EUREC

RENEWABLE ENERGY PROJECTS CATALOGUE

A guide to successful and innovative projects in the area of renewable energy

INTRODUCTION

FINANCING A GREEN TRANSFORMATION OF THE ENERGY SYSTEM

The global transformation to sustainability is the key task of our generation, of this century. Among the many issues that have to be addressed, the transformation of the energy system towards higher energy efficiency using increasing fractions of renewable energy is the most pressing one. We are well aware of the looming dangers of catastrophic climate change that we have to expect if we continue increasing the atmospheric content of CO_2 and other greenhouse gases. The recent international climate accord at the Paris IPCC conference shows the way we have to follow.

Fortunately, in addition to the argument of climate protection, there is now a second powerful thrust boosting this increasingly disruptive transformation process: the low cost of renewable energy, combined with the rapidly decreasing cost of energy storage, which make the transformation process more and more attractive just on economic grounds.

The EU is the global powerhouse of technology development in this field, and EUREC is the leading organization of European research institutes working in this area. The 41 EUREC member research centres and institutes have produced numerous examples of innovative technologies, often developed with support from the EU, that were already implemented in the field and work to expectations, exceeding, in many cases, our conservative performance predictions.

This brochure presents an impressive showcase of projects in the fields of renewable electricity, renewable heating and cooling, sustainable transport, grid integration and energy system studies, including education and training efforts. These projects were carried out by EUREC member institutions. Most of these projects were conducted with decisive support from the European Commission and showcase the impact the EU research support has in these key technologies.

It is to be hoped that this laudable research support will be increased by a smart industrial policy, aimed at levelling the global playing field with respect to locating and keeping productive industries in Europe, especially in this rapidly growing industrial sector of renewable energy technologies. The European market has been key to the impressive cost reductions of renewable energy technologies, in particular solar and wind, but Europe did little to create an investment scheme that could compete with attractive financial conditions such as credit guarantees available in Asian countries. These countries succeeded in dominating the world market today with their products. It is imperative for Europe to retain productive industries who translate the results of first-class innovative research into marketable technologies. Here, the energy sector is just one of many key enabling technologies that we need to keep in Europe to ensure a bright economic future for our continent.

Yours sincerely,

Eicke R Weber
EUREC President

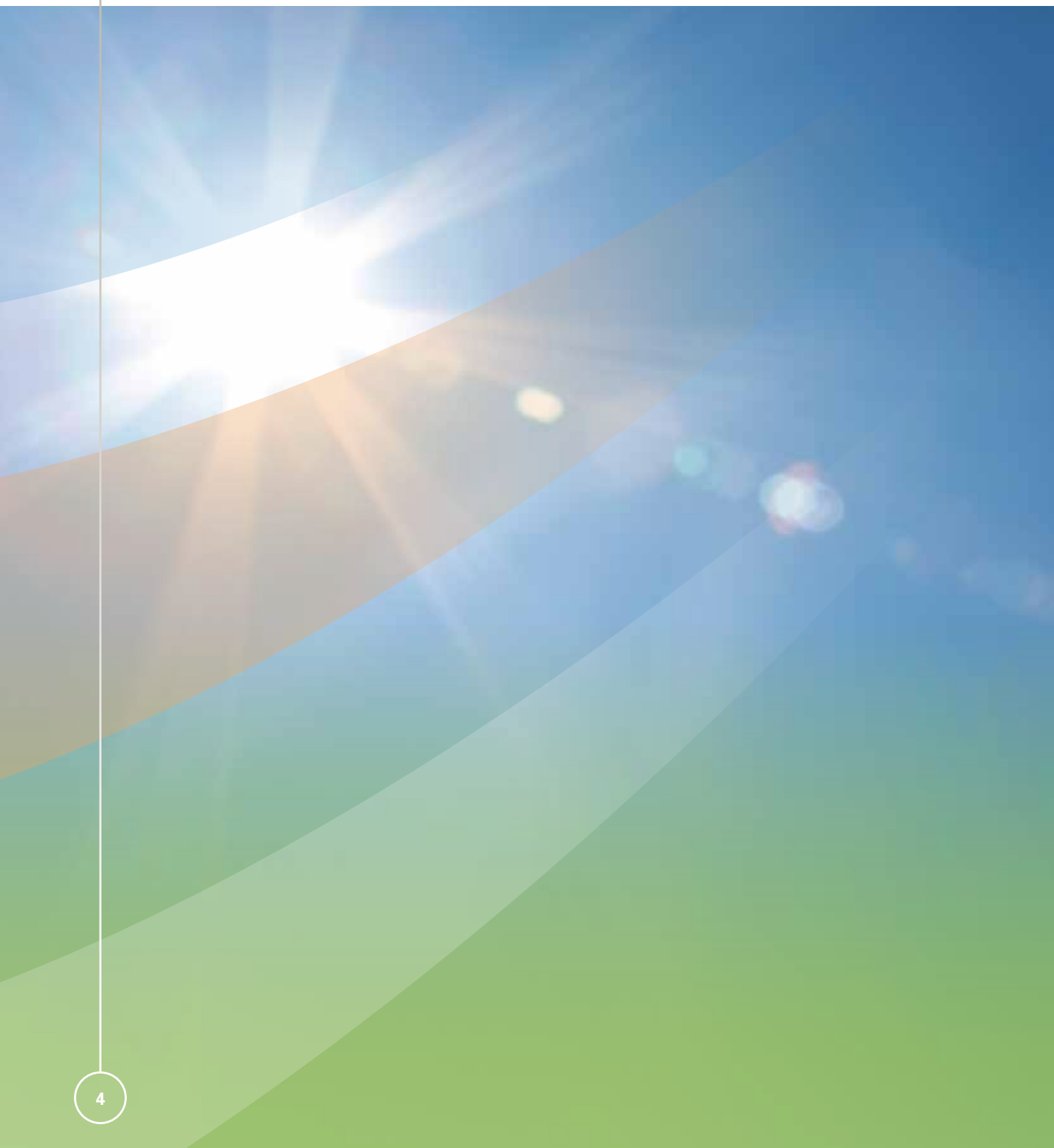


TABLE OF CONTENTS

PROJECTS

1. RENEWABLE ELECTRICITY 06 > 37

2. RENEWABLE HEATING AND COOLING 38 > 47

3. SUSTAINABLE TRANSPORT 48 > 55

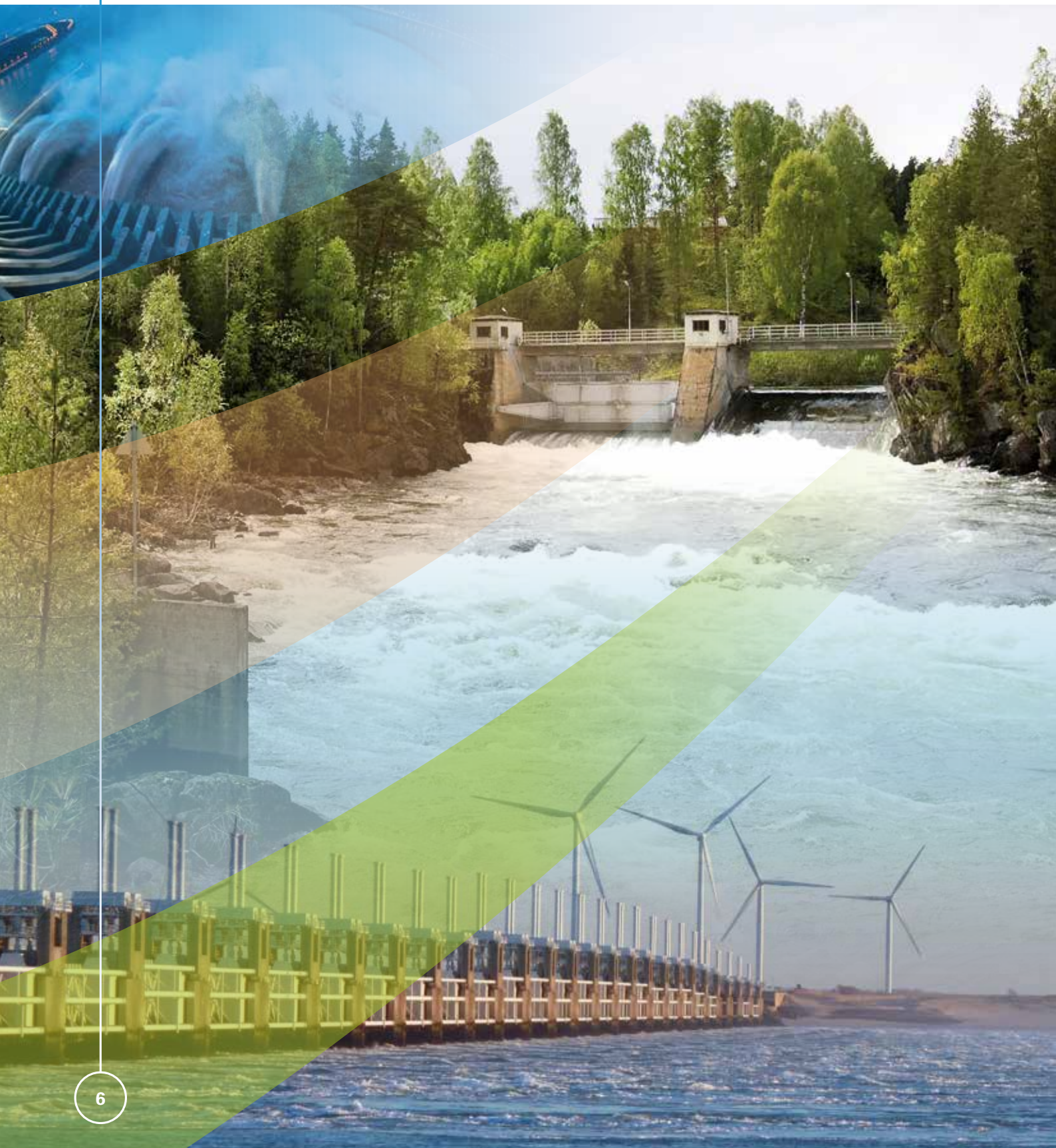
4. HORIZONTAL TOPICS 56 > 75

CONCLUSION 76 > 78

EUREC MEMBERS 79 > 80

Editor
Vinicius Valente
Communication Adviser, EUREC

I. RENEWABLE ELECTRICITY



PROJECTS

1. AVATAR - Advanced Aerodynamic Tools for Large Rotors 8

2. AWESOME - Advance Wind Energy Systems Operation and Maintenance Expertise 10

3. CAPTure - Competitive SolAr Power Towers 12

4. CHEETAH - Cost-Reduction through Material Optimisation and Higher Energy Output of Solar Photovoltaic Modules 14

5. ECO-SOLAR 16

6. EPICOMM - "Commercialization of Epiwafers for Use in Highly Efficient Solar Cells" 18

7. EUROSUNMED - Euro-Mediterranean Cooperation on Research & Training in Sun Based Renewable Energies 20

8. FSFOUND 22

9. KESTCELLS - Training for Sustainable Low Cost PV Technologies: Development of Kesterite Based Efficient Solar Cells 24

10. NEXT-CSP - High Temperature Concentrated Solar Thermal Power Plant with Particle Receiver and Direct Thermal Storage 26

11. POWER-TO-FLEX - Flexible Energy Supply by Energy Storage 28

12. SOLAR BANKABILITY 30

13. SONG - Solar Nano-Grids 32

14. SHARC25 - Super High Efficiency $Cu(In,Ga)Se_2$ Thin-Film Solar Cells Approaching 25% 34

15. SWInG - Development of Thin Film Solar Cells based on Wide Band Gap Kesterite Absorbers 36

AVATAR - ADVANCED AERODYNAMIC TOOLS FOR LARGE ROTORS

www.eera-avatar.eu

CHALLENGES

In the coming years offshore installations are expected to comprise the major element of wind energy penetration. Taking into account that the rotor cost as % of the total cost of Energy (CoE) is much less compared to onshore installations, there is a drive to increase the turbine size to levels beyond 10 MW which implies larger rotor diameters. Today's commercial rotor sizes are still limited to within 130 meter diameter (corresponding to rated powers of 6-7.5 MW) while prototypes exist up to 164 meter. Upscaling to sizes beyond 10 MW goes together with severe technical challenges due to the considerable increase of the blade weight which renders its practical operation unrealizable.

To make such large wind turbines reality innovations in aerodynamic design suggest lower solidity rotors with larger diameter and long slender blades with thicker airfoils running at high tips speeds. Moreover, active and passive flow and load control devices offer interesting design options in order to further reduce load levels. Rotor designs of this kind fall outside the validated range of current state of the art tools and create new challenges: Very large blades operating at high tip speeds will lead to high Reynolds and Mach numbers effects; thick airfoils need to be assessed in terms of aerodynamic performance and structural/aeroelastic implications; aerodynamic modeling of flow devices must be included in the design process; increased flexibility will lead to larger deflections and more pronounced non-linear aeroelastic behavior with unknown aerodynamic implications. The above indicate the need to improve and validate the existing aerodynamic models. Advance CFD modeling requires significant computational cost, so an additional challenge is the assessment and calibration of engineering models in order to keep the computational effort of design calculations within reasonable limits.

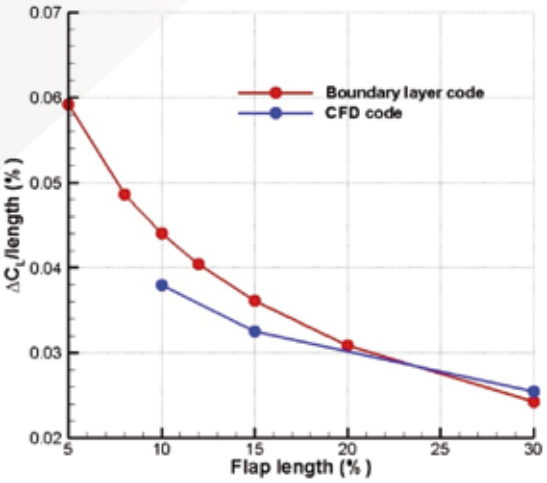
MAIN FEATURES OF THE PROJECT

The main objectives of the AVATAR project are:

- To develop validated and reliable tools for the design and aeroelastic evaluation of the very large turbine rotors (10+ MW) of the future. These tools will be able to predict both the performance and the static and dynamic loading of the rotors, potentially enhanced with passive and active flow devices.
- To demonstrate the capability of producing valid aeroelastic calculations, suitable for the design, analysis and certification of large wind turbines.
- To assess the consequences these issues have on design improvement and uncertainty reduction in power performance and loads calculations.

The strategy of the project is clearly directed towards improved aerodynamic modeling for large-scale rotors. The first step is the design and evaluation of a reference rotor taking into account all design aspects in an integrated way. The reference rotor forms the basis for the improvement and calibration of the aero-tools. The model improvements are based on a philosophy

Figure 1 : Effect of flap length on the lift coefficient – Increase per unit of flap length



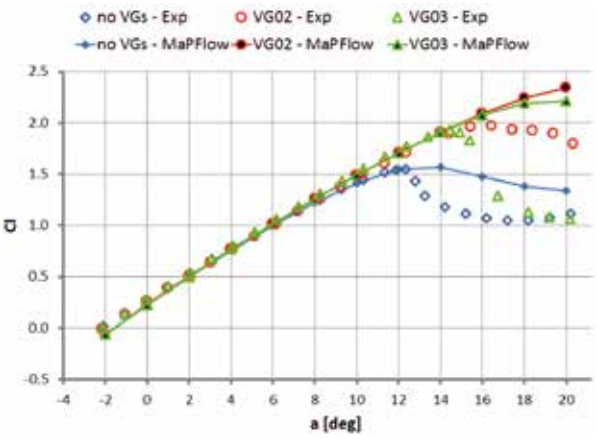


Figure 2 : Effect of Vortex Generators on the lift coefficient for different positions along chord

in which high fidelity tools feed results towards the efficient comprehensive industrial tools. In parallel the models for flow devices and flow control are developed and improved in aerodynamic terms, basically on a sectional level. Then the aeroelastic aspects are considered, including validation, where it should be noted that aerodynamics and aeroelasticity are inextricably connected. Finally, the emphasis of activities moves to the re-evaluation of the reference rotor based on the newly developed engineer tools. This is followed by a redesign of the turbine using the advanced control options. The results from these activities will form the input for the development of aerodynamic/aeroelastic design guidelines including the perspectives for a further upscaling towards 20 MW.

