energy innovation austria

2/2013

Current developments and examples of sustainable energy technologies

Photovoltaics – technology for tomorrow

Research and pioneering developments from Austria

simpliCIS – flexible epitaxial solar cells,
Source: © Ringhofer/Climate and Energy Fund

Photovoltaics (PV) are going to play an increasingly important role as an energy source in the future. PV has the greatest technical potential, across Europe but also worldwide, for generating electricity from renewable sources. New technological developments aimed at increasing efficiency, integrating PV into buildings and appliances and improving cost-benefit ratios create the right conditions for spreading this sustainable way of producing electricity more widely.

Andreas Zimmermann of Sunplugged with flexible simpliCIS epitaxial solar cells, Source: © Ringhofer/Climate and Energy Fund

More electricity from sunlight
International and national developments in the field of photovoltaics

In its "BLUE Map" scenario, which defines a path for achieving the goals set by the IPCC (Intergovernmental Panel on Climate Change) for reducing carbon dioxide emissions, the International Energy Agency (IEA) reckons that in 2050 46 % of global electricity generation will come from renewable sources (currently approx. 20 %). Photovoltaics (PV) convert sunlight directly into electricity – silently and without emitting exhaust fumes, noise or smell. The PV technology is an important element in a sustainable electricity scenario which also requires new grid management strategies.

As the cost of PV will probably continue to go down as a result of technological developments, the technology has great potential for worldwide implementation. In an ambitious scenario the EPIA (European Photovoltaic Industry Association) estimates that by 2020 12 % of the electricity needed in Europe can be supplied by PV. The Austrian Photovoltaics Association gives 8 % as the target for Austria by 2020; at the end of 2013 it will be about 1 %.

Austrian engineering competence & market development

The growing PV market worldwide offers enormous opportunities to producers of materials, components and parts. The Austrian photovoltaics industry is active in many segments of the value creation chain, ranging from fabricating solar panels, modules and power electronics via semiconductor technology, special protective films for solar panels and accumulators, all the way to power inverters, tracking systems and various other components.

In recent years Austrian manufacturing companies have made their mark on the international photovoltaics market; some of them have already reached the position of world market leader in some technological areas.

The PV generating capacity installed in Austria has risen significantly in the last few years, jumping 114 % from 2010 to 2011. 2012 saw another increase in newly installed capacity from 91.7 MW to 175 MW. All in all 360 MW of installed capacity were up and running in 2012.

Research and development

To develop PV technology further Austrian companies collaborate closely with research partners. The foundation of the "Austrian Photovoltaics Technology Platform" association in 2012 created a network with the aim of further strengthening collaboration between science and industry and of joint profiling internationally. Members of the platform include prominent Austrian manufacturing companies involved in PV as well as research facilities, universities and industry associations – amongst others, the Austrian Institute of Technology (AIT), University of Applied Sciences Technikum Wien, Vienna University of Technology, Graz University of Technology, Johannes Kepler University Linz (JKU), the Association of the Electric and Electronics Industry (FEEI), Photovoltaics Austria, Austrian Research Institute for Chemistry and Technology (ofi) and the Polymer Competence Center Leoben GmbH (PCCL).

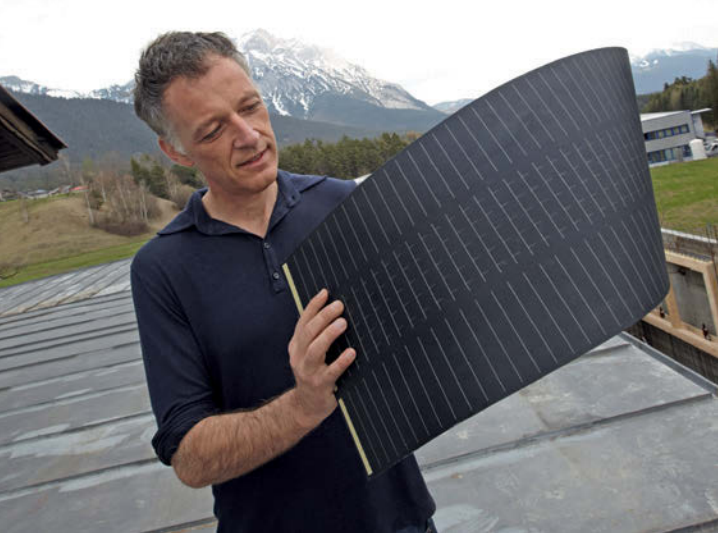
At the international level Austrian agents from industry and research organizations are actively participating in various networks (e. g. within the framework of the IEA research collaboration, the EU research framework programme and the European SET Plan Initiative SOLAR-ERA.NET). Several research and development projects in the field of photovoltaics are supported by programmes of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund (e. g. New Energies 2020 and its successor programme e!Mission.at).

