energy innovation austria

3/2021

Current developments and examples of sustainable energy technologies

klima+ energie fonds

Federal Ministry
Republic of Austria
Climate Action, Environment, Energy, Mobility, Innovation and Technology

Photovoltaics in the energy system of tomorrow

Research and technological development in Austria

Photovoltaics (PV) is a key technology in the energy transition and a major step towards meeting the climate targets that form part of the European Green Deal. Austria boasts some highly successful manufacturing and research companies in the PV segment and has the chance to position itself on the global stage as a centre for innovation in this sector.

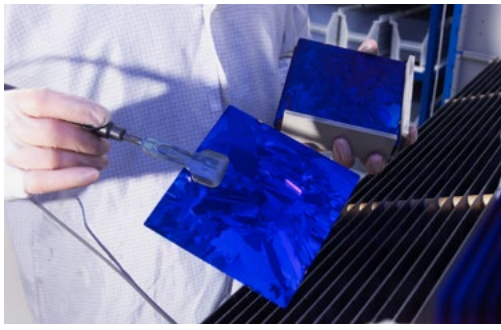
Installing a PV facility, photo: Fronius International GmbH

Photovoltaics

Key technology for climate-neutral energy supply

Electronics manufacture, photo: Fronius International GmbH

PV tracker, photo: Zotter Schokoladenmanufaktur GmbH



Polycrystalline silicon wafer, photo: BSW-Solar-Sunways

Photovoltaics (PV) will play an important role in the energy system of the future and will continue to develop and spread across the world over the next few years. PV is one of the key technologies in the energy transition and is seen as a core component in the major expansion of renewable energy sources and the realisation of the European Green Deal, which commits the EU to becoming climate-neutral by 2050.[1]

Demand for electrical energy will rise further in the coming years, due not least to the growth of electromobility and the increased use of heat pumps. PV has the potential to make a significant contribution to power supply. PV facilities provide high-quality electrical energy, need little maintenance, have a long lifespan and enable built-up areas to serve a dual purpose. If Europe is to achieve climate neutrality, PV technology must be expanded so that it makes up as much as 60% of the energy mix, which equates to a huge increase of the current photovoltaic energy of at least 7,700 GW.[2]

NATIONAL OBJECTIVES

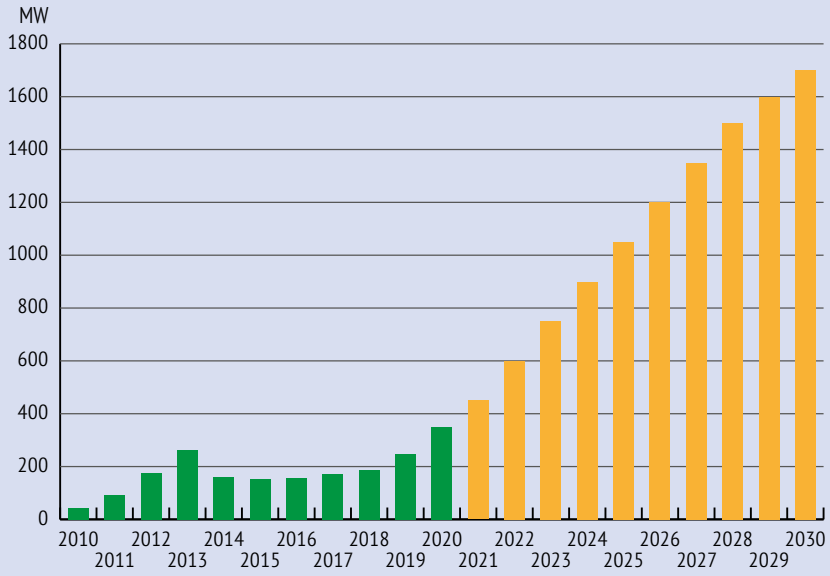
Austria has set ambitious targets for its energy and climate policy and intends to become climate-neutral by 2040. It plans to generate 100% (national balance) of its energy from renewable sources by 2030. Specifically, this means that the percentage of renewables in the energy mix will have to be increased by 27 terawatt-hours (TWh) by that date while observing strict environmental criteria. Of this amount, 11 TWh is to come from photovoltaics, 10 TWh from wind power, 5 TWh from hydropower and 1 TWh from biomass.[3] The "Erneuerbaren-Ausbau-Gesetz" (EAG) is intended to create the necessary legal and organisational framework and an investment climate that will remain stable over the long term.

