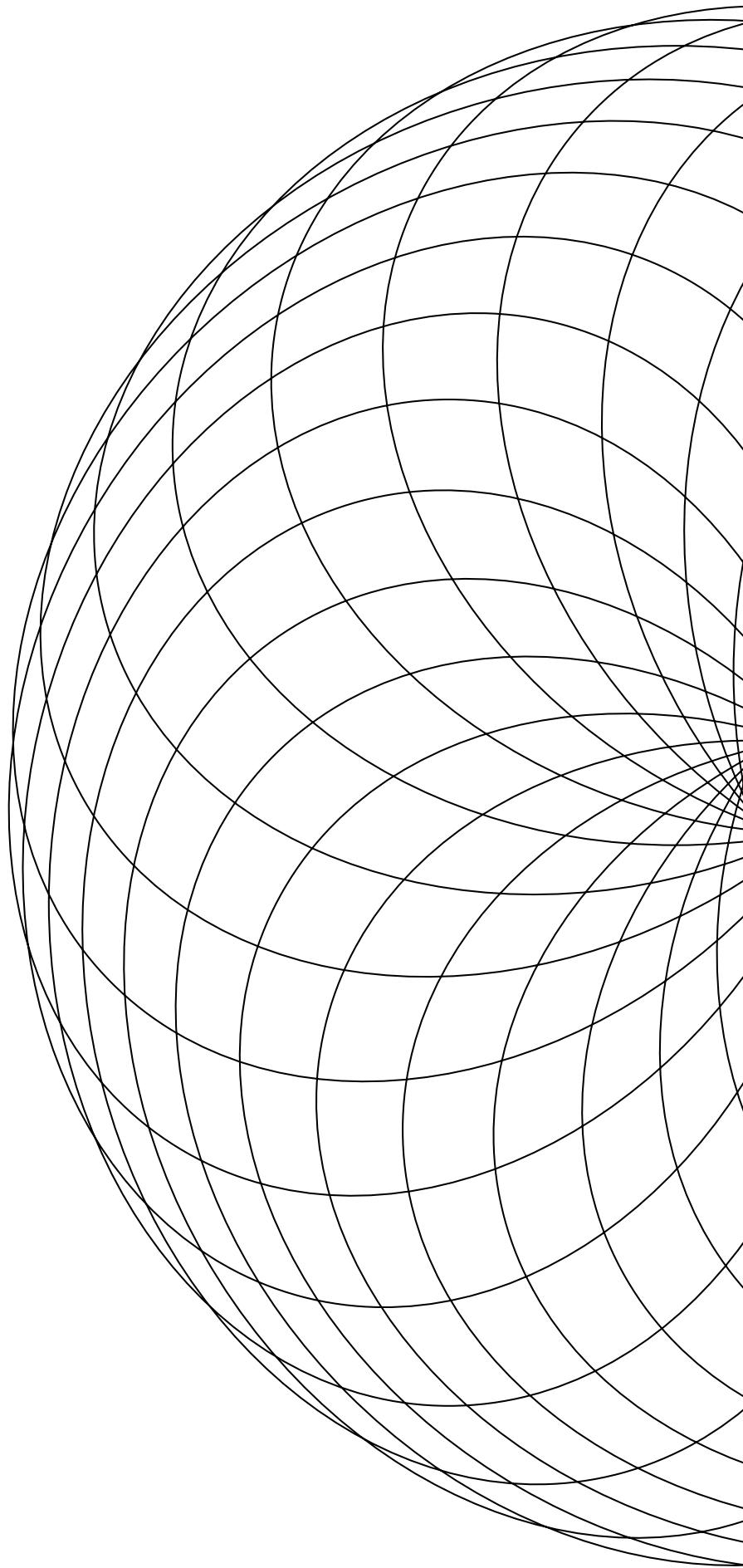


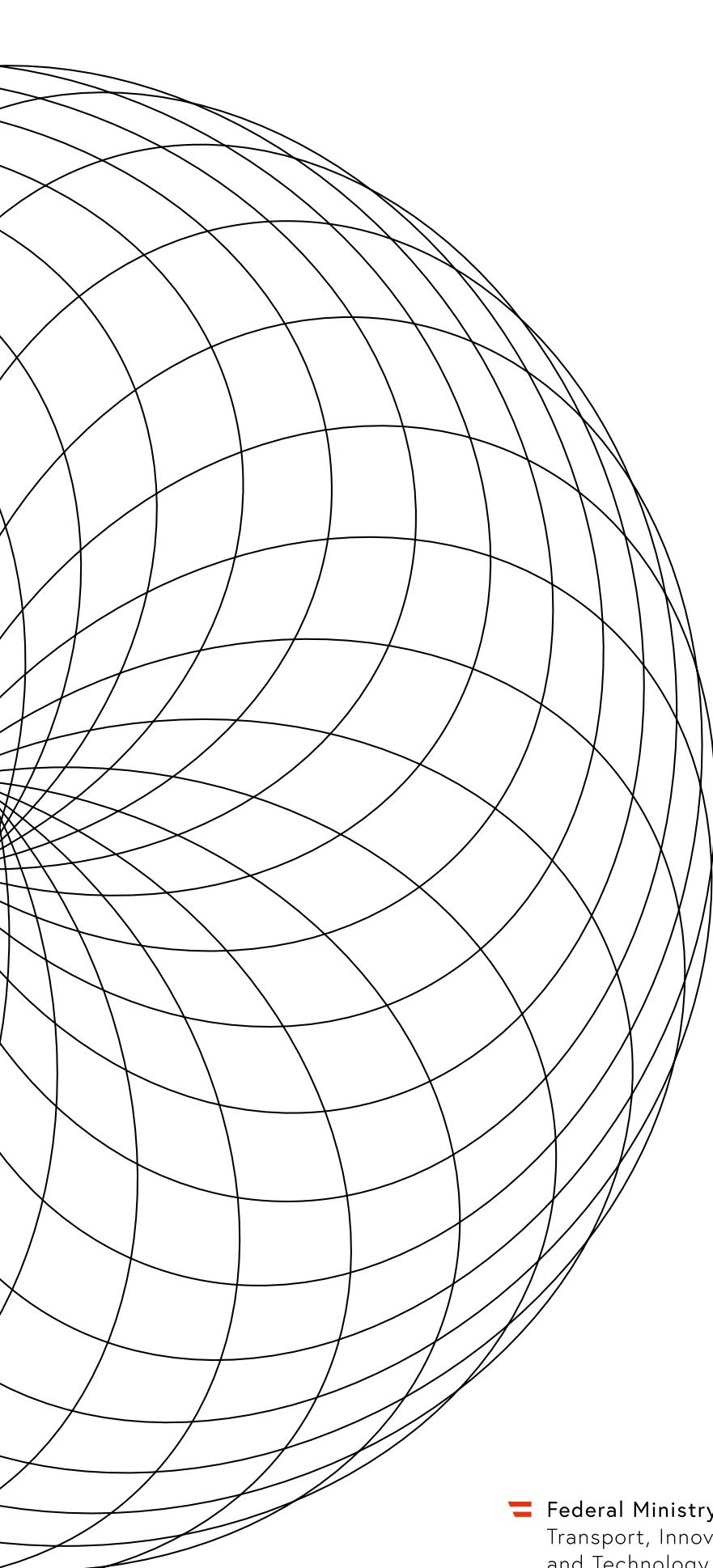
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