The research is mainly focused on increasing efficiency (i. e. better performance or less area required) and also with industrial fabrication processes and cost optimization. Developing new photovoltaic components for integration into building, vehicle and appliance shells is of great current interest. With more and more PV facilities being installed in Austria, the issue of grid integration is in the focus of the Smart Grids Initiative. ◘

The EU´s Strategic Energy Technology Plan (SET Plan)

Until 2020 the SET Plan provides the framework for developing and implementing cost-efficient, low-emission energy technologies in order to meet the EU's 20-20-20 targets:

- Reducing greenhouse gas emissions by at least 20% compared to their levels in 1990 (– 20 % CO_2)
- Increasing the use of renewable energy sources (wind, sunlight, biomass etc.) to 20 % of overall energy production (+ 20 % renewables)
- Reducing energy consumption by 20 % compared to the forecast for 2020 by improving energy efficiency (+ 20 % energy efficiency respectively – 20 % energy consumption)



simpliCIS – flexible epitaxial solar cells
for integrating into buildings, appliances and vehicles

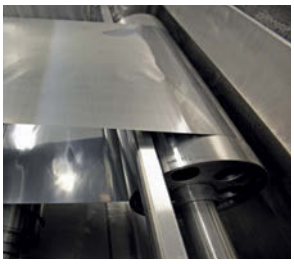
These days PV modules almost always look just the same: silicon wafers shimmering bluish under glass on the roofs of houses or in large solar arrays. This kind of solar cell is not necessarily suitable for integrating into façade or roof elements or into appliance housings or vehicle shells, where you need flexible solar cells that can be adapted to special requirements, often in unconventional shapes or sizes, or with particular electrical target values.

In collaboration with business and research partners, the firm of Sunplugged – Solare Energie Systeme is currently developing a flexible PV foil that can be adapted as regards shape, size and electrical voltage. This revolutionary technology will make customized PV solutions for building shells and appliances feasible.

As part of the "simpliCIS2" project a completely new type of epitaxial solar module is to be manufactured; its geometrical and electrical specifications can be defined individually during the production process. These foil-like solar modules are highly adaptable as regards mechanical properties (flexibility, low profile), design (size and shape) and electrical voltage. The solar cells developed in this project are based on composite CIS semiconductors.

The acronym CIS or CIGS stands for an epitaxial solar module technology using various combinations of the elements copper, indium, gallium, sulphur and selenium in the absorber layer. The CIS/CIGS solar cells have considerable efficiency potential; in laboratory tests they achieve anything up to just over 20 %, comparable with polycrystaline silicon solar cells. The "simpliCIS2" solar cell contains no toxic substances, can be manufactured in an endless production process, and is suitable for a new form of printable circuitry, because of the foil structure.

With its combination of flexibility and low production cost, the "simpliCIS2" solar module is not only of interest for generating electricity on façades and roofs, but can also be utilized as a construction material for energy-efficient solar-powered terminal devices such as mobile phones and street lights or in vehicles. ◘



Source: © Ringhofer/Climate and Energy Fund

TECHNOLOGY

Manufacturing the "simpliCIS" solar cell

The foil-like solar cell of unlimited length is manufactured roll-to-roll and cut to the right module length; the final shape and the module circuitry specified are defined in a machine specially developed for this purpose. A combination of short-pulsed lasers and precision screen-printing makes this entirely new technology of module circuitry.