[1] consilium.europa.eu/en/policies/green-deal
[2] Austrian Photovoltaics Technology Platform, tppv.at
[3] bmk.gv.at/service/presse/gewessler/20210317_eag.html
[4] Innovative Energietechnologien in Österrech: Marktbericht 2020 (published by the BMK/in german)

PV IN AUSTRIA – TODAY

New PV facilities with a total output of 341 MW_{peak} were installed in 2020, an increase of around 38%. At the end of the year, PV facilities with a total aggregate output of 2,043 MW_{peak} were in operation in Austria. This means an increase of 20%. These PV facilities generated at least 2,043 GWh of electricity in 2019, thus reducing CO_2 emissions by 888,000 tonnes.[4]

PV facility in Vienna's Stammersdorf district, photo: PV Austria



PV IN AUSTRIA – DEVELOPMENT

PV will play a crucial role in the energy system of the future. Assuming that the energy system will see large-scale electrification and all major industrial processes and the mobility system will switch to electricity, photovoltaics will be able to meet some 15% of Austria's electricity demand by 2030, rising to around 27% by 2050.[5]

Chart: PV Austria

RESEARCH AND TECHNOLOGICAL DEVELOPMENT TO CREATE NEW JOBS

Innovations that open the door to new kinds of application will be needed if Austria is to meet its targets for expanding photovoltaics. The country boasts some highly successful research and manufacturing companies in the electrical, electronics and glass processing industry, in building technology and in the construction sector that specialise in PV. Its "hidden champions" include inverter manufacturers and solar cell wiring specialists. The PV segment employed 2,749 people (full-time equivalents) in Austria in 2019. Innovative PV solutions, particularly those relating to integration and dual use in the building, transport and agricultural industries, are giving Austria the opportunity to create at least 60,000 new green jobs by 2030,[6] with the energy storage segment expected to contribute thousands more.

There is a need for significant research in several market segments: integration into buildings (e.g. industrial properties and multi-family homes), integration into the energy system (e.g. energy communities), mobility (noise protection, railway lines, roads and other surfaces used by traffic) and agriculture (agricultural PV and floating PV).

The challenge over the next few years will be to make increased use of the opportunities for positioning Austria as a centre of PV innovation of international relevance. In this issue, we present a few pioneering research and technological development projects that are being implemented as part of the programmes run by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and the Climate and Energy Fund. ●

[5] pvaustria.at/wp-content/uploads/2020_07_05_Fact_Sheet_PV_Branche-1.pdf
[6] tppv.at/2021/04/27/pressegespraech-photovoltaik-forschung

"The innovative power of Austrian companies will be needed to drive the energy transition forward. We've been working with photovoltaic systems since the early 1990s. Our products – which are 100% made in Austria – have evolved over the years, of course. Equipped with new digital features, they're now exported all over the world. But the aim has remained the same: generating as much energy as possible from the power of the sun. In doing what we do, we're strengthening Austria's reputation as a centre for research and technology while also creating many new jobs. Plus – and this is particularly important to me – we're fulfilling our responsibility to future generations."

ELISABETH ENGELBRECHTSMÜLLER-STRAUSS
CEO OF FRONIUS INTERNATIONAL GMBH

Photo:
Fronius International GmbH

PV facility in Feistritz, photo: VERBUND AG

OPTPV 4.0

Optimised operation of PV facilities with innovative sensor systems

Long-term operational reliability and a consistently high energy yield are key if a PV facility is going to be economically viable. Sudden faults and creeping degradation often result in significant drops in performance and reduce economic efficiency. As part of the OptPV 4.0 project, a consortium of corporate and research partners led by Silicon Austria Labs (SAL)[1] developed an innovative tool for detecting faults and energy losses at an early stage and improving the maintenance of PV facilities.