RESULTS

Valuable results in terms of aerodynamic modeling of large wind turbines (10MW and more) were obtained in the context of the AVATAR project. Regarding CFD simulations, the initial scattering of the results was considerably reduced after paying attention to grid refinement and domain size in relation to grid topology. Predictions were compared against wind tunnel measurements at high Reynolds numbers of 3 and 15 Million. The choice of the proper transition model was proved important to reproduce the 'flattening' of the cl/cd peak towards high Reynolds numbers.

Another significant activity refers to the modelling and measurements of flow devices. It was shown that the rotor design, mainly in terms of the rated angles of attack, has significant influence on the flap performance and its practical application so the use of flaps must be talken into account in the initial design. In principle, it is not recommended to increase the length of the flap more than 10-15% of the chord. The main reasons are that small flaps are relatively more effective to vary the loads as shown in Figure 1 where the relative increase in the lift coefficient is presented for different flap lengths. On the other hand the modelling of vortex generators turns out to be challenging. At high angles of attack (above 10º) vortex generators increase the lift coefficient and decrease the drag values leading to higher airfoil efficiencies. This trend is depicted in Figure 2 where CFD predictions of the lift coefficient are compared with the experimental data.

AVATAR
AdVanced Aerodynamic Tools for lArge Rotors

CONTACT DETAILS

Professor Spyros Voutsinas

National Technical University of Athens, Department of Fluid Mechanics Engineering,

Tel : +302107721096
E-mail : spyros@fluid.mech.ntua.gr

EUREC MEMBER

National Technical University of Athens

AWESOME - ADVANCE WIND ENERGY SYSTEMS OPERATION AND MAINTENANCE EXPERTISE

www.awesome-h2020.eu

CHALLENGES

The growing trend of the wind energy sector (10% of annual increase in the last 10 years), the aging of existing onshore parks (above 10 years), the high operation and maintenance costs (average share of 20%-25% of total levelised cost per kWh produced), as well as the general agreement within the European wind energy industry on the fact that the sector is suffering an increasing shortage of skilled labour, makes the operation and maintenance (O&M) one of the critical tasks for ensuring a cost-effective exploitation of wind farms.

In this scenario, AWESOME network aims to educate eleven young researchers in the wind power O&M field by constructing a sustainable training network gathering the whole innovation value chain. The main EU actors in the field of wind O&M have worked together, under the umbrella of the European Wind Energy Academy (EAWE), in order to design a training program coping with the principal R&D challenges related to wind O&M while tackling the shortage of highly-skilled professionals on this area.

The overall AWESOME research program tackles the main research challenges in the wind O&M field identified by the European wind academic and industrial community:

- Developing better O&M planning methodologies of wind farms for maximizing its revenue.
- Optimising the maintenance of wind turbines by prognosis of component failures.
- Developing new and better cost-effective strategies for Wind Energy O&M.

AWESOME network includes companies, universities, associations and research centres experts in the wind energy sector from Spain, Italy, Germany, UK, Denmark and Norway.

MAIN FEATURES OF THE PROJECT

The three main AWESOME research goals have been divided into eleven specific objectives, which has been assigned to the fellows, for them to focus their R&D project, PhD Thesis and professional career.

AWESOME fellows have been recruited by project beneficiaries who has designed a training program that answers the challenges identified by the SET Plan Education Roadmap. The program includes local training (PhD enrolment), intra-network activities (secondments and specific AWESOME courses) as well as network-wide actions such as scientific conferences coordinated with EAWE, summer schools and industrial workshops.

Personal Development Career Plans has been also tuned up for every fellow, being their accomplishment controlled by a Personal Supervisory Team formed of senior researchers coming from different research environments. Along the project, each fellow is being exposed to three different research environments from both, academic and industrial spheres through secondments at partner organizations and between beneficiaries.

Apart from the obvious prospects in wind energy, the fellows are receiving complementary training in project management, entrepreneurship, IPR management and R&D results exploitation, opening their careers to other fields.

The international character of the project, even in the same environment, also contributes to the exchange of knowledge providing the fellows with different approaches and ways of facing R&D works.

AWESOME network at the Torque 2016 conference (Munich, Germany)

Wind energy O&M

RESULTS

According to the eleven research lines developed by the fellows, AWESOME main results and major innovations contributing to wind energy cost reduction are the following:

1. Methodology for very short time wind field forecasting and power output forecast.
2. Simulation game for the operational phase of a wind farm.
3. Tool to operate a whole wind farm as a wind sensor for improving the operation and control of the wind farm.
4. Prognostic methods for particular failure modes in wind turbine components and maintenance strategies for turbine fleets.
5. Tool of the assessment of commercial Condition Monitoring systems by determining whether and when the CM systems detect faults and with what reliability.
6. Methodologies for the prognosis of wind turbine component failures using only SCADA data.
7. High performance Condition Monitoring system.
8. Tool for risk-based decision about post-design life operation.
9. Tool to schedule maintenance on a wind farm to improve availability and decrease the cost of O&M.
10. Reliability based methods for the reduction of the cost of O&M.
11. Optimization methodologies for the cost-effective management of wind farms.

By June 2018, at the end of the training period, AWESOME fellows will complete their PhD degree, providing them with a solid background for the development of their research and technical career, and being positioned as experts on specific fields and on general research on the concepts of wind O&M.

CONTACT DETAILS

Susana Matas,
smatas@fcirce.es

CIRCE
(www.fcirce.es),
Zaragoza, Spain

EUREC MEMBER

Since January 2015, all AWESOME fellows have completed their secondments and have attended three network specific courses (Spain, Norway and Germany), two summer schools (UK and Germany), two industrial workshops (Norway and Spain) and one PhD Seminar coordinated with the EAWE.

ACKNOWLEDGMENT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642108.

CAPTure - COMPETITIVE SOLAR POWER TOWERS

www.capture-solar-energy.eu

Call: H2020-LCE-2014-1.Grant Agreement Nº: 640905

Dates: May 2015 – April 2019

Coordinator: CENER; Partners: PSA-CIEMAT, Tekniker, EDF, CEA, TSK-Flagsol, BlueboxEnergy, Fraunhofer IKTS, FCT-Ingenieurkeramik, Haver & Boecker, EUREC, CERA System, QuerDenkFabrik.

Total budget: 6.461 970,43 €

More info: www.capture-solar-energy.eu

CHALLENGES

The **main goal** of the Competitive Solar Power Towers (CAPTure) project is to significantly reduce costs of concentrated solar power (CSP), in order to pave the way for its deserved competitiveness on the power market.

In order to increase plant efficiencies and reduce levelized cost of electricity (LCOE), the project will develop all relevant components that allow implementing an innovative plant configuration.

This plant configuration is based on a multi-tower decoupled advanced solar combined cycle approach that not only increases cycle efficiencies but also avoids frequent transients and inefficient partial loads, thus maximizing overall efficiency, reliability as well as dispatchability, all of which are important factors directly related to cost competitiveness on the power market.

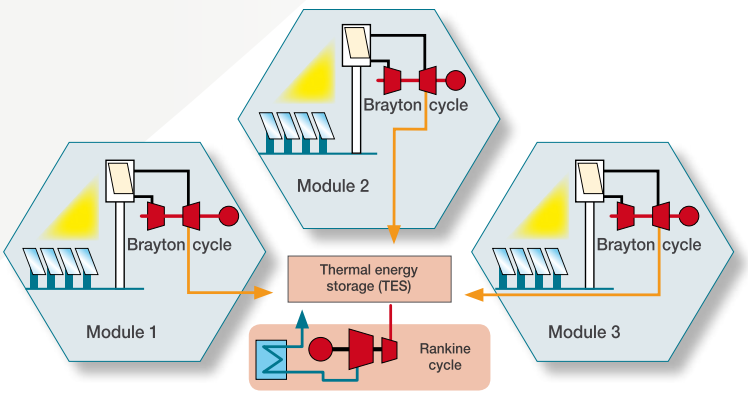
The innovative solar receiver will be an open volumetric receiver allowing operating temperatures beyond 1200ºC, providing the absorbed solar heat to the pressurized air circuit of the Brayton cycle via a network of fixed bed regenerative heat exchangers working in alternating modes (non-pressurized heating period, pressurized cooling period).

The **global objective** of this project is to increase concentrated solar power plant efficiencies and reduce levelized cost of electricity (LCOE) by developing the key components of an innovative plant configuration. This plant configuration is based on a multi-tower decoupled advanced solar combined cycle approach that not only increases cycle efficiencies but also avoids frequent transients and inefficient partial loads, maximizing overall efficiency, reliability as well as dispatchability.

MAIN FEATURES OF THE PROJECT

CENER is the coordinator of this European project. CAPTure's work plan implementation is divided into 10 work packages (WPs), outlined as follows:

- WP 1: Definition of the overall specifications of the CAPTure concept, the decoupled solar combined cycle (DSCC) as well as the development of system model and concept optimization through simulations.



The CAPTure plant configuration is based on a multi-tower decoupled advanced solar combined cycle approach

- WP 2: Development of two high efficiency volumetric solar receiver concepts.
- WP 3: Development of the CAPTure regenerative heat exchanger system.
- WP 4: Development of a high efficiency Brayton cycle specifically addressing the needs of the CAPTure combined cycle configuration.
- WP 5: Development of the down-sized heliostat and related lean manufacturing analysis, the smart calibration system, as well as the innovative dynamic multiaiming-point strategy.
- WP 6: System integration and testing in relevant environment.
- WP 7: Detailed risk analysis.
- WP 8: Coordination of communication and dissemination activities.
- WP 9: Exploitation of results.
- WP 10: Overall management of the CAPTure project.ww

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640905

COMPETITIVE SOLAR POWER TOWERS

CONTACT DETAILS

Technical issues:

Dr. Marcelino Sánchez
Director, Solar Thermal Energy Department, CENER
msanchez@cener.com
Phone: +34 948 25 28 00

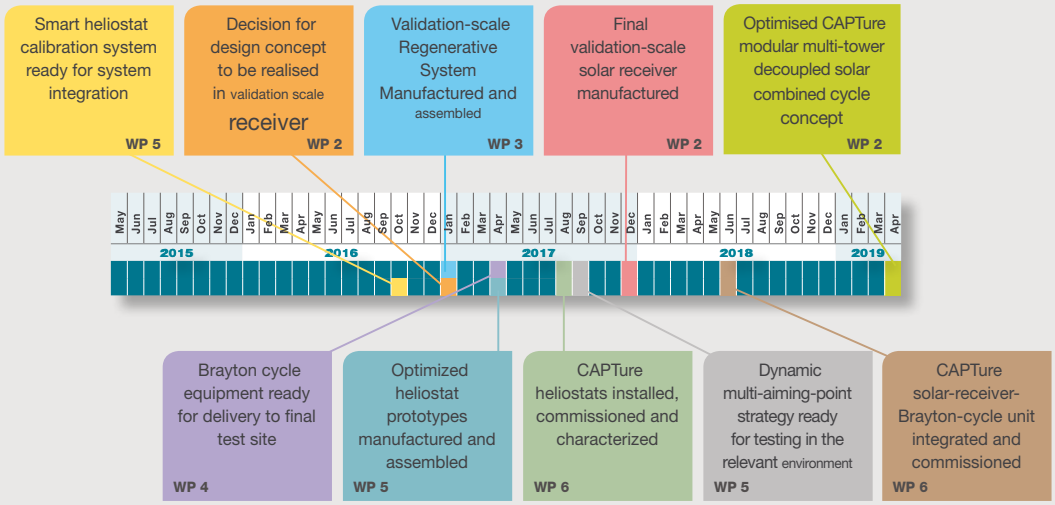
Dr. Fritz Zaversky
Solar Thermal Energy Department, CENER
fzaversky@cener.com
Phone: +34 948 25 28 00

EUREC MEMBER

CENER

TIMELINE

The CAPTure project started its activities on 1 May 2015 and will run until 30 April 2019



CHEETAH - COST-REDUCTION THROUGH MATERIAL OPTIMISATION AND HIGHER ENERGY OUTPUT OF SOLAR PHOTOVOLTAIC MODULES

www.cheetah-project.eu

CHEETAH - Cost-reduction through material optimisation and Higher EnErgy outpuT of solAr pHotovoltaic modules - joining Europe's Research and Development efforts in support of its PV industry - is a 4 year combined collaborative project and coordination and support action funded under the European Commission's 7th Framework programme and runs since January 2014. The project consortium consists of 34 partners from research institutes and universities.

CHEETAH's aim is to solve specific R&D issues as outlined in the EERA-PV Joint Program, to overcome fragmentation of European PV R&D in Europe and intensify the collaboration between R&D providers and industry to accelerate the industrialization of innovations.

CHEETAH'S OBJECTIVES

The main objectives in this project are threefold:

- **More power with less materials:** developing new concepts and technologies for wafer-based crystalline silicon PV (modules with thin cells < 100 micron), thin-film PV (advanced light management) and organic PV (very low-cost barriers), resulting in (strongly) reduced cost of environmentally benign/abundant/non-toxic materials and increased module performance.
- **Fostering long-term European cooperation in the PV R&D sector,** by sharing knowledge, organizing workshops, exchange and training researchers inside and outside Europe, efficient use of infrastructures, promoting best practices and standards
- **Accelerating the implementation of innovative technologies in the PV industry**

MAIN ACHIEVEMENTS

In this contribution we will present a broad overview of some selected highlights of the CHEETAH project divided into joint research activities and coordinative and support actions.

Joint research activity results:

- **Wafer based crystalline Si:** epitaxial growth of (ultra) thin crystalline Silicon wafers up to 80 micrometer and the successful development of Heterojunction (HJ) and Back Contact cell and module manufacturing processes for thin devices down to 80 µm (best x-Si HJ cell with 4 busbars: 21.2% efficiency for 97 µm);
- **Thin film PV:** Advanced light management solutions and modelling for micro concentrator CIGS cells and thin film Silicon based on Liquid Phase Crystallization of thin film Silicon. A 22.5 % CIGS micro concentrator was achieved under concentrated light for sub- mm² cell using the innovative approaches;
- **Organic PV:** Improvement of intrinsic stability of organic PV via fullerene free acceptors and development of cost efficient flexible organic and inorganic protective films for extended lifetime of unprotected devices.