Source: Sunplugged – Solare Energiesysteme GmbH

Flexible PV systems
High-barrier materials to protect sensitive solar cells

Christina Schinagl of ISOVOLTAIC with a flexible solar module
Source: © Ringhofer/Climate and Energy Fund

„With the market for really cost-effective PV integrated in buildings constantly expanding, this project has market potential way above average. Particularly as PV roof sheeting can be fabricated at low cost and installed and utilized elegantly, it can contribute to securing future supplies of energy – while bolstering Austria's technological position."
Christina Schinagl, ISOVOLTAIC

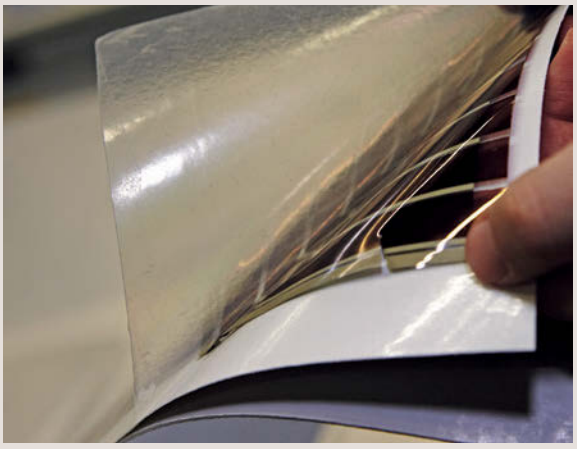
The Austrian company ISOVOLTAIC, the worldwide market and technology leader in developing and manufacturing backsheets for PV modules, is concerned with researching and developing new, cost-efficient technologies for encapsulating solar cells. As part of a collaborative project with business and research partners and a timeframe of several years, a flexible solar module 34 metres long, applied to a roofing membrane, is currently being developed.

The prototype, which merges membrane and solar module into an integrated construction element, has considerable potential for generating solar electricity in a cost-efficient way in future. The project involves developing high-barrier materials to encapsulate flexible solar cells, then fabricating the modules in a roll-to-roll process and finally roll-to-roll laminating on roofing membranes.

Various cell technologies are employed for the solar modules used. The material for encapsulating must satisfy cell requirements as regards its effectiveness as a barrier to water vapour/oxygen, its optical transparency, UV resistance, adhesion to

TECHNOLOGY

Fabricating the flexible "roof sheeting PV modules"
The high-barrier materials developed by ISOVOLTAIC are combined with encapsulation material from Isosport, and then assembled with the various types of cell in a roll-to-roll process. Both CIGS (copper-indium-gallium-diselenide cells/Flisom) and organic cells (Konarka) are employed; here e. g. differences in temperature stability between different types of cell must be taken into account. This multi-layer composite is then fused with roofing membrane (Renolit) in a roll-to-roll process.



Source: © Ringhofer/Climate and Energy Fund

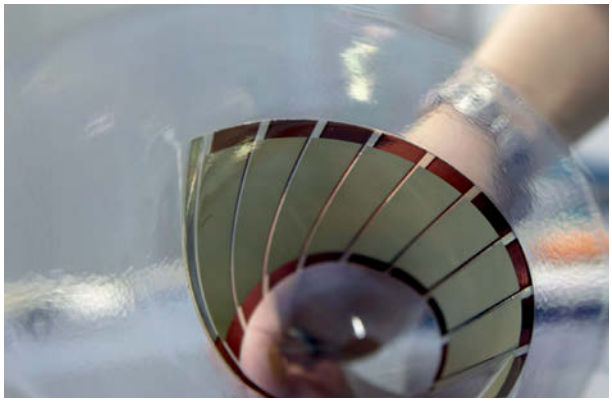
encapsulating media and flexibility during roll-to-roll processing. In addition, excellent resistance to weathering is required for use in long-term PV applications.

Quality and cost efficiency by means of industrial production

Until now high-barrier materials have been manufactured, and cell systems then encapsulated, in batches. The goal of the project is to transfer know-how acquired in batch manufacturing flexible PV modules to continuous roll-to-roll processing.