The causes of faults have to be identified quickly and reliably so that downtime can be minimised by taking appropriate countermeasures. Negative trends in the performance of the facility as a whole also need to be spotted in good time and preventive maintenance carried out before the performance deteriorates significantly.

The methods used to date for determining the causes of drops in performance are based on specific measurements taken on site and are very expensive and time-consuming. In the OptPV 4.0 project, whole-system data analysis and modelling concepts for the early detection of faults and the gradual degradation of PV facilities were studied and tested out in practice for the first time.

ANALYSING LARGE VOLUMES OF DATA

Faults in PV facilities can have many different causes, the characteristics of which will depend on climatic, topographical and geographical conditions. Identifying and modelling the sources of faults reliably thus calls for specific analytical methods based on large volumes of data and supplemented by the collection of additional metadata.

The project involved standardising fault patterns present in existing data and storing them in a database structure defined specifically for the purpose. A sensor system upgrade kit was also developed to gather important facility data and metadata that is not recorded by default. This kit was then installed in real-life facilities to collect data.

Data from the facility and the sensor system upgrade kit enabled physical and statistical analytical models based on "digital twin" facilities to be formulated and evaluated. These models are used to identify fault patterns that emerge suddenly to be identified rapidly and to implement predictive maintenance concepts. Concepts for pre-emptive maintenance that included cost/benefit considerations were also devised.

[1] **PROJECT PARTNERS**:
Silicon Austria Labs Gmbh (consortium leader), VERBUND Greenpower, the peak lab GmbH, ENcome Energy Performance GmbH, Uptime Engineering GmbH, MUL, Verbund Hydro, Fronius International GmbH

> **“At Silicon Austria Labs, we want to advance developments that benefit humanity and the environment. As well as enabling green energy to be produced, optimising PV facilities also allows the facilities themselves to be made sustainable. So projects such as OptPV 4.0 let us contribute our expertise in researching, developing and connecting up smart sensors and thus do our bit for a green future.”**

CHRISTINA HIRSCHL
HEAD OF RESEARCH DIVISION SENSOR SYSTEMS, SILICON AUSTRIA LABS

Photo: Silicon Austria Labs

NEWLY DEVELOPED SENSOR SYSTEM USED IN REAL-LIFE OPERATIONS

In September 2020, VERBUND AG set up the first large-scale PV facility on the premises of the power station on the Drava River in Ludmannsdorf/Bilčovs in Carinthia’s Rosental valley. The technical possibilities for improving the economic efficiency of PV facilities over the long term that were developed in the OptPV 4.0 project are currently being researched and tested further on this site. The pilot plant, which has a peak output of 1.3 megawatts, was equipped with a special sensor system. The solar power generated is fed straight into the Austrian transmission grid.

The findings from the project will lay the technical foundations for making the operation of PV facilities of any size more cost-effective and predictable. Both of these are key prerequisites for enabling the spread of photovoltaic technology and their contribution to the energy transition to be accelerated further.

https://silicon-austria-labs.com/forschung/projekte/details/optpv40/

Drava power station site in Ludmannsdorf/Bilčovs, photo: VERBUND AG

PV facility and sensor, photo: Silicon Austria Labs GmbH

Sensors, photo: Silicon Austria Labs GmbH

PV sensor kit, photo: Silicon Austria Labs GmbH

NoFRONTIERS

Flexible thin-film PV modules for new fields of application

As well as silicon technology, CIGS thin-film solar cell technology[1] has also emerged as an innovative manufacturing method for the PV market in recent years. CIGS PV modules can be produced at low cost using the roll-to-roll technique and are lightweight and highly bendable. The technology is opening up many potential new uses for photovoltaics, e.g. in the automotive industry, aerospace and building integration.