Coordinative and support action results:

- The creation of an advanced Knowledge Exchange Web Area Portal (KEAP) which is an online and dynamic information source aiming at promoting knowledge exchange among experts and trainees on photovoltaic solar energy research in Europe;
- A complete e-learning platform to offer lectures, courses and remote on-line experiments;
- An indicative cost assessment was made for thin wafer based x-Si technology revealing the cost reduction potential of using thinner Si wafers.
- Start project: 1-1-2014, End project: 1-1-2018: duration 48 months

Joint research activity results

Cost reduction strategy in Wafer based silicon, thin film PV and Organic PV

1. Fabricate (ultra)thin wafers by
   - Epitaxial growth EPI `kerf free` foils (low TRL) from 40-80 micron
   - Wire sawn wafers (high TRL) down to 80 micron
2. Development of a process for the fabrication of advanced solar cells and modules Develop new technology bricks for ultra-thin wafers (40 µm)
   - Develop front side textures > optical light trapping, Jsc improvement
   - High surface passivation level > Voc improvement
   - Advanced metallization > low breakage rate, Jsc and FF improvementDevelop and/or redesign industrially compatible cell and module processes for thin cells
   - Maximize yield, maintain performance

- **Cell processing of ultra-thin wafers**
  - A successful HJ process integration was done on 40 to 50µm 125x125 Epifoils (4x 4 cm^2 cells) with optimized efficiencies up to 17 %
  - Heterojunction (HJ) cells down to 80 µm can be processed in automatic mode with minor process adjustments with 21.2 and 22.0 % cells obtained for resp. 96 µm 4 bus bar and 82 micron bus bar less solar cells. Wafers were chemically thinned from 120 µm sawn wafers.
  - Interdigitated Back Contact (IBC) cells down to 80 µm were processed using a pre-pilot process flow chart

- **Cell integration in modules**
  - Functional mini (4 cells) and full sized (60 cells) modules based on cells between 80 and 100 µm have successfully been fabricated.

Cost reduction strategy in Thin film PV

Higher efficiencies of thin-film solar cells (TF-Si, Cu(In,Ga)(S,Se)2 and Kesterites) with less solar cell base materials by enhancing todays maximum efficiency and an envisaged cost reduction of 20 %

CHEETAH
Knowledge Exchange Web Area

CONTACT DETAILS

J.M. Kroon
ECN Solar Energy,
P.O.Box 1, 1755 ZG Petten,
The Netherlands

j.kroon@ecn.nl

www.cheetah-project.eu

Cheetah knowledge Web Area Portal:
http://www.cheetah-exchange.eu/

EUREC MEMBER

JÜLICH FORSCHUNGSZENTRUM

ECN

Cost reduction strategy in materials research for Organic PV

- To develop an "encapsulation less" organic solar cells
- To build the methodology to screen materials and layers combinations for enhanced stability
- To use that innovation as platform for an encapsulated long-lived organic solar cell

ACKNOWLEDGEMENT

The European Union is acknowledged for funding the CHEETAH project through the Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 609788 (CHEETAH)

ECO-SOLAR

www.ecosolar.eu.com

CHALLENGES

Eco-Solar envisions an integrated value chain to manufacture and implement solar panels in the most ecologic way, taking into account reuse of materials while manufacturing and repurposing solar panel components at end of life stage.

To realise this, the following challenges need to be overcome:

- Recycling of high purity argon purge gas and reuse of crucibles in multi- and single crystalline silicon ingot growth.
- Demonstrate the possibility to industrially recycle the silicon kerf-loss from wafer sawing for solar ingot production, thus turning waste into a high value material with benefits in terms of reduction of virgin poly-silicon consumption, carbon footprint and energy consumption.
- Develop a solar-cell "doctor": a fully automated system capable of identifying defects in finished cells and repairing those that are capable of being rescued
- Develop automated module disassembly, based on the NICE-module design

We want to provide a comprehensive analysis of the progress made with respect to resource efficiency, environmental impacts, material consumption and energy use. A target is to identify reuse and recovery routes for the main products and the by-products within the solar and -if this will not be possible- in other industries. Both business plan data and environmental data will be used to create the eco-efficiency portfolio.

MAIN FEATURES OF THE PROJECT

The Eco-Solar project aims to maximise resource productivity and reduce pollution in PV, through minimising use of critical resources like energy, water, chemicals, aluminium, silver and lead, while simultaneously maximising recycling possibilities, by introducing design for recovery, reuse and recycling in this sector, and collaborating over the value chain for improvements in waste reduction.

This will lead to the realisation of PV modules with a reduced number of critical components and arrives at reduction of the total mass of organic components by 90% and of metal (mainly aluminium) structural elements by 50% to 66%.

The consortium will manufacture and test industrial size modules using Eco-Solar cells and material modules to investigate ageing and degradation aspects of solar modules during installation, assess the technological viability to capture and recycle components at end of life, and to assess environmental and economic aspects

The consortium aims to demonstrate an increased eco-efficiency, validated by LCA, with competitive STC power per module of 260Wp with multi-crystalline silicon cells and 285Wp with mono-crystalline cells.

CONTACT DETAILS

Martin P. Bellmann
Ph.D. Senior Research Scientist
Martin.Bellmann@sintef.no

EUREC MEMBER

RESULTS

Argon recycling has been introduced at Norsun ingot manufacturing site recycling argon exhaust gas at a rate of 96%. The method is based on a chemical looping combustion process to convert combustible species in the exhaust gas stream to carbon dioxide and water, followed by efficient of carbon dioxide and water in regenerable reactor beds. First results from crystals grown with argon recycling show similar material performance as grown by standard process without recycling. A similar recycling unit is installed at SINTEF to conduct experiments for multi-crystalline silicon ingot growth.

Steuler Solar Technology has developed a concept for reusable crucibles based on advanced silicon nitride ceramics. SINTEF tested the technical potential by reusing the silicon nitride crucible for crystallisation of multi-crystalline silicon in 5 subsequent runs. The obtained material quality is similar to material crystallised from electronic grade fused quartz crucibles.

Si-kerf-loss from wafer sawing was cleaned and compacted by Garbo. Transition metals were reduced to ppm level, but oxygen remained in the range 2-5 wt%, due to the extremely large specific surface leading to substantial amount of silicon native oxide. To remove oxygen recycled silicon was thermally treated at 1350 °C under low pressure. Thermal treated material was directionally solidified. The material has potential for PV applications, but the thermal treatment needs to be further optimised to reach acceptable lower oxygen levels.

A solar cell process using only one etching and cleaning step was developed by ISC, where first results show good performance for p-type Cz wafers. Omitted chemical etching steps so for are the etching of the PSG and the wet chemical edge isolation.

After Solitek manufactured the first set of two industrial size (60 cells) modules based on glass-glass lamination technique, material content was demonstrated to be reduced by more than 70% and aluminum by 90%. The cells originated from two Eco Solar processes, where n-type sc-single crystalline silicon ingots were grown with argon recycling at Norsun and where p-type multi-crystalline silicon ingots were grown from reusable crucibles at SINTEF.

bifa has implemented an initial material and energy flow model for all standard production procedures and process chains for the production of PV modules.

At the mid-term assessment, the significant benefit from argon recycling, reducing organics and aluminum in module manufacturing was demonstrated. Moreover, potential for reducing silver, ceramics, silicon and DI-water was visible, but further work is needed to come closer to the project targets.

EPICOMM - COMMERCIALIZATION OF EPIWAFERS FOR USE IN HIGHLY EFFICIENT SOLAR CELLS

www.ise.fraunhofer.de

CHALLENGES

The cost of PV modules has been reduced by 80% in the last six years. During the past decades the prices for PV modules dropped by 22% upon doubling the total amount of installed PV power generation capacity. This development has mainly been driven by continuous improvements and evolutionary advances in technology. Future progress is likely to be driven mainly by technology innovation. Besides improving the efficiency of the modules, cutting the production cost is of outmost importance. The silicon wafer counts for about 40% of the module cost. The conventional wafer production technology is very well established and its future cost reduction potential is very limited. Disruptive approaches are needed to bring the wafer costs further down significantly. NexWafe´s epitaxially grown silicon wafers (EpiWafer) produced by high throughput silicon deposition is such a disruptive technology which will cut the cost of wafer manufacturing by more than 50%.

The objective of the project EpiComm is therefore to bring epitaxially grown silicon wafers for photovoltaics (PV) from lab scale to a market ready product. The silicon wafer is the main commodity for the production of solar modules and makes up a high share of the cost of the solar module. It is very difficult for manufacturers of conventional wafers to reduce cost quickly while maintaining high quality. The EpiWafer in contrast enables dramatically reduced costs of this commodity at a very high quality level. Due to its drastically shorter value chain and reduced material consumption compared to the so far used silicon wafer, the EpiWafer technology enables these targeted cost savings in mass production. The EpiWafer technology was developed at the Fraunhofer ISE and is exclusively licensed to the NexWafe GmbH, who will bring the technology to mass production.

MAIN FEATURES OF THE PROJECT

The project focusses on developing and commercialization of a new type of silicon wafer used for production of solar cells and modules, the so-called "EpiWafer". A key property of the EpiWafer is its "drop-in" ability, i.e. solar cell producers will be able to use EpiWafers as one-to-one replacement for standard wafers. EpiWafers can be produced at disruptively reduced costs and can obtain very high efficiencies in solar cells.

The project has five partners, three of which are companies operating in the solar energy sector and two are research institutes with expertise along the whole value chain of the project. The partners are located in Germany, Czech Republic and Hungary:

- NexWafe GmbH (Freiburg, Germany): Founded in May 2015, the company managed to close a Series A investment round of € 6m in February 2016. NexWafe will commercialize and produce monocrystalline "EpiWafers" with an initial capacity of 50 Million wafers (250 MW) per year.

Epitaxially grown Si wafer.

CONTACT DETAILS

Dr. Stefan Janz
Fraunhofer Institute for
Solar Energy Systems

Heidenhofstrasse 2,
79110 Freiburg, Germany
+49 761 4588 5261
stefan.janz@ise.fraunhofer.de

EUREC MEMBER

Fraunhofer ISE

Inline tool for the cost-efficient epitaxy of 150 µm thick and highly pure Si layers.

- EcoSolifer Modulgyártó Kft. (Budapest, Hungary): European pioneer in innovative solar cell manufacturing to produce 80 MWp per year of highly efficient heterojunction (HJT) solar cells and modules
- Fill Factory s.r.o (Roznov Pod Radhostem, Czech Republic): Producer of specialized bifacial ntype solar cells and modules with a capacity of 20 MWp, applying upcoming "n-PERT" cell architecture
- Fraunhofer Institute for Solar Energy Systems (Freiburg, Germany), an institute of the Fraunhofer Gesellschaft für Angewandte Forschung e.V.: Europe's largest solar energy research institute who developed the EpiWafer technology licensed to NexWafe. The institute will focus on EpiWafer characterization within the project.
- International Solar Energy Research Center Konstanz e.V. (Konstanz, Germany): Research institute with the mission to reduce PV production costs and to increase the efficiency of solar cells. ISC Konstanz will apply its solar cell processing know-how to characterize EpiWafers.

RESULTS

After one year of project duration an efficient management has been established successfully. At the moment a pilot line is taken into operation to proof scalability of the EpiWafer technology for mass production. Lots of EpiWafers produced so far have been qualified by project partners and will now be fed into industrial solar cell and module processes. The goal is to deliver statistical evaluation and real productivity data which will help to determine and overcome bottlenecks. In parallel a factory for mass production of EpiWafers is in the planning stadium.

The project will enable NexWafe to seamlessly address the wafer market with a totally accessible size of more than USD 10 Billion in 2018, first approaching the market for n-type high-efficiency wafers having an expected size of USD 3 Billion in 2018. The value for the solar cell producing industry partners is high as well, since an early qualification of the EpiWafer allows for a much more competitive cost structure.

EUROSUNMED - EURO-MEDITERRANEAN COOPERATION ON RESEARCH & TRAINING IN SUN BASED RENEWABLE ENERGIES

www.eurosunmed.eu

CHALLENGES

EUROSUNMED is a 4-year collaborative project supported by the FP7 Programme of the European Commission. This innovative project targeted the following objectives:

Developing new technologies in three energy field areas, namely photovoltaics, concentrated solar power and grid integration, at the EU research centres, national agencies and SMEs in strong collaboration with Mediterranean Partner Countries (MPCs).

Testing innovative components (PV cells/modules, heliostats…) under specific conditions of MPCs (irradiation, hot climate, dust…)

Establishing a strong network between EU and MPCs through exchanges of students, senior researchers/engineers for transferring knowledge and technologies.

Disseminating the results of the project through the organization of scientific events open to a large public from universities, engineering schools and stakeholders.

MAIN FEATURES OF THE PROJECT

The scientific targets of the EUROSUNMED project were the development of new technologies in three energy field areas, namely photovoltaics (PV), concentrated solar power (CSP) and grid integration (GI), in strong collaboration with research institutes, universities and SMEs from Europe in the north side of the Mediterranean sea and from Morocco and Egypt from the south of the sea. The focus in PV was on thin film (Si, CZTS) based solar cells and modules while the goal in CSP field was to design and test new heliostats as well as novel solutions for energy storage compatible with these technologies.

The project aimed at producing components to be tested under specific conditions of MPC (Mediterranean Partners countries): hot climate, absence of water, etc.. Such investigations were complemented with studies on grid integration of energy sources from PV and CSP in Morocco and Egypt context. Additionally, the consortium envisaged training PhD students and post-docs in these interdisciplinary fields (chemistry, physics, and materials science) in a close and fruitful collaboration between academic institutions and industry from EU and MPCs. The consortium was well placed around leading academic groups in materials science and engineering devices and equipments for the development of PV and CSP, and also in the promotion of the renewable energies in general. Moreover, technology transfer and research infrastructure development in the targeted areas was provided. Disseminating the results of the projects was done through the organization of summer schools, workshops and conferences towards large public from universities, engineering schools and stakeholders involved in the 3 selected energy area and beyond. Another outreach of the project was the proposal for a roadmap on the technological aspects (research, industry, implementation) of the PV, CSP and grid area as well as on the best practice for the continuation of strong collaboration between the EU and MPCS partners and beyond for mutual interest.

RESULTS

The main results can be divided into 3 categories: scientific and technical (S&T), training and dissemination, and roadmap for future actions.

Concerning S&T, the first CZTS/Si mini-modules were fabricated, protective coatings for heliostats were tested, rocks based thermal storage were evaluated, innovative configurations for CSP plant power cycles were proposed, and advanced grid codes for renewable energy implementation in Morocco and Egypt were analysed. For demonstration purposes, photovoltaic EURSOUNMED modules were installed in Morocco. oreover, a heliostat test facility with the required equipment and capacities is now running at Helwan university (Egypt). In addition, promising protective coatings for heliostat mirrors as well as an associated deposition technique have been developed and further work is envisaged to valorise these results in the near future.

In parallel, more than 60 exchanges of researchers between EU and MPC were carried out and more than 600 students have benefited from lectures in the field of renewable energies which have been provided by outstanding professors during EUROSUNMED schools. Several EUROSUNMED workshops and sessions were organized at the premises of highly attended conferences (E-MRS, IRSEC…).

Finally, several actions to continue and reinforce the collaboration between EU and MPCs in the field of solar energy were established through for instance the MEDSOL project (ERASMUS+ action) and INFINITY project (RISE call in H2020). In addition, a joint research lab involving CNRS (FR) and UMV (Morocco) was launched in 2017. As for the industrial sector, two EUROSUNMED industrial workshops were organized to offer more opportunities to strengthen the strong link between the researchers and the industry towards the development of the solar industry worldwide.

CONTACT DETAILS

CNRS Icube

Abdelilah Slaoui,
CNRS Research Director

Tel. +33 (0) 388 10 63
http://icube-macepv.unistra.fr/fr/index.php/Accueil
www.eurosunmed.eu

EUREC MEMBER

This project has received funding from the European Union's 7th Framework Programme for research and innovation under grant agreement No 608593.