The processes recently developed make cost-efficient fabricating of flexible PV roof sheeting on a large scale to high quality standards possible. The modules come in the form of a flexible roll; they can be handled like conventional roof membranes (they weigh only slightly more than these), so further savings in installation costs are achieved.

The modules can be integrated into buildings in many ways, e. g. as shading elements that can be rolled up.



Source: © Ringhofer/Climate and Energy Fund

The "roof sheeting PV modules" fabricated are to be installed in test rigs at three different sites by the project partner Austrian Institute of Technology (AIT)/Energy Department, who will subsequently monitor the modules as regards optical and engineering parameters. It is planned to install a facility of this type on the roof of the ISOVOLTAIC headquarters in Lebring by the end of 2013. ◘

morePV2grid
Voltage control with PV power inverter

FRONIUS INTERNATIONAL GmbH, the largest Austrian producer of power inverters, has a leading position in the world market for solar electronics. Electronic control of PV facilities has been one of the company's concerns for many years, and it is constantly developing brand-new power inverter systems that convert DC – which the PV modules generate – into usable AC. The electricity produced in this way can then be consumed on the spot or fed into the grid.

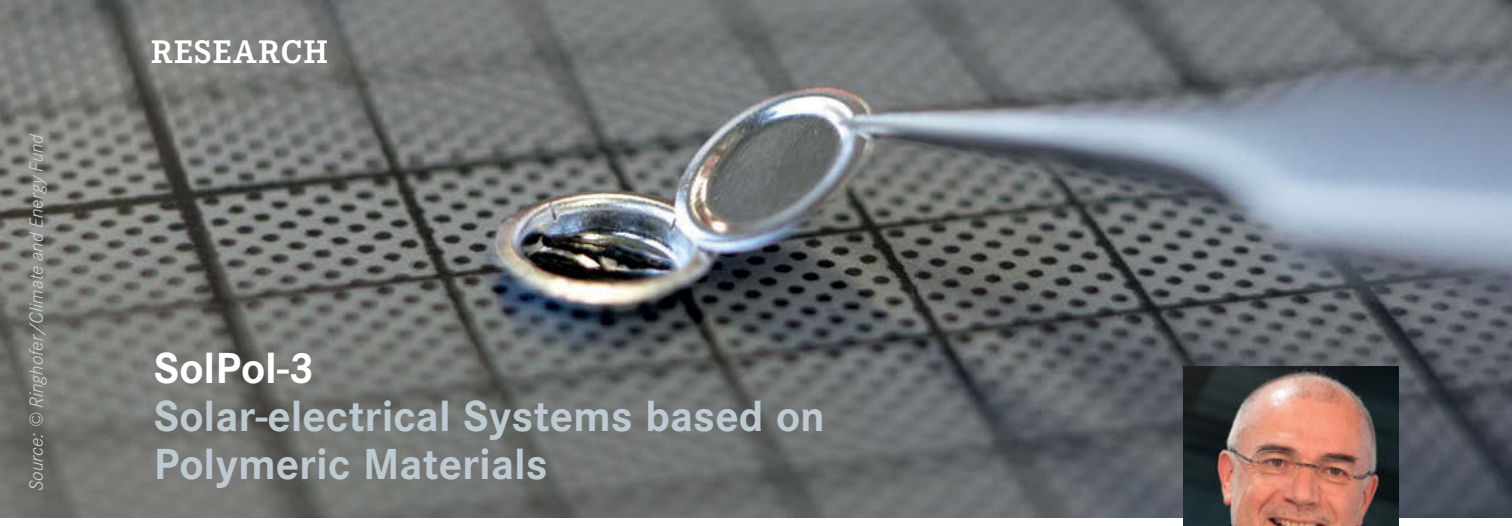
Due to the expansion of PV, it will be necessary to integrate numerous small local suppliers into the existing electrical networks in the future. This might lead to difficulties in low-voltage grids, since some segments are already at the limits of their capacity. The main challenge here is to maintain a stable voltage. Smart Grid approaches offer a possible solution to this problem; these should feature two-way communication between suppliers, consumers and storage facilities, and are intended to make intelligent energy management possible. Products to help with this, and suitable control strategies, are currently undergoing development and testing.