The Austrian company Sunplugged – Solare Energiesysteme plays a pioneering role in the production of flexible CIGS PV modules. It has developed the innovative SunP CIGS process as well as the Monoscribe interconnection concept, which is suited to industrial application. Flexible PV modules are custom-made in a "post-monolithic" interconnection process with the help of laser structuring and inkjet printing. Sunplugged has achieved a degree of maturity in its technology that allows fully functional PV modules to be produced. Peak efficiency is currently 14% at cell level and 8% at module level.

R&D TO IMPROVE EFFICIENCY

As part of the NoFRONTIERS project, the company is collaborating with Austrian and international research institutions[2] to develop the technology further and increase efficiencies to a level that makes it economically viable. This is achieved with a peak efficiency of 17% at cell level and an average efficiency of 12% at module level.

Scaling up thin-film processes for solar cells containing no heavy metals, photo: Sunplugged

The complexity and variety of the technologies that can be used (coating methods, laser equipment, printing techniques, etc.) call for a systematic, scientific evaluation. The comprehensive analysis of the process is intended to form the basis for selecting the right technology so that future-oriented investments can be made in industrial production.

RESEARCHING THE ENTIRE PROCESS CHAIN

In the course of the project, all production steps (absorber layer, front layers and interconnection) are being optimised and coordinated based on the very latest research findings. These include:

- Optimising the process for making the absorber layer: initial results show that the new techniques are suitable, particularly in terms of the homogeneity and production costs of the absorber layer
- Using femtosecond and picosecond lasers for individual "post-monolithic" interconnection
- All-in-one sputtered top layers
- Ultra-gentle preparation of polished cross-sections of thin films on flexible, bendable substrates
- Straightforward, stable diagnostics for process monitoring

The findings from the project will help to optimise the SunP CIGS process so that Sunplugged can play a pioneering role on the world stage in the production of customisable PV modules. The research partners are benefitting from the international exchange of knowledge and have the chance to hone their expertise in PV technology (specifically in CIGS PV), thin-film and coating technology and material analysis. ●

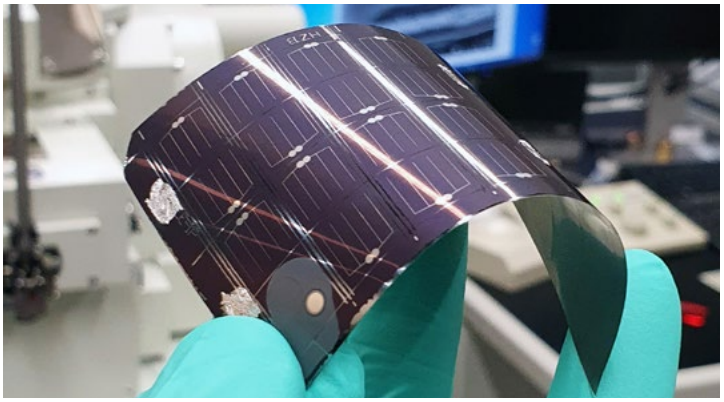
https://energieforschung.at/projekt/novel-flexible-r2r-produced-non-toxic-individualizable-high-effficent-and-robust-solar-modules-2/

[1] CIGS refers to the combination of several materials – copper, indium, gallium and selenium – in thin-film solar modules

[2] **PROJECT PARTNERS:** University of Innsbruck (consortium leader), PhysTech Coating Technology GmbH, Sunplugged – Solare Energiesysteme GmbH, JOANNEUM RESEARCH Forschungsgesellschaft mbH, Helmholtz-Zentrum Berlin (HZB)

Developing flexible, transparent front layers for highly efficient CIGS solar cells, photo: Sunplugged

Serial interconnection of thin-film solar cells using inkjet material printing, photo: Sunplugged