FSFOUND

(part funded by the EU DemoWind (ERA-NET) project, Grant Agreement No. 646517)

www.ore.catapult.org.uk

ORE Catapult is working with Blyth Offshore Demonstrator Limited, BAM Wind Energy JV and EDF Energy R&D UK Centre Limited on the FSFOUND project. FSFOUND is part of the larger Blyth Offshore Demonstrator project which is wholly owned by EDF Energies Nouvelles and has been constructed by EDF Energy Renewables. FSFOUND is about demonstrating and validating float-and-submerge gravity based foundations (GBF) which have the potential to impact positively on the development of deep-water offshore wind farms (>35 metres) and lower the cost of offshore wind energy. FSFOUND demonstrates the feasibility of GBFs, which will be used during the installation of the Blyth Offshore Wind Farm in 2017, at all critical project stages.

CHALLENGES

The Blyth Offshore Demonstrator project incorporates a number of new and innovative features as part of its role in testing and proving new and emerging offshore installation methods and technologies.

The project utilises a 'float and submerge' (FS) GBF design method – **the first time this has been used for the installation of offshore wind turbines**. It is also **the first offshore wind project to use 66kV-rated inter-array and export cables** to connect the turbines to the new onshore substation being built by Balfour Beatty on part of the site of the former Blyth power station in NE England.

ORE Catapult has designed and commissioned a sensor system for the GBFs. By synchronising data from the wind turbines and ORE Catapult's met-mast, the performance of the foundations in the challenging conditions they are exposed to will be analysed.

Construction of the float-and-submerge gravity based foundations in the Neptune dry dock, Wallsend (Image courtesy of EDF Energy Renewables)

The first float-and-submerge gravity based foundation being towed on the River Tyne (Image courtesy of EDF Energy Renewables)

Why instrument these foundations?

1. Design validation, including input to verifying simulation models
2. Provides feedback to the design limits of the structure, such that an updated life-expectancy can be calculated
3. Aids interface understanding between:
   a. GBF and Seabed (e.g. settlement)
   b. GBF and WTG (e.g. modal interaction, load transfer)
   c. GBF/WTG combination and the environment (e.g. wind/wave misalignment loads)
   d. Effect of internal divisions on the displacement of the caisson outer walls
4. Provides design inputs for a Structural Health Monitoring system for the GBF system
5. Provides cost model inputs, in the form of estimated O&M operational expenditure (OPEX) costs
6. Provides a development platform for a prognostic methodology for non-destructive testing (NDT) of the GBF

MAIN FEATURES OF THE PROJECT

The first part of the project comprises five wind turbines located around 6km off the Blyth coast at a water depth of 38 metres. The project will have a total generating capacity of 41.5MW - enough low carbon electricity to power approximately 34,000 homes.

The GBFs have been constructed by Royal BAM Group in the Neptune dry dock on the River Tyne, Wallsend. These concrete and steel structures have been floated into position at sea and submerged onto the seabed to provide the support structures that act as the foundations for the installation of the turbine towers.

Each gravity based foundation includes over 1,800m^3 of concrete and weigh over 15,000 tonnes when fully installed on the seabed. The structures have a total height of approximately 60 metres from the base to the access platform.

The scheme will incorporate five MHI Vestas V164 8.0 MW turbines. These will incorporate a power mode uprating to 8.3MW - the largest currently available. The turbine tip height of the rotor blades will be approximately 191.5 metres from the sea level.

Specific project objectives

- To move the FS GBF solution closer to full commercialisation;
- To verify the manufacturing and installation methodology and benefit from the lessons learnt in order to optimise plans for the future transnational exploitation of GBFs;
- To minimise potential delays and cost overruns through the development of multiple installation scenarios against a meteorological model;
- To compare the actual costs and performance with the cost–benefit analysis performed during the project;
- To design and install a condition monitoring system on two GBFs to monitor their behaviour;
- To assess the structural response to extreme and fatigue loads on the GBF and compare theoretical loads with real ones.

Benefits

- Lower foundation installation costs by employing standard tugs and self –buoyancy rather than specialised vessels;
- Lower costs during the operational phase as a result of reduced inspection and maintenance;
- Fabrication and deployment of the GBF in physical proximity to the offshore site;
- Increased deployment of WTGs in sites where piling is not technically feasible.

CONTACT DETAILS

Paul McKeever
Head of Strategic Research
paul.mckeever@ore.catapult.org.uk

EUREC MEMBER

RESULTS

Work completed:

- Manufacturing of wind turbine generators;
- Fabrication of gravity based foundations (GBFs) in Neptune dry dock in Wallsend, UK;
- Construction of onshore substation on former Blyth power station site;
- Marine and sea bed investigations and sea bed preparations;
- GBFs floated out and submerged onto the sea bed.

Work planned/ongoing (Quarter 3/4 2017):

- Energising of onshore substation;
- Offshore installation of wind turbines onto GBFs;
- Commissioning of entire offshore cabling system;
- First power from offshore turbines;
- Handover to operations team.

> *"The FSFOUND project is a perfect example of how EU funding can be used to supplement larger renewable energy demonstration projects in our quest to meet greenhouse gas targets at EU level."*
>
> ***Paul McKeever**, ORE Catapult*

KESTCELLS - TRAINING FOR SUSTAINABLE LOW COST PV TECHNOLOGIES: DEVELOPMENT OF KESTERITE BASED EFFICIENT SOLAR CELLS

www.kestcells.eu

CHALLENGES

The project proposed the development of new technologies compatible with the requirements of cost, efficiency, sustainability and mass production needed for photovoltaics (PV) to become a reliable alternative to conventional energy sources. Key to future development is the need for skilled researchers and deeper understanding of candidate new materials. The KESTCELLS project aimed to address this need.

Specific scientific objectives of KESTCELLS included: a deeper understanding of the fundamental properties of kesterites that determine their optoelectronic behaviour; the identification and understanding of the role of secondary phases; an improved knowledge of the mechanisms that determine and control p-type conductivity;

Using the understanding to: Design and develop of new kesterite solar cells with improved performance, using industrial scale processes with low environmental impact. In addition, to demonstrate progress by producing devices > 10% without use of hazardous reagents such as hydrazine.

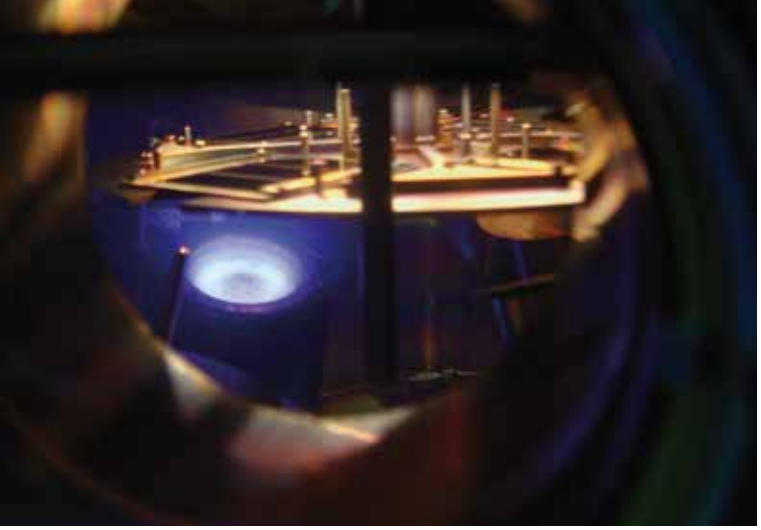
METHODS

The 3.7 M European Commission FP7 funded KESTCELLS, FP7, Marie Curie ITN network for the structured interdisciplinary training of researchers in advanced thin film PV technologies. KESTCELLS focused on the development of kesterite (Cu2ZnSn(S,Se)4 – CZTSSe) based solar cells. Kesterites are quaternary/pentenary compounds with a crystalline structure very similar to that of chalcopyrites (CIGS: Cu(In,Ga)(S,Se)2). They have a strong potential as a low cost, thin film, PV technology, due to their direct bandgap and high optical absorption. Unlike CIGS -where future large scale mass production is compromised by restricted availability of In and Ga – kesterites are based on abundant elements.

RESULTS

One of the SET-Plan objectives for 2020 was to ensure a sustainable increase of the production of energy through renewable sources, in which low cost thin film PV devices would play a central role. The kesterite material, offers low consumption of raw materials, industrial scale production and better performances at elevated temperatures than current technologies. There are few academic institutions able to train new researchers to the multidisciplinary approach necessary to train highly skilled professionals in this field due. The lack of such researchers is a potential bottleneck that could hinder further development in the medium to long-term. The KESTCELLS project was built on the close collaboration between three research centres, six universities and two industrial partners and actively worked to provide a significant advance in the development of new kesterite based solar cells with improved characteristics and efficiencies beyond the 10% threshold. KESTCELLS trained 14 new high-level researchers on this topic, validating the feasibility of the training program developed by the Consortium.

As one of the most promising materials for future thin films PV applications, CZTSSe meets the requirements of abundance of the constituent elements, low toxicity level and a full compatibility with the standard processes employed in current commercial PV production.. During the KESTCELLS project, the fundamental properties of kesterites were studied using different advanced characterization methods, including X-ray and neutron diffraction, Raman spectroscopy, photoluminescence and ellipsometry. KESTCELLS has contributed significantly to the basic understanding of these materials, including deeper understanding of the band-gap related properties, ionisation energy of defects, crystal structure and the origin of intrinsic point defects, as well as their dependence on the compound composition and growth process. This is a significant step forward in the funda-



CONTACT DETAILS

Dr. Ian Forbes
ian.forbes@northumbria.ac.uk

Dr. Edgardo Saucedo
esaucedo@irec.cat

www.kestcells.eu

mental knowledge of kesterites. The project has also developed different approaches for the synthesis of high-quality kesterite layers, which combined with the re-design to optimize the device structure, resulted in solar cells with efficiencies in the range of 9-11%, and a record value of 11.8%. The project also laid the foundations to identify characterization methods suitable for future in-line quality control tools, and produced a complete 2D model for the simulation of kesterite based devices.

In achieving the scientific results, KESTCELLS trained fourteen researchers working at the leading edge of this research through a customized programme, designed in accordance with each fellow's needs. Fifty-six specific seminars, five specialized workshops, eight project meetings, two business schools, one summer school in photovoltaics, ten open day activities, three newsletters, twelve video-clips, and thirty-eight secondments were implemented during the project. This represents an outstanding training achievement at network level. This comprehensive training exceeds the scope that any individual institution is able to offer. The fellows received training focused on scientific aspects and complementary soft-skills in management, IPR, communication, writing, reporting, business creation, entrepreneurship and others. The success of the training is exemplified by the outputs that include 147 contributions to international conferences (invited, key-note speeches, oral and poster presentations) and 82 peer-reviewed journal papers.

EUREC MEMBER

northumbria UNIVERSITY NEWCASTLE

In summary, KESTCELLS demonstrated the potential of kesterite-based solar cells technology, increasing the TRL from 2 (basic technological research) to 4 (validation at a laboratory level) at the end of the project. Through an effective scientific collaboration between partners, the Doctoral Degrees achieved by KESTCELLS' ESRs were enriched with multidisciplinary and industrially relevant training. The project represents a step towards more integrated collaborative schemes in PV at EU level.

This project has received funding from the European Union's 7th Framework Programme for research and innovation under grant agreement 316488

"The project was an excellent example of a collaborative training network and research project that was a pleasure to be part of. Managed with efficiency, enthusiasm and friendliness it created a team of skilled and enthusiastic researchers from around the world that achieved all the project goals and a valuable resource for future research."

***Ian Forbes**, Northumbria University*

NEXT-CSP - HIGH TEMPERATURE CONCENTRATED SOLAR THERMAL POWER PLANT WITH PARTICLE RECEIVER AND DIRECT THERMAL STORAGE

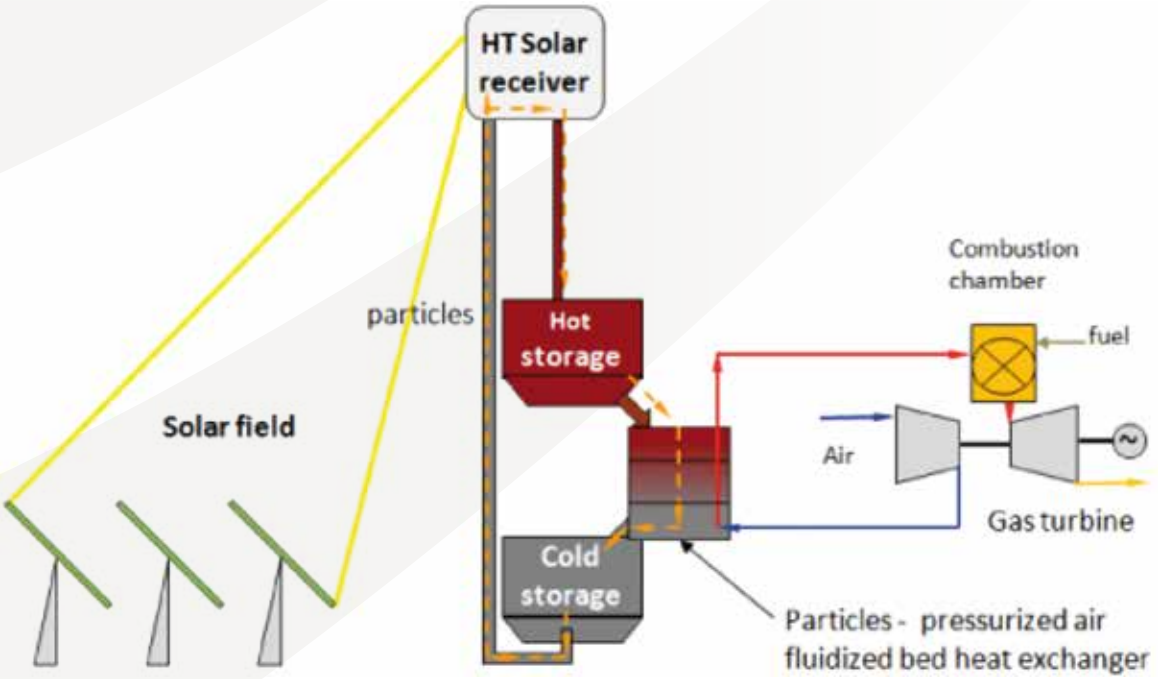
www.next-csp.eu

CHALLENGES

The Next-CSP project has been approved and funded by the European Commission through the H2020 framework programme under the call: LCE-07-2016-2017 on "Developing the next generation technologies of renewable electricity and heating/cooling". The specific challenge covers innovative components and configurations for Concentrated Solar Power (CSP) plants. In spite of cost reductions in recent years, cost competitiveness remains a crucial barrier to the deployment of CSP plants. Several concepts with a potential for cost reduction are being explored. It is necessary to validate in relevant environment the feasibility of these concepts.

MAIN FEATURES OF THE PROJECT

Next-CSP is a consortium of 10 partners gathered to fulfil one objective: improving the reliability and performance of CSP plants through the development and integration of a new technology based on the use of high temperature (800°C) particles as heat transfer fluid and storage medium. To achieve this objective, the project will demonstrate the technology in a relevant environment (TRL5) and at a significant size (4 MWth). The complete system will be tested at "Thémis" experimental solar tower facility (France). The project started on the 1st of October 2016 and will end on the 30th of September 2020 (4 years in total).



The proposed fluidized particle-in-tube concept is a breakthrough innovation that opens the route to the development of a new generation of CSP plants allowing high efficiency new cycles (50% and more) and 20% improvement of CSP plant efficiency. A 4-MWth tubular solar receiver able to heat particles up to 800°C will be constructed and tested as well as the rest of the loop: a two-tank particle heat storage and a particle-to-pressurized air heat exchanger coupled to a 1.2 MWel gas turbine.