In the morePV2grid project FRONIUS, in collaboration with research partners and grid operators, has developed a strategy for voltage control by means of power inverters, and tried it out with eight test units in a field trial in Upper Austria.

Symo power inverter, Source: Fronius International GmbH

As a follow-on 140 units are currently undergoing testing as part of the DG Demonet Smart LV Grid project in Salzburg and Upper Austria. The goal is for numerous local PV facilities to contribute to keeping grid voltage stable by adjusting their active and reactive power autonomously, without higher-level system and communication engineering. In this way it should be possible to integrate a large number of PV facilities into the grid at reasonable cost.

These projects are not only concerned with how effective the control strategies are; special attention is paid to how often they are needed and to possible effects on the PV facilities' energy yield. In addition, recommendations are being worked out for the relevant national and international standards committees. ◘



Source: © Ringhofer/Climate and Energy Fund

SolPol-3
Solar-electrical Systems based on Polymeric Materials

Scientists at the Johannes Kepler University Linz (JKU) are currently developing new types of polymer for encapsulating solar cells that perform better and cost less than those on sale so far.

Whereas researchers working on the SolPol-1 and SolPol-2 projects were concerned with polymer-based solar collectors, completely new materials for the PV industry are being developed in SolPol-3, which is organized as an industrial research project. The experts see considerable potential for developing PV modules further in the merging of scientific and industrial competence in the fields of PV and polymer technologies.

The project brings leading Austrian research organizations together with firms active in the PV and polymer sectors. Alongside three scientific partners (the Institutes for Polymeric Materials and for Analytical Chemistry at the JKU and the Austrian Institute of Technology, AIT), the companies Borealis, Lenzing, Senoplast and APC, and the PV firms KIOTO and Sunplugged, are collaborating on the project.

The main technological challenge is to utilize completely new polymeric materials to encapsulate the PV cells, which involves special processes for fabricating PV modules. With the new polymeric materials for encapsulating, PV modules should be improved and the cost of material and processing during fabrication be lowered in future.

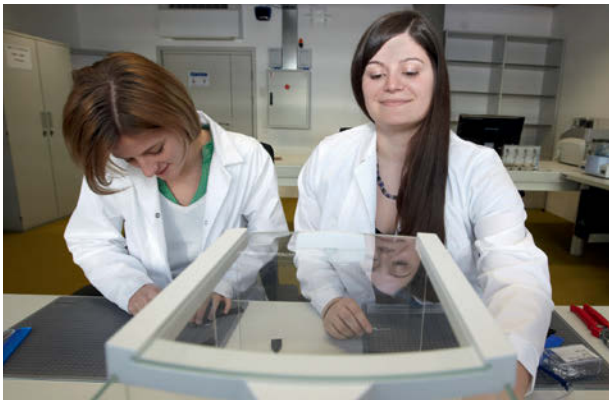
Innovation on the material front is mainly focused on encapsulating materials and backsheets for rigid and flexible PV modules. As part of the project all the requisite test engineering and analytic-experimental prerequisites are being developed and implemented.

Stage one of this three-year project has already been completed; it involved identifying suitable methods of testing and employing them to work out full property profiles for PV polymeric materials. Encouraging preliminary results with polyolefin and polystyrene materials (including copolymers and blends), both for encapsulating and for backsheets, are important for future developments. ◘

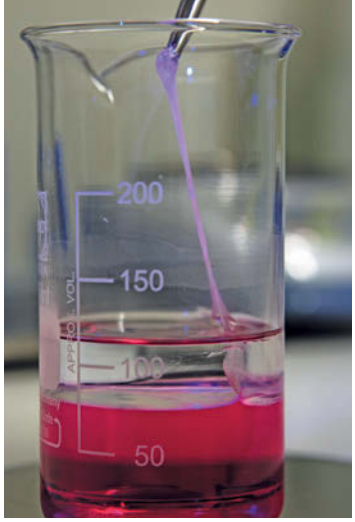
Reinhold W. Lang, JKU Linz, Institute of Polymeric Materials and Testing