CIGS-based thin-film solar cells on steel film, photo: University of Innsbruck

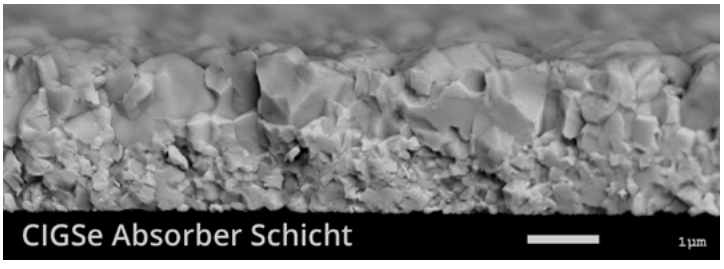
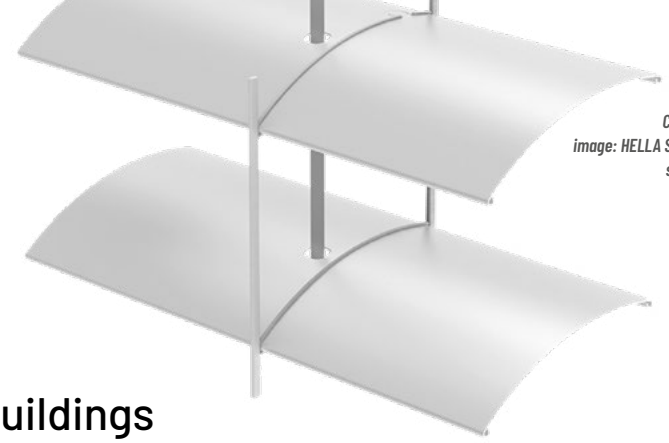


Image from a scanning electron microscope showing a cross-section of a CIGS absorber layer, photo: University of Innsbruck



Connecting the slats, image: HELLA Sonnen- und Wetterschutztechnik GmbH

PowerShade

PV sunshades increase the energy flexibility of buildings

The PowerShade project is all about combining flexible photovoltaic technology with sunshades that are fitted with smart control. The aim is to develop low-cost shading solutions that generate electricity and are suitable for universal applications. By combining smart control with artificial intelligence (AI), these systems are intended to enable an increase of the energy flexibility of buildings in urban spaces.

By the end of this century, 75% of people across the world will be living in towns and cities. These require a lot of energy and are particularly exposed to the impact of climate change, not least as a result of the "urban heat island" effect. At the same time, conurbations have a large amount of space that could potentially be used to produce energy. Building-integrated photovoltaics (BIPV), i.e. integrating PV into window and facade elements, has a key role to play in this regard. PowerShade's innovative concept is enabling new areas to be used that conventional PV solutions would be unable to access, increasing the potential for sustainable energy generation in urban spaces many times over.

SMART, SELF-LEARNING CONTROL SYSTEMS

Integrating photovoltaics into products designed to offer protection against the sun poses major challenges for the PV technology and the controllers used in the shading systems. With transparent building surfaces, there is generally a conflict of use between glare and overheating protection on the one hand and the needs of the building users for visual contact with the outside world, daylighting and the desire for free solar heat on the other. Integrating photovoltaics makes these requirements even more complicated. A photovoltaic yield will only be generated when the sunshade is active (i.e. extended or lowered). This yield will also depend on the angle at which the slats are tilted and the shadows cast by adjacent slats and soffits.

As part of the project, a smart, self-learning control system is being developed based on neural networks in order to coordinate energy flows with the needs of users and strike a balance between the various aspects of building use.

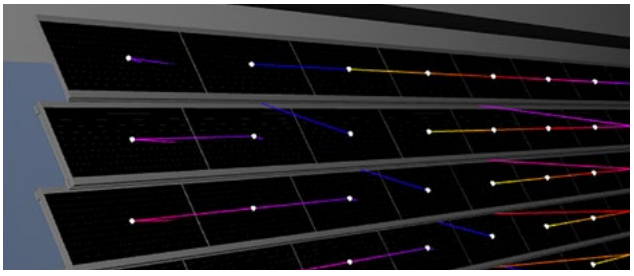
PARTNERSHIP BETWEEN RESEARCH AND INDUSTRY