Figure: 3D view of the pilot multi-tube solar receiver (Credit: PROMES-CNRS), with solar cavity, refractory lined; and 16 parallel UBFB receiver tubes.

RESULTS

The Next-CSP project is still in initial stage, however the upwards flow of particles in an Upflow Bubbling Fluidized Bed (UBFB) were studied experimentally and modelled from pressure drop considerations and energy loss equations. The results from the project are presented in this peer-reviewed scientific publication published in open acces in the online journal "Scientific Reports" from the publishers of Nature : http://next-csp.eu/documents/scientific-productions/

CONTACT DETAILS

Dr Quentin Falcoz

quentin.falcoz@promes.cnrs.fr

EUREC MEMBER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 727762

POWER-TO-FLEX - FLEXIBLE ENERGY SUPPLY BY ENERGY STORAGE

www.powertoflex.eu

CHALLENGES

The region of Northwest Germany and the north of The Netherlands is developing as a hot spot in sustainable energy. One of the main challenges is to realize the balancing function of supply and demand. A promising line is the storage of power in a hybrid way, as hydrogen, methane or methanol. Near market solutions, on the level of houses or communities, are challenging as they generate innovation opportunities for the many SME partners involved in the project. Selected concepts will be demonstrated (TRL 4 to 7) in order to stimulate and guide as many partners as possible to develop businesses, based hereon.

MAIN FEATURES OF THE PROJECT

Start: April 2016

End: October 2019

Priority: enhancing cross border innovation potentials on sustainable energy

Specific goal: increasing product and process innovation on CO_2 reducing technologies

Strategic initiative: energy and low carbon economy

Project identity: Interreg V A; Germany – The Netherlands; project nr. 151074; EDR (Eems Delta Region)

Project initiated by Province of Groningen, Hochschule Emden/Leer and Hanze University of Applied Sciences Groningen; one of the knowledge partners is Next Energy, Oldenburg

Budget of project: 3.4 Meuro.

Energy Transition Centre (EnTranCe) building in Groningen, The Netherlands

RESULTS

In the first stage of the project, that has been completed by end of 2016, the selection of the concepts to develop and demonstrate has been made. These are:

- A mikro power to fuel and fuel to power skid demo, to be implemented in houses and small companies (mikro level).
- A hydrogen storage and refueling station on a mikro and meso level.
- A power to fuel demo on a meso level connected to a sewage treatment and biogas generating plant.

As the concepts inherently demonstrate a thermodynamically dermined efficiency loss, in form of heat production, special attention is and will be payed on the integrated feasibility of the concepts, based on combined heat and flexibility values. The equivalent of the highly successful development of Combined Heat and Power systems (CHP) in EU and the world, in the late 20th century, is taken as a guiding example.

In accordance with the planning, therealisation of the demo's will be by mid 2018.

POWER TO FLEX

CONTACT DETAILS

Hanze University of
Applied Sciences Groningen

Tjerk Jansma
T.Jansma@pl.hanze.nl
Tel 31(0)620426914

Prof. Wim van Gemert
W.J.T.van.Gemert@pl.hanze.nl
Tel (31(0)610837245

EUREC MEMBER

Hanze University of Applied Sciences Groningen

The demo's will be built on EnTranCe, that is the living lab of Hanze University of Applied Sciences Groningen, and on Hochschule Emden/ Leer. Here, SME's, researchers and education will collaborate to push the concepts to maturity and develop the business models.

As a main outcome of the project, a number of next generation projects (TRL 4 to 7) will be proposed for follow up innovations. Essentially, these will be on a EU level and create opportunities for SME's.

Renewable energy also means another prove of the people's ability to take their own initiatives for match their needs. The result will be an innovation boost in society. For this to be realized, we urgently need open innovation projects where many stakeholders collaborate and share. This project and the EU partnerships create perfect conditions to accelerate innovation.

***Wim van Gemert**, Hanze University of Applied Sciences*

SOLAR BANKABILITY

www.solarbankability.org

CHALLENGES

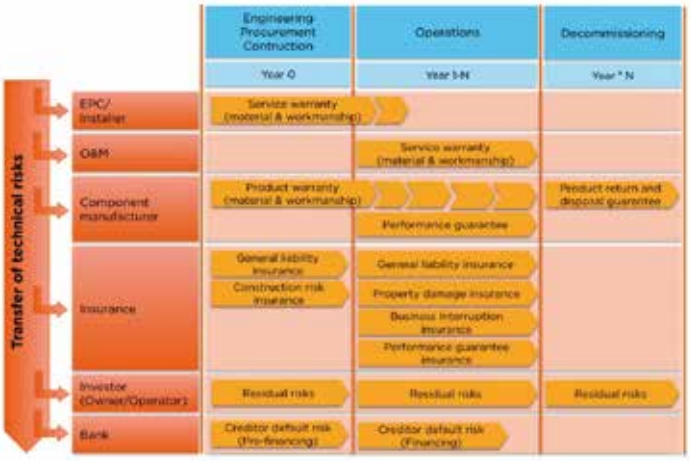
Solar Bankability aim was to contribute to the reduction of the risks associated with investments in photovoltaic projects. The project results had the ambitious target to increase trust from investors, financers and insurance companies. The project aimed to establish a common practice for professional risk assessment based on technical and commercial due diligence.

The main objectives of the project were:

- To develop, document and establish practices for evaluating and mitigating the technical risks associated with investments in photovoltaics
- To evaluate how these risks affect the electricity production and the expected return on investment in different business model
- To develop, document and establish practices on how to reflect these risks in the financial modelling of photovoltaic projects by investors
- To enable the key actors, and particularly the financial market actors, to widely adopt the project results as best practices for the mitigation of risk of sustainable energy investments with current and new business models

MAIN FEATURES OF THE PROJECT

The project formulated recommendations based on input data that were statistically significant and based on market data from historical due diligences, operation and maintenance records, as well as damage and claim reports. The project involved all relevant stakeholders being financial market actors, valuation and standardization entities, building and PV plant owners, PV industry players, energy prosumers and policy makers. Solar Bankability run during the period 2015-2017 and was coordinated by EURAC Research. The other consortium members were : 3E, Accelios Solar GmbH, SolarPower Europe, TUV Rheinland Energy. The Solar Bankability



Consortium organised two very successful public workshop : presentations, deliverables, and tools are all available online.

RESULTS

In the Solar Bankability project, we have developed a set of best-practice guidelines and useful tools: a de-risking tool to reduce the risks associated with investments in PV projects, and a standardization tool which serve as guidelines for a common practice for professional risk assessment in the PV investment sector. These guidelines and tools are to assist stakeholders to develop their own individual risk management strategy along the lifecycle of a PV project through the following steps:

- Risk identification;
- Risk assessment;
- Risk management;
- Risk controlling.

In **risk identification**, we have compiled technical risks caused by incorrect technical assumptions in the calculation of the PV levelized cost of electricity (LCOE), and technical risks associated with PV plant failures. The LCOE technical assumption risks were obtained from gap analyses on the technical assumptions used in samples of present-day PV financial models and plant yield estimation reports. The plant technical risks were collected by going through databases of technical failures in samples of hundreds of MW of PV plants and tabulating the different failures into a Risk Matrix organized by the project phases and plant components. The results of the risk identification work are **two tools** – *a list of top 20 LCOE technical risks* and a technical Risk

Matrix, which could be used by stakeholders such as PV plant component suppliers, EPC contractors, and O&M operators.

For **risk assessment**, we evaluated the technical risks in terms of how they impact i) the initial yield estimate (for technical risks during planning), ii) costs during operation and maintenance phase, and iii) PV LCOE. Three tools were developed for risk assessment: a new methodology *(CPN methodology)* which assigns a cost priority number (CPN) to each risk based on the associated economic impact on plant operation, *an LCOE sensitivity analysis excel calculation tool,* and *cash flow risk categorization.* These tools will serve stakeholders in assessing the different technical risks and their impacts on the operation costs of their PV plants and what electricity cost should be set for profitable investment.

For **risk management**, a list of eight mitigation measures were put forward. Furthermore, the effectiveness of the mitigation measures was assessed by evaluating how their implementation changes the cost priority number and PV LCOE. Scenarios consisting of different mitigation measure combinations and market segments were studied and the mitigation measures were ranked based on their effectiveness in reducing the CPN and LCOE. The analyses of the effectiveness of mitigation measures also allow for assessing the best PV project phase for implementation, thus the risk management is achieved by transferring risk from one actor to another.

The transfer of risks can help to allocate these risks to those parties, which have the best control of each risk. Finally, we have developed six best-practice checklists relevant for EPC and O&M contracting, and yield estimation. *The list of mitigation measures* and *the six best-practice checklists* will assist market actors from PV system designer to plant owner to lenders and investors in minimizing risks due to improper yield estimation and settings of EPC and O&M contracts.

For **risk controlling**, new financial market regulations have been introduced after the 2008 financial crisis to improve the transparency and stability for institutional investors from the banking, insurance and investments fund sector. These enhanced controlling and reporting requirements apply also to large-scale PV investments. The overview of these regulations is summarized and presented for informative purpose in the Solar Bankability project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649997.

CONTACT DETAILS

Viale Druso, 1 / Drususallee 1
39100 Bolzano / Bozen - Italy
Tel: +39 0471 055 055

David Moser
david.moser@eurac.edu

EUREC MEMBER

SONG - SOLAR NANO-GRIDS

www.lboro.ac.uk/departments/geography/enterprise/case-studies/song/

CHALLENGES

Around the world around 1.2 billion people lack access to electricity. This limits opportunities for human development that electricity brings such as education, work and health benefits. Sustainable Development Goals mandate the need for clean affordable and secure access to modern energy services to the world population by 2030. Developments are taking place in developing countries to increase electricity access through the use of grid extension or solar home systems (SHS). But the power supplied to grid extension is often unreliable and SHS only provide basic power needs such as lighting and charging a mobile phone or fan. In addition, micro-grids can be used which can not only provide basic power but also have enough capacity to engage in economic activities. In this project the development of small micro-grids, the Solar Nano-Grid which operates in the 1kW-5kW space for small communities, is reported.

METHODS

The SONG project brought together a multidisciplinary team of international engineers and social scientists from UK, Kenya and Bangladesh. After the project parameters had been developed two suitable communities were identified on both Kenya and Bangladesh. Initial engagement was carried out by in country team members. The main rationale was not to take a top-down approach but to co-design the project with the local communities. Stakeholder engagement sessions were held with different community groups to prioritise energy services including income generation activities. Based on the findings the SoNG was designed.

CONTACT DETAILS

Richard Blanchard
R.E.Blanchard@lboro.ac.uk

RESULTS

Community co-design identified the electricity priorities as well as the economic limitations of the villages and the income generation activities that included egg incubation, milling, water pumping and IT services. Village Energy Committees were created to manage the project in the long term. Four 3kW SONG systems have been developed, deployed and been operational since 2016. In Bangladesh DC grids have been used with household metering. In Kenya where the village is spread out a battery swap system was employed to cut down on the wiring costs to the community.

With an intervention of this type there have been a few technical setbacks which have been overcome. However both communities have engaged well with the project and have experienced benefits. These communities used to rely on kerosene for lighting which had potentially harmful effects. SoNG provides clean, reliable and affordable electricity to these small off-grid communities. It is important to provide clean energy to improve quality of life, empower women, improve health, increase children's educational attainment, and boost the local economy in a sustained manner.

EUREC MEMBER

Loughborough University

SHARC25 - SUPER HIGH EFFICIENCY $Cu(In,Ga)Se_2$ THIN-FILM SOLAR CELLS APPROACHING 25%

www.sharc25.eu

CHALLENGES

- Prime objective and main challenge of the Sharc25 project is to develop super-high efficiency Cu(In,Ga)Se_2 (CIGS) solar cells for the next generation of cost-efficient solar module technology. It is planned to boost the single junction CIGS solar cell performance towards 25%, and thus to significantly reduce the gap to the theoretical Shockley-Queisser limit (33%). For these reasons innovative processes, advanced materials with improved functionality, sophisticated characterisation methods, device modelling, and absorber calculations are applied.
- Secondary aim and challenge is to prove the industrial relevance of the new processes by fabrication of a monolithically integrated mini-module with efficiency above 20%.
- Finally, a realistic strategy will be provided, based on achieved results, for large-area industrial module production with envisaged cost targets of <0.35 €/Wp and <0.60 €/Wp for installed systems, along with a reduced capex of <0.75 €/Wp for factories of >100 MWp/a.

MAIN FEATURES OF THE PROJECT

This European project will directly combine the expertise on advanced device processing at ZSW and Empa to elaborate novel concepts for engineering of bulk and interface properties as well as innovative approaches to light management and passivation layers with the help of additional partners having excellence in advanced materials and device characterisation. Other topics and keys to understand current performance limitations and to elaborate novel PV concepts and alternative optimisation routes beyond the state-of-the-art are device simulations.

The main limiting factors in state-of-the-art CIGS solar cells are the non-radiative recombination and light absorption losses. Thus advanced concepts are deployed to over-come these issues.

Key measures in detail:

- Advanced characterisation of CIGS bulk material of highest state-of-the-art quality will be combined with density functional theory calculations and 2D device modelling analysis. This approach will allow correlating electrical and physical properties in the bulk material with device performance parameters and ultimately deliver new insight into (still hidden) processing parameters.
- A tailoring of the CIGS/buffer heterointerface will be carried out. In current solar cells the heterointerface is built between p-type CIGS and n-type CdS (so-called buffer layer or emitter). Modifications of the near-surface CIGS absorber region could improve the open-circuit voltage significantly. For such modified CIGS absorbers wide bandgap buffer layer materials will be adopted to yield higher short-circuit current due to the more transparent buffers and improved open-circuit voltage stemming from the optimised CIGS surface/interface.
- The concept of combining passivation layers with point contacts is very successfully used for high efficiency c-Si solar cells to minimise surface and interface recombination losses. This concept will be introduced also to CIGS thin-film technology.
- Solutions from optoelectronic technologies such as broad-band anti-reflection coatings and highly transparent (also in near-IR) conductive electrodes will be implemented in the CIGS layer structure in order to minimise reflection and parasitic absorption losses. Light scattering strategies at the front side and novel light reflection strategies at the back side are developed in order to increase the optical thickness of the absorber layer.

Furthermore, a monolithically integrated mini-module with efficiency above 20% will be fabricated in order to demonstrate feasibility for an industrial approach.

RESULTS

Alkali metal salt post-deposition treatment (PDT) applied to the Cu(In,Ga)Se_2 absorber has shown to be a potent measure to improve the efficiency of CIGS thin-film solar cells and modules. The PDT process usually employs sodium and/or potassium directly after the CIGS deposition under selenium atmosphere. However, also the heavier alkali elements rubidium and caesium affect the absorber and the device performance. CIGS bulk and interface properties were studied by the consortium and compared to the commonly-used potassium PDT and to non-treated reference samples. The investigated CIGS samples were prepared by co-evaporation and exhibit efficiencies around 20%.

The macroscopic CIGS bulk absorber properties were assessed in-depth by admittance and photocurrent spectroscopy, photoluminescence, and by mass spectrometry depth profiles. Atom probe tomography analyses showed that rubidium preferentially Locates at grain boundaries and at dislocations on a nanometre scale. All accessible parameters, including chemical gradients and defect concentrations, served as input data for 2D/3D solar cell simulations.