How do you rate the chances of solar technologies, in particular photovoltaics, spreading across the globe?
With worldwide around 60 % per annum PV has steadily shown the highest growth rate of all renewable energy technologies over the last ten years. For instance, the PV capacity installed worldwide in 2011 was already around 70 GW. Until 2011 the EU accounted for the lion's share of this market growth, in future non-European markets (especially Asia, with China leading the way) will become more important. All in all PV has already achieved a degree of maturity, technologically and costwise, such that further worldwide market penetration is certain.

What is the significance of new polymeric materials for advancing photovoltaics?
In the form of encapsulation materials (cell encapsulation and composites for backsheets) and PV junction boxes, and also, for example, for various components in power inverters and for cable insulation, polymeric materials already play a considerable part in PV module and PV facility fabrication. The anticipated growing prominence of semi-flexible and flexible modules translates into polymer films covering the front face in future, too. In many experts' judgement new encapsulation materials which can be



Institute of Polymeric Materials and Testing, JKU Linz, Source:© Ringhofer/Climate and Energy Fund



Institute of Polymeric Materials and Testing, JKU Linz, Source:© Ringhofer/Climate and Energy Fund

processed faster, possibly continuously and therefore at lower cost than materials currently in use are going to be a key factor in advancing the technology and penetrating markets.

What forms does collaboration between research organizations and companies in the fields of photovoltaics and polymer technology take?

The Austrian PV Technology Platform was launched in 2009 to retain competitiveness internationally and enhance the attractiveness of the Austrian market. Funded programmes such as the Austrian Climate and Energy Fund's New Energies 2020, and more recently e!Mission.at, play a pivotal role in multilateral collaboration on research. The R&D project SolPol-3, funded through one of these programmes, has managed for the first time to involve a wide range of both Austrian companies and Austrian research organizations concerned with PV and polymeric materials.

What role do network building and the transfer of know-how play in the context of international programmes, such as the IEA research collaboration scheme?

A successful research strategy consists of an appropriate mix of national and international research activities. IEA collaboration in the form of participation in IEA tasks has a special role as a worldwide facility for swapping expertise. Alongside IEA tasks already in place concerned with PV, in my view a separate task on the issue of PV Encapsulation would be desirable.

PhiLiP
Photonics for entirely new management of light in PV modules

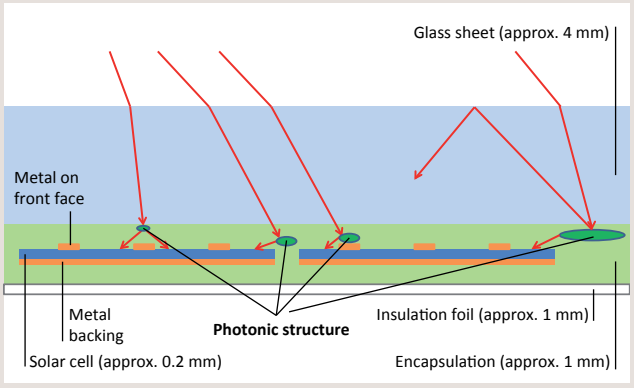
As part of a research project with a timeframe of several years JOANNEUM RESEARCH Materials and NanoTecCenter Weiz are working on entirley new approaches to making PV modules more efficient. While intensive research into increasing the efficiency of solar cells is being conducted in many countries, little attention has so far been paid to the potential for improving the efficiency of the whole module, which is of the same order of magnitude.

More than 80% of the PV modules currently being produced employ solar cells fabricated from silicon wafers. These cells are fully metal-backed, with a metal lattice on the front face. A significant proportion of the sunlight reaching the module face is wasted, since around 7 to 9 % of the front of the cell is in the shadow of electrodes, while roughly 10 to 15 % of the module area is not covered with cells (for production engineering reasons); so overall optical losses add up to around 20 % of the light impinging on the module.