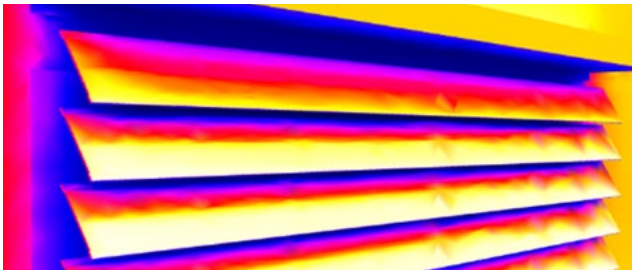
A consortium[1] led by the University of Applied Sciences Technikum Wien is looking into optimising the PV system in terms of the output, durability, weather-resistance and look of the modules. The sun protection experts from the Tyrolian company HELLA are integrating bendable, ultra-lightweight PV thin-film modules into the shading systems, while the University of Applied Sciences Technikum Wien and TU Wien are providing input into the product concepts. Simulations and tests under real-life conditions are being run to study the radiation behaviour, daylight supply, temperature behaviour, electrical behaviour and mechanical strength of the solutions.

The team from TU Wien uses AI methods to optimise building simulation models in order to achieve their objectives as best possible and highlight the potential offered by sunshades that generate electricity. The researchers from the University of Applied Sciences Technikum Wien are experts in BIPV, dynamic building simulation and analysing urban quarters and are investigating these integrated simulation models in a range of scenarios. ●

https://nachhaltigwirtschaften.at/de/sdz/projekte/power-shade.php

[1] **PROJECT PARTNERS**: University of Applied Sciences Technikum Wien (project management), TU Wien / Institute for Computer Technology, HELLA Sonnen- und Wetterschutztechnik GmbH





Configuring a simulation of PV yield, Images: University of Applied Sciences Technikum Wien

Photo: PV Austria / Nauschnegg

PV Re² – sustainable photovoltaics

Optimising the recycling of PV modules

The PV Re² lead project is focused on sustainable recycling and the further development and repair of defective PV modules in order to improve the environmental and sustainability footprint of PV facilities in the future. PV modules have an expected lifespan of some 25 to 30 years, with many first-generation facilities currently approaching the end of their useful lives. These systems are made up of many components including glass, silicon cells, silver, copper, plastic and an aluminium frame. Some of the elements they contain, such as lead and fluorine, are especially critical in environmental terms. No waste disposal system that is tailored specifically to PV technology has been invented yet. Faulty modules are processed at recycling facilities using standard technologies and are usually crushed, with the leftover materials often being burnt. Valuable raw materials inside the solar panels are thus wasted.

OPTIMISING THE RECYCLING PROCESS

The project consortium[1] comprises five industry partners and four research institutions whose expertise covers the entire PV value chain (from the production of the materials, components and PV modules through to the operation of PV systems and applications, recycling and waste treatment). The project sets out to optimise the entire recycling process of PV modules while also making it easier to recycle the individual solar components.

The underlying chemical, physical and mechanical processes required to separate the individual components of a PV module in stages are being investigated to this end. To enable materials to be sorted accurately for recycling, the team is developing automatic measuring systems that allow the material composition of individual modules to be identified precisely. The aim is to preserve the purity and functionality of the materials as best possible so that the raw materials can be reused.

TARGETED SELECTION OF MATERIALS

What materials are selected for a solar system plays an important role in the recycling and reusability of its components. The researchers are therefore focusing on a design that is conducive to recycling (e.g. easily detachable adhesive connections and thermoplastic materials) as well as on reducing and avoiding toxic materials and hazardous substances. This work builds on the results of previous projects. Even just using glue rather than solder has enabled the lead content of each PV module to be reduced from around 20 grams to virtually zero. Research findings are also being harnessed to develop climate-adapted photovoltaics. The impact of climatic conditions on materials, components, cell connectors and backsheets has been analysed and improvements made.