Lab- and synchrotron-based x-ray and electron spectroscopies as well as Kelvin probe force microscopy revealed that the various alkali PDT processes lead to different CIGS surfaces and CIGS/buffer interfaces. This comprehensive study is complemented by density functional theory calculations which include all alkali elements from lithium to caesium, supporting the experimental results and conclusions relating to the role of the alkali elements in CIGS.

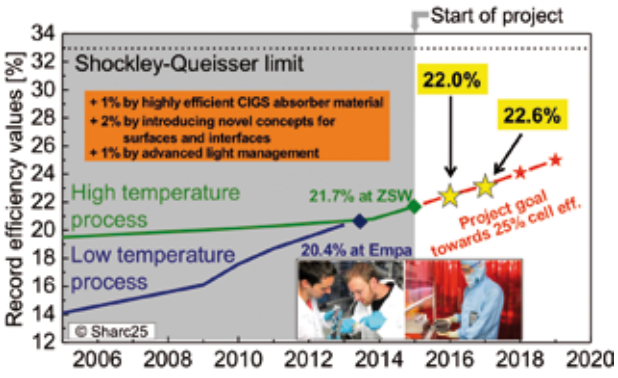


Figure 1: On the rocky road towards 25% CIGS solar cell efficiency (all data with anti-reflective coating).

SHARC25

CONTACT DETAILS

Dr. Wolfram Witte (ZSW)
info@sharc25.eu - www.sharc25.eu

EUREC MEMBER

ZSW

With novel alkali PDT combined with optimised surface treatments a CIGS solar cell with an efficiency of 22.6% could be demonstrated. Furthermore, promising methods for realising front and back passivation of the CIGS absorber layer were developed and analysed. Multidimensional device simulation proved to be very valuable to predict the optimum geometry of point openings in such passivation layers.

The optical properties of all functional layers in device quality were analysed in detail to complete the required data set for accurate device simulation. This allowed detailed optical loss analysis of the record devices and provides guidance on how to increase the current density.

ACKNOWLEDGEMENT

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641004.

This work was supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number REF-1131-52107. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Swiss Government and the view of the *European Commission*.

SWInG - DEVELOPMENT OF THIN FILM SOLAR CELLS BASED ON WIDE BAND GAP KESTERITE ABSORBERS

www.swing-h2020.eu

SCOPE

Photovoltaic (PV) solar cell technologies are becoming cheaper and more efficient in terms of converting sunlight into electricity. Further progress, with higher efficiencies and lower cost, requires improving current technologies in new ways, whilst using cheap, abundant materials. Kesterites ($Cu_2ZnSnS(e)_4$) are potentially one group of promising materials, but it still needs to be established which kind of kesterites is the most suitable and what is the best way to manufacture them.

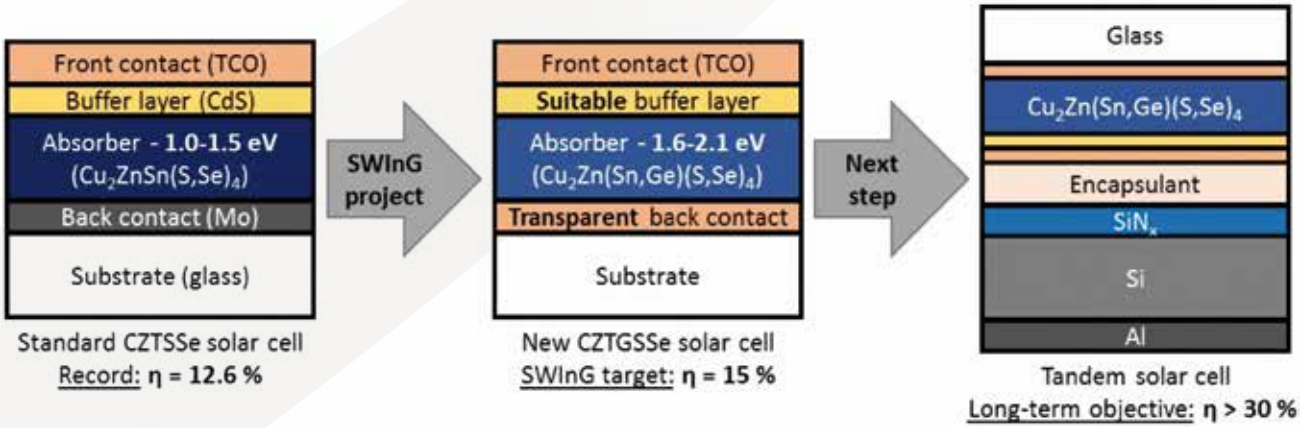
CONCEPT

The SWInG project aims to validate in a laboratory one promising technique: a tandem solar cell using kesterite. A tandem solar cell is a thin transparent solar cell stacked on a standard silicon cell. The thin transparent kesterite cell will absorb part of the sunlight that the solar cell underneath it cannot use. This will increase the overall amount of sunlight converted to electricity. Based in the unique characteristics of kesterites, the main objective of SWInG is to develop a sustainable wide band gap Thin Film solar cell technology based on non-toxic and earth-abundant kesterite absorbers, which could be used in low-cost and stable tandem PV devices with 30% efficiency, see Figure 1.

THE SWInG PROJECT

The SWInG consortium focuses both on the development of the processes for the synthesis of such solar cells based on the Cu_2ZnXY_4 (with X = Sn, Si, or Ge and Y = S or Se) compounds, and on the understanding of the physical and electrical properties of the high band gap absorber in order to reach high conversion efficiency. The key research challenges are: (i) developing up-scalable processes for the synthesis of the absorbers; (ii) defining the specifications for high-quality wide-band gap absorbers as well as suitable back contact and buffer layers; and (iii) assessing the potential of this technology for PV applications. The wide band gap thin film solar cells developed in this project are expected to reach state-of-the-art efficiencies.

Figure 1: A schematic presentation of the transition from the narrow band gap $Cu_2ZnSn(S,Se)_4$ technology (left) to the wide band gap Cu_2ZnXY_4 (X = Sn, Si, Ge and Y = S, Se) cell design – using an optimized (non-toxic) buffer layer and transparent back contact (middle) – to be developed in the SWInG project as potential candidate for tandem applications (right).



Publication of specifications for the synthesis of high quality Cu_2ZnXY_4 absorber as well as suitable back/front contact are expected. The lead users will be PV modules manufacturers and companies that design and produce the machines for the synthesis of such devices. The results will be disseminated and communicated to the European PV industries and the scientific community. The intensive exchange of researchers between the partners during the project will also lead to an enhanced European collaboration in the research field of thin film solar cells.

RESULTS

After 2 years, the project is on track what concerns its 3 main technological targets, i.e. the development of (i) the high band-gap absorber layer, (ii) a suitable non-toxic buffer layer, and (iii) a suitable transparent rear contact. (i) $Cu_2ZnGeS(e)_4$ kesterite solar cells with 1.6 to 2.1 eV bandgap, and low absorption below the bandgap (< 10 %) are developed. Best cell efficiency is 7.9 %, without anti-reflection coating (ARC). (ii) Zn(O,S) preceded by a surface treatment is found to be an adequate buffer layer for these kesterite absorber layers, showing potential to increase J_{SC} and V_{OC} even further. (iii) Several transparent conductive materials with > 90 % transmission below the absorber's bandgap have been tested, and a best solar efficiency of 6.3 % (also without ARC) is obtained in case of a ITO/TiO_2) rear contact.

MAIN PUBLICATIONS

- G. Brammertz et al.,
  Thin Solid Films 616 (2016) 649–654,
  DOI: 10.1016/j.tsf.2016.09.049
- G. Brammertz et al.,
  Phys. Status Solidi C 1600162 (2017),
  DOI: 10.1002/pssc.201600162
- S. Sahayaraj et al.,
  Sol. Energy Mater. Sol.
  Cells 171 (2017) 136–141,
  DOI: 10.1016/j.solmat.2017.06.050
- T. Schnabel et al.,
  RSC Advances 7 (2017) 26–30,
  DOI: 10.1039/c6ra23068g
- T. Schnabel et al.,
  RSC Advances 7 (2017) 40105–40110,
  DOI: 10.1039/c7ra06438a

CONTACT DETAILS

Bart Vermang
Bart.Vermang@imec.be
IMEC

EUREC MEMBER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 640868

II. RENEWABLE HEATING AND COOLING

PROJECTS

1. BIOMASUD PLUS - Developing the Sustainable Market of Residential Mediterranean Solid Biofuels 40

2. CELSIUS - Smart District Energy 42

3. COMTES - Compact Thermal Storage Technologies 44

4. ENERBIOSCRUB - Sustainable Management of Shrubs Formation for Energy Purposes 46

BIOMASUD PLUS - DEVELOPING THE SUSTAINABLE MARKET OF RESIDENTIAL MEDITERRANEAN SOLID BIOFUELS

www.biomasudplus.eu/en_GB/

Starting date: 1 January 2016

Duration: 36 Months

Budget: 1.971.610,00 €

Developing the sustainable market of residential Mediterranean solid biofuels.

CHALLENGES

- Development and extending a quality and sustainability certification system
- Assesment of the existing barriers and identifying solutions with emphasis on the sustainability and quality control systems.
- Development of tools and databases with information about sustainable biomass resources to have a global vision and identifying sustainable solid biofuels supply chains.

MAIN FEATURES OF THE PROJECT

The overall objective of this Project is to develop integrated solutions to promote the sustainable market for Mediterranean solid biofuels for residential heating.

The aim of the project is to promote a sustainable market for Mediterranean residential thermal solid biofuels, on the basis to develop alternatives to some of the most important breakthroughs that have been described for the sustainable development of the Mediterranean residential solid biofuels. The strategy is supported in relevant tools specifically developed for the Mediterranean conditions (BIOmasud certification scheme, BIORAISE) and that are improved and extended to new Mediterranean biofuels and countries in this project and it envisages the realization of an unavoidable biofuels characterization and combustion testing work which is required in order to assess the conditions for the sustainable market development.

The BIOmasud certification system, in operation since 2013 for Mediterranean biofuels, will be improved by including new biofuels, reviewing of the sustainability criteria system and spreading it to other countries concerned are other Project purposes. Currently the label is present in Spain, France and Portugal and, thanks to BIOMASUD PLUS project it is going to implement also in Italy, Greece, Slovenia, Croatia and **Turkey**.

RESULTS

Project works regarding characterization of emissions using this Mediterranean fuels on the appliances found on the market designed for them will be carry out. After these works guidelines for boiler and stove manufacturers, installers and users will be elaborated. These guidelines shall support manufacturers to further develop and optimize their technologies towards a more energy efficient low-emission operation with BIOMASUD fuels. Additionally they shall support installers and users with information about relevant quality criteria for appropriate boiler and stove selection and operation.

CONTACT DETAILS

Project coordinator:
Pablo Rodero
coordinator@biomasudplus.eu

TUBITAK
Contact Person:
Mahmut Ates
mahmut.ates@tubitak.gov.tr

EUREC MEMBER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 691763

CELSIUS - SMART DISTRICT ENERGY

www.celsiuscity.eu

CHALLENGES

There is enough waste heat produced in the EU to heat EU's entire building stock, and EU has recognized district heating and cooling systems as important players in order to reach the energy efficiency goals. However, in 2014 only 13 % of the heat use in the EU was supplied by district heating.

MAIN FEATURES OF THE PROJECT

The CELSIUS project has contributed to new knowledge and innovations in district energy through demonstrations of innovative state-of-the-art technologies, systems and practices. The project has made a commitment to inform and engage cities that are working on transforming their energy systems about district energy and the possibilities that the technology entails. The CELSIUS project has also focused on policy and support for cities that want to develop district energy. The project has resulted in a network of over 100 cities and other stakeholders, a wiki platform with information about district energy, systems for webinars and other methodologies for systematic sharing of knowledge. The project ends in December 2017 and will form a basis for further cooperation and diffusion of knowledge.

CELSIUS has been led by five partner cities; Gothenburg, Cologne, Genoa, London and Rotterdam. From every partner city/country there has also been participation from at least one research partner and an energy utility. In the case of Gothenburg, RISE has been the participating research partner.

In June 2017 the CELSIUS project won the Public Sector category of the EU Sustainable Energy Awards, which were presented as part of EU Sustainable Energy Week.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 314441.

RESULTS

The CELSIUS project contains 36 demonstrators that constitute a package of innovative state-of-the-art energy efficient technologies, systems and practices. To cover the whole CELSIUS City concept 12 new demonstrators have been built in addition to demonstrators already in operation before the project started. Combined the demonstrators secure a full range of innovations and solutions to display and demonstrate the CELSIUS City commitment.

Examples of demonstrators

In Gothenburg the ferry Stena Danica is docking in Gothenburg several times a week, as a part of CELSIUS the ferry has been connected to the district heating system when in the harbour. There were already possibilities available to connect ships at the quay to the electrical grid, but heating equipment on board were still used. When using district heating from the city to heat the ship, no emitting machines on board ships are needed at quay. Using district heating instead of burning bunker oil to in the ship generators and heaters reduces the CO2 emissions by 172 tonnes (62 %) per year and ship.

The City of Cologne has begun to use wastewater along with geothermal energy, solar energy and wood pellets as a sustainable source of heat for large buildings – a sensible addition to an economically viable mix of energy sources including natural gas, district heating systems and local heating sources. Wastewater systems promise major heat recovery potential. Studies have shown that around 20 per cent of all buildings in Germany could be heated using this technology. However, so far most projects have failed due to technical and/or financial obstacles. The CELSIUS project has aimed to identify the most effective methods so as to increase the success rate of future projects.

The London Underground's mid-tunnel ventilation shaft and UK Power Network's electricity substation have been identified as sources of waste heat that could be utilised within the local Bunhill Heat and Power Network. This demonstrator has looked at how these sources of waste heat can be captured and integrated into this local district heating system. It has also considered how this could form the beginning of a strategically important energy hub that will allow the subsequent extension of the heating system in the area. The second part of this demonstrator is the integration of a thermal store to help with energy balancing in the area. This demonstrator has developed an understanding of how waste heat can be economically captured and utilised within a local district heating system and how a thermal store can help with the balancing of both surplus electricity and heat within their respective networks.

Celsius City and Celsius City Supporters

One of the goals with CELSIUS was to recruit 50 New CELSIUS Cities and to provide them with relevant guidance to establish, construct or ultimately grow district heating and cooling systems in their cities. So far 67 cities have joined the network and actively follow the project for guidance in establishing and improving their own district energy systems. In addition to cities, other district energy stakeholders such as other EU projects, organisations, universities and the private sector can become CELSIUS City Supporters, at the moment there are 54 such members of the CELSIUS network.

celsius smart cities

CONTACT DETAILS

Coordinator :
Katrina Folland
Göteborg City
katrina.folland@stadshuset.goteborg.se

Åsa Jardeby
asa.jardeby@ri.se
Tel. +46 10-516 50 85

Anna Boss
anna.boss@ri.se
Tel. +46 10-516 55 11

EUREC MEMBER

RI. SE

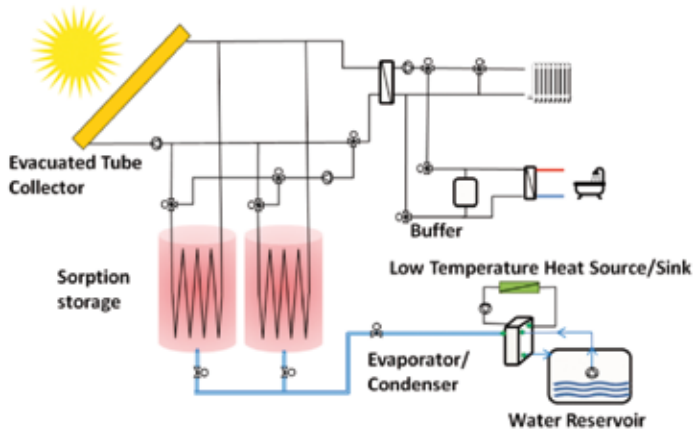
COMTES - COMPACT THERMAL STORAGE TECHNOLOGIES

www.comtes-storage.eu/

CHALLENGES

Solar thermal energy has the potential to cover 100 % of the heat demand of households through completely renewable energy. To achieve this, the surplus of solar heat from summer needs to be stored by a seasonal thermal energy storage to cover the demand in winter.