With the aid of photonic structures specially developed to deal with this the research team now intend to utilize the sunlight impinging on the inactive module area. These structures, implanted in the PV module, are designed to direct light specifically onto the active area of the solar cells, so as to make the module more efficient overall. The goal is to halve the optical losses, and thus to boost module performance by 10 % and module efficiency by 1.5 %.

On the way to realizing this aim, optical simulation is used to evaluate how diffractive and refractive optical structures can direct light precisely in a module; tailor-made structures can then be developed. To fabricate these structures and integrate them in test modules, a variety of low-cost methods are to be employed, such as laser processing or ink-jet printing. ◘

TECHNOLOGY



Source: G. Peharz, JOANNEUM RESEARCH

Schematic cross-section through a PV module with silicon solar cells. Photonic structures in various positions direct sunlight precisely onto active cell area.

IEA collaboration on PV research
Austria‘s participation in international networks

The Photovoltaic Power Systems Programme (IEA PVPS) is the largest PV research platform in the world. Within the framework of the International Energy Agency it is one of the Implementing Agreements in the Renewable Energy Working Party‘s remit, and provides a platform for applied research activities and commercial launch strategies.

The programme is concerned with all aspects of PV systems. Research activities are directed toward cutting costs, spreading awareness and eliminating non-technical obstacles to better market penetration. With 23 countries currently taking part in this research programme, swapping experience at the international level is greatly facilitated. Austrian experts are actively involved in five of the seven Tasks currently in progress, and Task 14 is headed by Austria.

- Task 1: Exchange and dissemination of information on photovoltaic power systems
- Task 11: PV hybrid systems within mini-grids
- Task 12: PV environmental health and safety
- Task 13: Performance and Reliability of Photovoltaic Systems
- Task 14: High Penetration of PV Systems in Electricity Grids

“Taking part in national and international networks in the PV field is the key to innovation – a prerequisite for success in international markets. The National PV Technology Platform, the association of manufacturers based in Austria in the PV value creation chain and related areas, provides stimuli to encourage innovation by means of close cooperation between business and research organizations. The IEA‘s Photovoltaic Power Systems Programme ensures that participants are linked to leading PV agents at the international level. Austria takes full advantage of of these networks so as to play a leading part in selected technological areas internationally.”

Hubert Fechner
represents Austria on the PVPS Executive Commitee and chairs the Austrian PV Technology Platform

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 Transport, Innovation and Technology and the Climate and Energy Fund. **www.nachhaltigwirtschaften.at** **www.klimafonds.gv.at**

INFORMATION

simpliCIS
Sunplugged – Solare Energiesysteme GmbH
Contact: Andreas Zimmermann
andreas.zimmermann@sunplugged.at
www.simplicis.at

Flexible PV systems
ISOVOLTAIC AG
Contact: Christina Schinagl
christina.schinagl@isovoltaic.com

PhiLiP
JOANNEUM RESEARCH Forschungsgesellschaft mbH
Contact: Gerhard Peharz
gerhard.peharz@joanneum.at

morePV2grid
FRONIUS INTERNATIONAL GmbH
Contact: Martin Heidl
heidl.martin@fronius.com

SolPol-3
Johannes Kepler University Linz (JKU) - Institute of Polymeric Materials and Testing
Contact: Reinhold W. Lang, Gernot Wallner
jku.solpol@yahoo.de
www.solpol.at

Austrian Photovoltaics Technology Platform
Contact: Hubert Fechner
hubert.fechner@technikum-wien.at
www.tppv.at

Information on IEA activities:
www.nachhaltigwirtschaften.at/iea
www.iea-pvps.org
www.iea.org

IMPRINT
Published by Federal Ministry for Transport, Innovation and Technology (Renngasse 5, 1010 Vienna, Austria) in cooperation with the Climate and Energy Fund (Gumpendorferstr. 5/22, 1060 Vienna, Austria)
Edited and designed by Projektfabrik Waldhör KG, Am Hof 13/7, 1010 Vienna, Austria, www.projektfabrik.at