Another research topic is the development of suitable repair systems that will allow repair work to be carried out easily and quickly in the field on the PV facility itself, which will extend the performance and lifespan of the PV modules. ●

https://energieforschung.at/projekt/sustainable-photovoltaics

PV modules with defective back skins, photo: OFI

[1] **PROJECT PARTNERS**: PCCL Polymer Competence Center Leoben GmbH (project management), Silicon Austria Labs GmbH, University of Leoben, OFI Austrian Research Institute for Chemistry and Technology, ENcome Energy Performance GmbH, Borealis AG, KIOTO Photovoltaics GmbH, Peter Seppele GmbH, VDE Renewables GmbH

Sharing PV power in an urban quarter

Blockchain technology for local energy communities

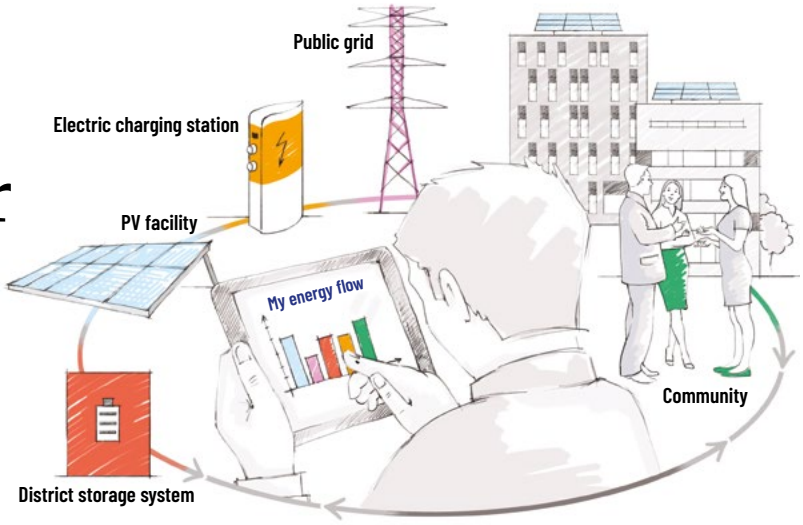


Illustration: Wien Energie

In Vienna's "Viertel Zwei" urban development area, Wien Energie and Vienna Marketing & Energycontracting (VMEC) are trialling smart approaches for the energy world of the future together with local residents. Pilot customers not only get access to innovative products and services, but can also actively shape the new offers. Energy is the issue at the heart of the "Urban Pioneers Community" and "Energy Community Advanced" projects. Mobility, telecommunications and smart-living applications are also being studied alongside electricity and heat. An important focus is on testing new pilot tariffs for electricity that were developed in co-creation workshops.

With the "Pioneers Tariff", all participants were assigned a share of the production from the local PV facility and a P2P feature was used to divide up and charge for the electricity with the aid of blockchain technology. Combined with a district storage system, this is intended to maximise the percentage of PV power used locally. The idea is based on the "P2PQ – Peer2Peer im Quartier" research project, which Wien Energie ran in partnership with AIT Austrian Institute of Technology and Riddle&Code.[1]

"Since we've been involved in the project, we've been more mindful of how much electricity we're using," says Katharina Laggner, a local resident taking part in the project.
Photo: Wien Energie/Christian Hofer

PEER2PEER IM QUARTIER (P2PQ)

As part of the P2PQ project blockchain-based applications for local energy communities were developed. The blockchain technology (Riddle&Code) allows locally generated PV power to be divided up amongst residents of a housing complex or district in the best possible way as well as guaranteeing data security and confidential billing on a prosumer platform. The proof of concept of these innovative solutions was provided in "Viertel Zwei". The blockchain-based PV facility on the roof of the building complex allows residents to trade the electricity they generate themselves, share it or sell it on to other members of the community. Consumption is monitored and tariffs managed via an easy-to-use online platform.

Using a predictive optimisation tool (developed at AIT), the locally produced PV power can be stored efficiently in a battery and released to or traded amongst residents depending on anticipated demand. To get an overview of the generated transactions and electricity consumption and production, a user-friendly web application has been developed that presents the complex blockchain data in simple graphs.