To meet the special requirements for a solar seasonal thermal energy storage used in households, which are mainly a high energy density (low space requirement) and low losses, an adequate technology has to be found.



MAIN FEATURES OF THE PROJECT

The EU-funded project COMTES, with a research grant of 4.7 Mio, was divided in three different development lines that all work on a different technology for seasonal thermal energy storage. In development Line A, AEE INTEC, ITW Stuttgart, Vaillant and TH Wildau collaborated on the development of a solid sorption thermal storage based on the working pair zeolite 13XBF and water vapour.

The aim of the project was to develop and demonstrate a solar seasonal thermal energy storage system which has a significantly higher energy storage density than sensible water storages. To this end, full scale prototypes were developed, tested and improved and integrated in a complete storage system.

The sorption storage stores the heat gained by the evacuated tube collectors and release the heat in case of heat demand (domestic hot water or space heating), see the system diagram below. The low temperature heat source supplies the necessary heat to evaporate the water coming from the water reservoir. The generated vapour flows to the sorption storage and the adsorption (discharging) takes place. Reversely, during desorption (charging) the solar heat is used to drive the water vapour out of the zeolite and the released vapour is condensed at the evaporator/condenser heat exchanger again and the heat of condensation is transferred to the low temperature heat sink in this case. The storage system is under vacuum and therefore a low temperature level is sufficient to evaporate the water.

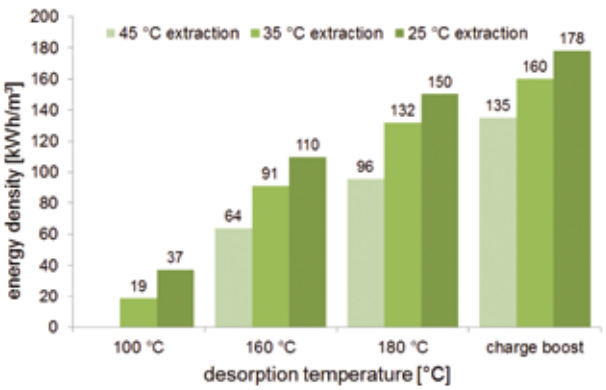
RESULTS

The testing period was separated in two steps. First, explicit system experiments were carried out to test the system under given boundary conditions and to determine the main parameters of the system. The second part was the completely automated operation of the system over a heating period under realistic conditions at the AEE INTEC laboratory in Gleisdorf, Austria.

At first, the system was tested to gain knowledge about the energy density under different boundary conditions. Therefore, the desorption, adsorption, evaporation and condensation temperatures were varied.

The results show that under good, but realistic conditions a storage energy density of 178 kWh/m³ is achievable. This is about three times more than sensible water storages can store, with the additional advantage that this amount of energy can be stored over months without losses. This high energy density could be achieved due to the application of the novel charge boost method, which is used to further increase the storage capacity of the material.

In the second step the heating capacity of the system was tested in automated operation for a longer period. To this end, the system was integrated in a "hardware-in-the-loop" system, where a building simulation calculated the heat demand of a low-energy single family house according to the actual weather conditions at the test site in real time. This way a heating period could be demonstrated and the feasibility of the technology could be proven. The result was a solar fraction of 83 % which could be achieved with the demonstrated system over the heating period.



CONTACT DETAILS

Wim van Helden
Thermal Energy Storage
AEE - Institut für Nachhaltige Technologien

A-8200 Gleisdorf, Feldgasse 19
Mobile: +31 6 2014 3224
w.vanhelden@aee.at

EUREC MEMBER

The results of the experiments and the demonstration period prove that this technology is promising for application as seasonal thermal energy storage, but also other applications are promising e.g. for temperature conditioning of electric batteries of electrical or hybrid cars, for storing waste heat from industrial processes or for using surplus electricity from PV or wind.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 295568.

ENERBIOSCRUB - SUSTAINABLE MANAGEMENT OF SHRUBS FORMATION FOR ENERGY PURPOSES

www.enerbioscrub.ciemat.es/

CHALLENGES

In the EU28, according to the "Land Use and Cover Area frame Survey" (LUCAS, 2012) performed by EUROSTAT, the shrub land reaches 46 million hectares (10,6% of the EU continental territory). Within the EU the Mediterranean countries support the largest relative coverage of shrub land, about 21 million hectares that are concentrated in the territories of Greece, Portugal, Italy, Cyprus and Croatia and particularly Spain where about half (10.7 million hectares) are located. Shrub lands usually suffer from lack of management, which in conjunction with the abandonment of traditional forestry uses, leads to produce a forest structure more prone to wildfires. In most cases, the uncontrolled concentration of shrubs is frequently the cause of the start and spreading of new forest fires.

Figure 1. Harvester-baler system and round bale

Figure 2. Harvester-mulcher system and collected biomass

Fire experts recommend the cleaning and clearing of woods, grazing lands and paths as a preventive measure to avoid wildfires whilst it could entail the development of a new biomass resource to increase the potential of bioenergy in the EU, helping to achieve the EU climate and decarbonized energy targets. In addition, new incomes and new jobs to rural areas could be brought thanks to shifting installations from fossil fuels to biomass.

In the above context, the ENERBIOSCRUB project aims to demonstrate that the sustainable exploitation for biomass energy use of many shrubs formations is a viable issue.

Within ENERBIOSCRUB Project activities, there can be cited the following:

1. Inventorying the shrubs areas present in four demonstrative Spanish selected locations by the utilisation of Satellite + LIDAR technology to estimate the existing biomass potential.
2. Mechanised clearing demonstration: big efforts are being paid in evaluating the technical and economic feasibility of the shrubs harvesting and logistics in a context of sustainable strategies. The demonstrative actions included two different harvesting methods: a harvester-baler machine (Figure 1) and a harvester-mulcher machine (Figure 2).
3. After collection, a study of the storage, milling, drying, pelletisation and combustion of the collected scrub biomass to be performed in

pilot plants at CEDER-CIEMAT is foreseen. Demonstrative use of scrub biomass in a municipal district heating plant and a power plant are also envisaged The biomass collected will be converted to hog fuel and to pellets to evaluate the different costs of valorisation and to assess the quality of the biofuels obtained, and to effect the combustion characterization.

4. A key issue of the project is the monitoring of the environmental impacts caused by the biomass extraction, in particular the impacts on biodiversity (composition and shrub structure), physical and chemical properties of the soil, and on soil erosion and forest fire risks.

MAIN FEATURES OF THE PROJECT

The project ENERBIOSCRUB is partially funded by the European Union under the umbrella of the LIFE+ (2013) program. Coordinated by CIEMAT, the project consortium is formed by ten partners covering all the aspects related with the management of this biomass. The partners are, namely: Agresta, Avebiom, Montes de las Navas SA, Biomasa Forestal, INTACTA Gestión Forestal, Tragsa, Fabero City's Council, Gestamp Biomass, INIA, CIEMAT and AVEBIOM).

The project started in June 2014 and will finish in December 2017. The total budget is near 1.900.000 €.

RESULTS

The mechanized biomass collection works developed until now on a total of some 137ha (1,629 t of green biomass collected) reveal that the collection of shrub biomass is feasible although different aspects need still to be evaluated more in detail in order to obtain reliable conclusions. The exploitation of the biomass of many shrub lands can be profitable in the short-medium term (learning curve still ahead) with expected extraction and logistics costs similar to those of forest biomass under Spanish conditions.

The utilization of shrub biomass (pellets and hog fuel) in different pilot and industrial devices has revealed that it produces increased emissions in small domestic devices compared to A1 quality pellets and should not comply the environmental regulation for these installations, while the behavior in industrial(power) plants is similar to forest residue.

The evaluation on course of the impacts of the mechanized clearance on shrubs formations within different ecosystems is revealing as possible negative impacts a slight acidification and migration of fine and organic matter in some locations from the upper soil horizon in the first and second year after the clearing. These parameters must be followed in subsequent years to know their evolution in parallel with the regeneration of the masses. Regarding the risk of fire, there is a significant decrease after the clearing and two years later in the studied locations. The machines used in the clearing have had a very small erosive impact on the soil, with mainly superficial rolling and affecting a small surface.

CONTACT DETAILS

Luis S. Esteban Pascual,
luis.esteban@ciemat.es
Energy Department, Biomass Unit.
CEDER-CIEMAT.

For more information:
http://enerbioscrub.ciemat.es

EUREC MEMBER

III. SUSTAINABLE TRANSPORT

PROJECTS

1. I-NEXT - Innovation for Green Energy and Exchange in Transportation 50

2. MACROFUELS - Developing the Next Generation Macro-Algae Based Biofuels for Transportation via Advanced Bio-Refinery Processes 52

3. SUN-TO-LIQUID - Integrated Solar-Thermochemical Synthesis of Liquid Hydrocarbon Fuels 54

I-NEXT - INNOVATION FOR GREEN ENERGY AND EXCHANGE IN TRANSPORTATION

www.italtel.com/i-next-project/

CHALLENGES

Design, realization and validation of a solar-powered hydrogen fuelling station, included a Battery Energy Storage System to balance electricity production and consumption to limit the energy exchange with the power network.

Development of a hybrid fuel cell / battery electric minivan and of a pure electric vehicle for goods transportation.

Development of a hydrogen bicycle electrical assisted with low-pressure storage tank.

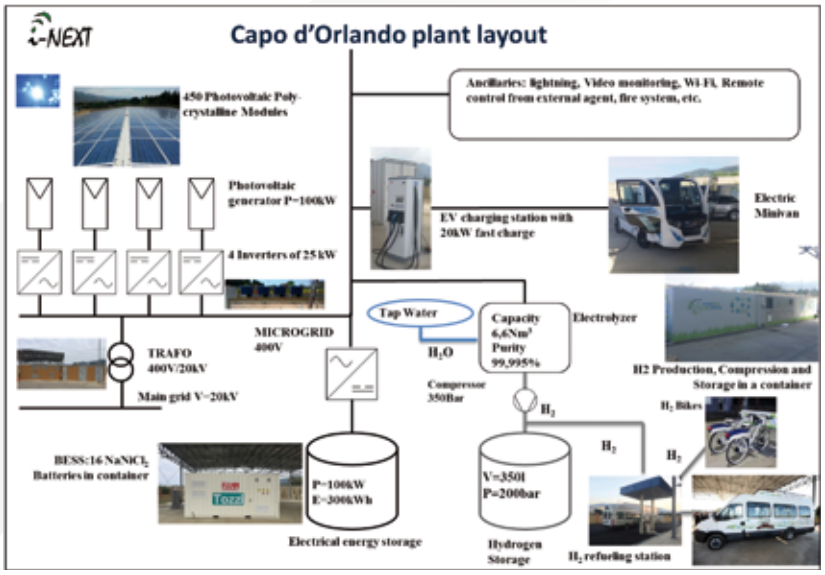
MAIN FEATURES OF THE PROJECT

The "i-NEXT" (innovation for greeN Energy and eXchange in Trasportation) research project, under the Italian call "Smart Cities and Communities and Social Innovation", within the frameworks "Smart mobility and last-mile logistic" and "Renewable energy and smart grid", aims at supporting the innovation both in transport and energy demand of buildings. The project partnership included CNR-ITAE, ITALTEL, TRE, Exalto, Muovo Sviluppo and Università di Palermo. The project funded by the Italian Ministry of Education and Research received about 16M€ and rewarded during the 2015 SMAU edition as best project in the Smart Communities sector.

Public Administrations was directly involved within experimental phases of the project. The experimental phase was carried out in Capo d'Orlando (Messina), Valle dei Templi and Palermo city. Within these sites, it was possible to test, demonstrate and validate the obtained results coming out from the research activities concerning the interaction between energy and mobility.

Both ecologic transport means and the demand and supply optimization in terms of mobility were supported and promoted. Moreover, the interaction among building energy demand, energy production from renewable energy source (RES), energy saving and energy storage were improved and optimized.

An integrated system concerning with electric mobility/energy production from RES/energy saving/energy storage was proposed.



A Smart Planning Lab was made available to allow the dissemination of research results supporting the PPAA in the innovation process. This will allow to the Smart Cities, and consequently to the Smart Citizens, to be able to benefit of the obtained results as well as of the new proposed services.

A "life cycle thinking" approach was utilized. The latter allows evaluating the technology performance during the whole life cycle. In this contest, Life Cycle Assessment (LCA) represented a valid and reliable instrument in order to define the FER environmental impact.

RESULTS

CNR-ITAE, in Capo d'Orlando site, has developed together other industrial partners, the first Italian hydrogen production and fuelling plant connected to a microgrid able to receive, as input, the energy coming from solar radiation and to deliver, as output, hydrogen and electricity for an electric and hydrogen vehicles fleet. The global plant energy system, where is integrated the hydrogen refuelling station, involves the implementation of a grid connected multi-purpose system where the generation of electricity from renewable sources is dedicated to the production of hydrogen and electricity for vehicle charging (able to recharge in 22 kW AC, 20 kW DC CHAdeMO and 20 kW DC CCS). Hydrogen is produced through electrolytic process by an alkaline electrolyzer at 10 bar nominal pressure and 6,6 Nmc/h flow rate. Once hydrogen is produced, it is stored and compressed at 360 bar for vehicles refuelling. The overall plant allows an energy supply safety with a reduction of electric power consumption during periods of maximum demand on the power utility (peak shaving) with a consequent knockoff of energy prices. In detail, a photovoltaic plant of rated power of 100 kW was installed on the roof of a shed for vehicles recovering (area of 720 m2). The Battery Energy Storage System (BESS) of 100 kW and 300 kWh equipped with 16 sodium nickel chloride high-temperature batteries is a plug and play containerized system connected through a bidirectional inverter to the 400 Vac microgrid. In the design of the plant, both solar irradiation data and daily hydrogen demand are optimized for across the year for the selected location (Capo d'Orlando - Sicily). The BEES function is to balance the energy coming from renewables and loads, in order to minimize the energy exchange with the grid and supporting the energy independency of the overall system. Demand response control is active on the electrolyzer in order to make simultaneous the operating of the electrolyzer with photovoltaic energy production. A remote agent, through VPN (Virtual Private Network) connections, monitors and controls the overall system. It can send commands to BESS, in order to regulate the amount of active and reactive power to deliver, supporting the local grid regulation (grid frequency and voltage).

CONTACT DETAILS

Francesco Sergi

CNR-ITAE
francesco.sergi@itae.cnr.it

EUREC MEMBER

Consiglio Nazionale delle Ricerche

ITAE

MACROFUELS - DEVELOPING THE NEXT GENERATION MACRO-ALGAE BASED BIOFUELS FOR TRANSPORTATION VIA ADVANCED BIO-REFINERY PROCESSES

www.macrofuels.eu

CHALLENGES

Biofuels have been promoted as a safe source of energy carriers. Today, however, there is a considerable concern about the competing use of agricultural land for the growth of crops for food vs. bioenergy uses. In 2012, the European Commission proposed a revision of its 10 % target for the amount of transport energy that has to come from renewable sources by 2020. It said that only half of this, or 5 % of total transport energy, should come from food crops.