The smart network of utility company, infrastructure and consumers is laying the foundations for creating one of the first P2P energy trading communities in Europe. Alongside the advances in technology, new business models and key factors for the economic efficiency of the innovative solutions have also been identified. ●

https://nachhaltigwirtschaften.at/de/sdz/projekte/peer2peer-im-quartier.php

[1] **PROJECT PARTNERS**: Wien Energie GmbH (project management), AIT Austrian Institute of Technology GmbH, Riddle&Code GmbH

Viertel Zwei PV facility, photo: Wien Energie

INTERNATIONAL COLLABORATION

Austrian experts are playing an active role in IEA-PVPS, the International Energy Agency's photovoltaic programme. This partnership is geared towards linking the Austrian photovoltaic innovation scene with the international research community. Austria is currently involved in seven out of the eight ongoing research activities ("tasks") and is leading two of them: "Solar PV in the 100% Renewable Energy Source Power System" and "Building Integrated Photovoltaic".
Further information:
nachhaltigwirtschaften.at/de/iea/technologieprogramme/pvps/
iea-pvps.org

"Europe is set for a renaissance in solar production, and Austria's PV industry can become a key part of that. This will require constant innovation in order to compete successfully against other countries. The continued diversification of photovoltaics, taking in new applications, is giving Austrian manufacturers a lot of scope for positioning themselves on the global market with innovative products. Key research areas are new cell and module concepts for further increasing efficiencies, all the questions about integrating photovoltaics into existing infrastructures, and systemic integration into an energy system that is 100% sustainable. Recycling and other elements of the circular economy are becoming increasingly important. All of this research is being conducted in international partnerships, with Austrian experts being well represented in all the major research networks."

Photo: private

HUBERT FECHNER
PHOTOVOLTAICS TECHNOLOGY PLATFORM AND VICE CHAIR OF THE IEA-PVPS PROGRAMME

You can also visit us at:

www.energy-innovation-austria.at

INFORMATION

PowerShade
University of Applied Sciences Technikum Wien
Renewable Energy Systems
Contact: Maximilian Wittmann
wittmanm@technikum-wien.at
technikum-wien.at

NoFRONTIERS
University of Innsbruck
Department of Structural Engineering and Material Sciences,
Unit of Material Technology
Contact: Nikolaus Weinberger
nikolaus.weinberger@uibk.ac.at
uibk.ac.at/mti

OptPV 4.0
Silicon Austria Labs GmbH
Contact: Wolfgang Mühleisen
wolfgang.muehleisen@silicon-austria.com
silicon-austria-labs.com

Peer2Peer im Quartier (P2PQ)
Wien Energie GmbH
Contact: Mathias Holzweber
mathias.holzweber@wienenergie.at
wienenergie.at

PV Re² – sustainable photovoltaics
Polymer Competence Center Leoben GmbH
Contact: Gernot Oreski
Gernot.Oreski@pccl.at
pccl.at

Photovoltaics Technology Platform
tppv.at

Photovoltaic Austria Federal Association
pvaustria.at

IEA PVPS
nachhaltigwirtschaften.at/de/iea/technologieprogramme/pvps
iea-pvps.org

Climate friendly production, FSC certified,
Green Seal and Austrian Eco Label

energy innovation austria presents current Austrian developments and results from research work in the field of forward-looking energy technologies. The content is based on research projects funded by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology and the Climate and Energy Fund.

www.energy-innovation-austria.at
www.open4innovation.at
www.nachhaltigwirtschaften.at
www.klimafonds.gv.at
www.energieforschung.at

IMPRINT
Publisher: Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, (Radetzkystraße 2, 1030 Vienna, Austria)
in cooperation with the Climate and Energy Fund (Leopold-Ungar-Platz 2/142, 1190 Vienna, Austria)
Edited and designed by: Projektfabrik Waldhör KG, 1010 Vienna, Am Hof 13/7, www.projektfabrik.at
For change of your shipping address contact: versand@projektfabrik.at