MacroFuels targets the development of aquatic biomass, *i.e. seaweed* or macro algae, for advanced biofuel production which, by diverting cultivation for fuels production from land to sea, will contribute to the 5% EU target. Seaweeds do not need any fresh water, arable land or added fertilizers to grow. Their use for the production of biofuels, however, requires an increase of seaweed production by orders of magnitude as compared to the current production. By cultivating and harvesting seaweeds all year round for the first time in Europe, and by combining this with novel technologies and techniques in automated harvesting, storage, pre-treatment and conversion routes, MacroFuels will pave the way towards large scale production of seaweed in the EU waters.

MAIN FEATURES OF THE PROJECT

MacroFuels addresses the challenge of generating more sustainable biomass for the successful transition towards a sustainable carbon society by producing advanced biofuels from seaweed. Targeted biofuels are ethanol, butanol, furanics and biogas. Furthermore, the sustainable cultivation of seaweed aids in reducing the eutrophication of coastal waters as seaweed metabolizes dissolved nutrients and converts them to biomass, solely from the CO_2 in the air and sunlight. To stabilize the highly perishable seaweed so that it can be used as feedstock year-round presents a significant challenge, together with taking the step towards large-scale cultivation which is required to make seaweed-derived biofuels economically viable. These challenges are addressed through MacroFuels' key objectives, which include:

- Increasing the biomass supply by developing a rotating crop scheme for the cultivation of seaweed using native, highly productive brown, red and green seaweeds, in combination with the use of advanced textile substrates resulting in a year round biomass yield;
- Improving the pre-treatment and storage of seaweed and to yield fermentable and convertible sugars at economically relevant concentrations (10-30%);
- Increasing the bio-ethanol and bio-butanol production to economically viable concentrations by developing novel fermenting organisms which metabolize all sugars at 90% efficiency;
- Increasing the biogas yield to convert 90% of the available carbon in residues by adapting the organisms to seaweed; and
- Developing a thermochemical conversion route of sugars to fuels from the mg. scale to the kg. scale.

MACROFUELS

CONTACT DETAILS

Karina Veum
Senior Researcher/Policy Advisor
Policy Studies
ECN
veum@ecn.nl

EUREC MEMBER

ECN

MacroFuels will perform an integral techno-economic, sustainability and risk assessment of the entire seaweed-to-biofuel chain as well as develop technology for the production of fuels which are suitable as liquid fuels, or precursors thereof, for the heavy transport sector as well as potentially for the aviation sector. Fuel (mixtures) will be prepared and tested in the relevant engines to assess the suitability of these fuels under realistic transport conditions. The MacroFuels technology has a high carbon dioxide reduction potential as well as it reduces the demand for natural resources on land. MacroFuels breakthroughs will create many novel opportunities for employment along the entire value chain.

RESULTS

In the first eighteen months, MacroFuels has demonstrated two large scale harvests of seaweed (visit https://youtu.be/XCIDr8IHh6Y for the 2016 harvest). Trials have been performed deploying different seaweed species and strains, cultivation substrates and seeding methods as well as timings of out-planting and harvesting. A public 'Cultivation and Harvesting Guide' based on the trial results is in preparation.

Furthermore, MacroFuels has demonstrated the conversion of seaweed to fuel alcohol. Results showed the high potential of brown seaweed *Laminaria digitata* for the development of a cost-effective seaweed-butanol industrial process, due to the strain's efficient utilization of sugars, lactic acid, and for the first time reported, alginate components. Detailed results are available in *Bioresource Technology* (Elsevier), 2017, Vol.238, p.16-21, http://dx.doi.org/10.1016/j.biortech.2017.04.035.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 654010

SUN-TO-LIQUID - INTEGRATED SOLAR-THERMOCHEMICAL SYNTHESIS OF LIQUID HYDROCARBON FUELS

www.sun-to-liquid.eu/

CHALLENGES

The EU energy roadmap for 2050 aims at a 75% share of renewables in the gross energy consumption. Achieving this target requires a significant share of alternative transportation fuels, including a 40% target share of low carbon fuels in aviation. Therefore the European Commission calls for the development of sustainable fuels from non-biomass non-fossil sources.

SUN-to-LIQUID[1] establishes a radically different non-biomass non-fossil path to synthesize renewable liquid hydrocarbon fuels from abundant feedstocks of H_2O, CO_2 and solar energy. Concentrated solar radiation drives a thermochemical redox cycle, which inherently operates at high temperatures and utilizes the full solar spectrum. Thereby, it provides a thermodynamically favourable path to solar fuel production with the potential of high energy conversion efficiency and, consequently, economic competitiveness.

The FP7 project SOLAR-JET achieved the first production of solar jet fuel, and SUN-to-LIQUID aims at advancing this technology from the laboratory to the field phase. The ambition is to advance solar fuel production technology well beyond the state of the art and to guide the further scale-up towards a reliable basis for development for future competitive industrial exploitation.

The primary objective of SUN-to-LIQUID is the scale-up and experimental validation of the complete process chain to solar liquid hydrocarbon fuels from H_2O, CO_2 and solar energy. Moving from a 4 kW setup in the laboratory to a 50 kW plant in the field will promote the technological readiness level (TRL) of solar thermochemical fuels from TRL 3-4 to TRL 5.

SUN-to-LIQUID will design, fabricate, and experimentally validate a complete solar fuel production plant at a 50kW level and will establish a new milestone in reactor efficiency. The field validation will integrate for the first time the whole production chain from sunlight, H_2O and CO_2 to liquid hydrocarbon fuels.

In SUN-to-LIQUID DLR is joined by other leading European research and innovation players in the field of solar thermochemical fuel research: Bauhaus Luftfahrt (DE), ETH Zurich (CH), IMDEA Energía (ES), Abengoa Research (ES), HyGear Technology & Services B.V. (NL) and ARTTIC (FR).

MAIN FEATURES OF THE PROJECT

SUN-to-LIQUID will implement a pioneering solar fuel plant which consists of three basic sub-systems:

1. A high-flux solar concentrating subsystem, consisting of a sun-tracking heliostat field, that delivers 50 kW of radiative power to a solar reactor positioned at the top of a small tower.
2. A 50 kW solar thermochemical reactor subsystem (see Figure 1) for syngas production from H_2O and CO_2 via the ceria-based thermochemical redox cycle.

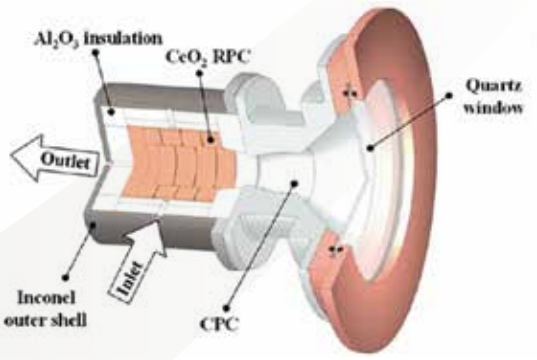


Figure 1: Reactor design of previous generation (from FP7 SOLAR-JET)[2].

3. A gas-to-liquid conversion subsystem, comprising compression and storage units for syngas and a dedicated micro FT unit for the synthesis of liquid hydrocarbon fuels.

1- Project website: www.sun-to-liquid.eu
2- P. Furler et al., Solar thermochemical CO_2 splitting utilizing a reticulated porous ceria redox system, Energy & Fuels 26, 7051, 2012

Figure 2: SUN-to-LIQUID site at IMDEA, Móstoles (© ARTTIC)

All subsystems will be integrated for a close-coupled operation of the whole fuel production chain. All research infrastructures are located at IMDEA Energía in Madrid. SUN-to-LIQUID will parametrically optimise the solar thermochemical fuel plant and run a long-term operation campaign on a daily basis under realistic conditions relevant to later commercial implementations. Beyond the physical implementation, SUN-to-LIQUID prepares the next steps with a design study of a MW-scale solar fuel plant.

RESULTS

The project started in the beginning of 2016. Now, after not even two years, the advanced modular solar concentration system for high-flux/high-temperature applications has been build and tested (see Figure 2). It consists out of 169 small size heliostats that are used to focus the sunlight on the receiver-reactors, providing flux densities of more than 2500 kW/m². By this the system exceeds solar concentration ratios typically obtained in CSP plants for electricity generation.

The up-scaled solar thermochemical reactor subsystem was designed, build, and tested at ETH Zurich (CH) using a high flux solar simulator radiation source delivering 60% nominal reactor power (30 kW). Thereby significant progress in material development has been achieved on large-scale reticulated porous ceramic (RPC) ceria structures, resulting in the capability to reliably fabricate large ceria RPCs with high strength and good heat and mass transfer performance for a 50-kW reactor. The reactor has been shipped to Spain and will be integrated on the tower in fall 2017.

Also completed were the automated flux measurement system for the concentration facility by DLR, the design of the interfaces between all system components, and the gas-to-liquids subsystem which is under construction at HyGear (NL).

SUN to LIQUID
Fuels from concentroted sunlight

CONTACT DETAILS

Dr.-Ing. Stefan Brendelberger

DLR
Tel.: +49 2203 601-2905
Fax: +49 2203 601-4141
stefan.brendelberger@dlr.de
www.DLR.de/sf
www.DLR.de/energie

EUREC MEMBER

DLR

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654408

> *"Working on a project that could help tackling one of the large challenges of our times is highly motivating. It is great to see how a team of international experts from different institutions grows together over the course of a project. Having a significant share of the project dedicated to test and improve the developed technology will be key to the success of Sun-to-Liquid."*
>
> ***Stefan Brendelberger,** DLR*

IV. HORIZONTAL TOPICS

PROJECTS

1. Decarbonisation Pathways for the Industrial Cluster of the Port of Rotterdam 58

2. iGREENGrid - Integrating Renewables in the European Electricity Grid 60

3. NOBEL GRID - New Cost-Efficient Business Models for Flexible Smart Grids 62

4. ORPHEUS - Optimizing Hybrid Energy Grids for Smart Cities 64

5. RESTABLE - Improvement of Renewables-based System Services through Better Inter-action of European Control Zones 66

6. SOSTURMAC - Sustainable Revaluation of Natural and Architectural Heritage and Development of Low Carbon Tourism Initiatives in the Canary Islands and Cape Verde 68

7. Synthesizing Residential Load Profiles using Behaviour Simulation 70

8. TWINPV - Stimulating Scientific Excellence through Twinning in the Quest for Sustainable Energy 72

9. Neo-Carbon Energy 74

DECARBONISATION PATHWAYS FOR THE INDUSTRIAL CLUSTER OF THE PORT OF ROTTERDAM

www.wupperinst.org

CHALLENGES

The Port of Rotterdam is the largest seaport in Europe. Its industrial cluster is made up to a great extent of companies operating in the energy-intensive sectors of oil refining, chemical manufacturing and power and steam generation. In 2015, the area's CO_2 emissions totalled approximatley 30 Mt and made up 18% of the Netherlands' total emissions. The port area's CO_2 emissions grew by 48% between 1990 and 2015. A main reason for the massive growth in emissions was the increase in electricity and steam generation from fossil fuel sources.

The Port of Rotterdam Authority is aware that future global and EU decarbonisation policies will affect the port's industrial cluster, as the bulk of its economic activities focuses on trading, handling, converting and using fossil fuels, i.e. fossil carbon. This makes the port's businesses particularly vulnerable to global and European decarbonisation efforts.

Against this background and in light of the targets agreed upon in the Paris Agreement, the Port Authority in early 2016 commissioned the Wuppertal Institute to conduct a study on Decarbonisation Pathways for the Industrial Cluster of the Port of Rotterdam. The study intended to explore the consequences of European decarbonisation efforts for the port's industrial cluster and to identify possible scenarios on how the port can prepare for such a future and how it can take a pro-active stance towards deep decarbonisation.

MAIN FEATURES OF THE PROJECT

The study's assumptions about future European GHG emission reduction efforts were mainly based on an analysis of available decarbonisation scenarios covering the EU's target range of reducing GHG emissions by 80% to 95% by 2050, relative to 1990. These "framework scenarios" expect considerable changes in the coming decades, particularly in the transport and power generation sectors. This will have strong effects on the production of fuels and electricity in the port and on the technologies and energy carriers used.

Based on the business environments foreseen by the framework scenarios, plausible economic visions for the industrial cluster were derived. Specifically, four energy and CO_2 emission scenarios for the port's industrial cluster were developed and quantitatively modelled (taking a territorial approach) , including one business-as-usual scenario and three CO_2 emission mitigation scenarios. The selection of low carbon technologies in the scenarios was informed inter alia by a survey among the port's industrial stakeholders and initial scenario results were discussed with stakeholders in two workshops and refined based on the feedback received. Figure 1 summarizes the project's approach.

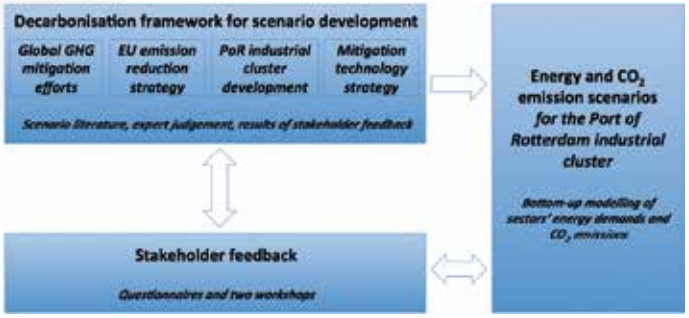


Figure 1: Steps taken in developing the scenarios for the port's industrial cluster

RESULTS

In the following, a brief overview of the three decarbonisation scenarios is provided. The first one, "Technological Progress" (TP), assumes that Europe reduces its GHG emissions by 80% by 2050. The scenario focuses on strong technological progress and on CCS for power plants, with only moderate structural changes in energy and transport systems. In this scenario, by 2050, CO_2 emissions in the port area are reduced by 75% compared to 2015.

The other two decarbonisation scenarios, in contrast, assume that the EU aims for a more ambitious 90 to 95% GHG emission reduction until 2050 and that respective policies are enacted. In regard to key decarbonisation technologies, the "Biomass and CCS" scenario (BIO) assumes that large amounts of biomass can be supplied sustainably and will be used in the port for power generation (BECCS) as well as for feedstock for refineries and the chemical industry. Fischer-Tropsch fuel generation plays an important role in this scenario, allowing the port to become a key cluster for the production of synthetic fuels in Western Europe.

The "Closed Carbon Cycle" scenario (CYC) on the other hand assumes that plenty of renewables-based electricity will be used at the port to supply heat as well as hydrogen for the synthetic generation of feedstock for the chemical industry as well as the remaining small rest of fuels in the transport sector. The carbon required for the chemicals will stem from recycled waste. Technologies particularly needed in this scenario are water electrolysis and gasification or pyrolysis to capture carbon from waste, as well as technologies for the production of base chemicals from syngas. A variant of this scenario (CYC-ECE) describes the development in case of an earlier closure of coal-fired power stations at the port by 2025, reflecting recent political discussions in the Netherlands.

By 2050, the BIO, CYC and CYC-ECE scenarios all achieve CO_2 emission reductions of 98% compared to 2015. The scenarios' cumulative CO_2 emissions are shown in Figure 2.

In all decarbonisation scenarios a significant expansion of onshore wind and solar PV power plants in the port area is assumed. However, the electrification strategies at the port's industries and the reduction or phase out (depending on the scenario) of fossil fuel power generation means that in the decarbonisation scenarios the port area will become a large electricity importer by 2050, particularly in the CYC scenario. Therefore, the study highlights the need for an ambitious expansion of electricity generation from renewable energy sources in Europe.

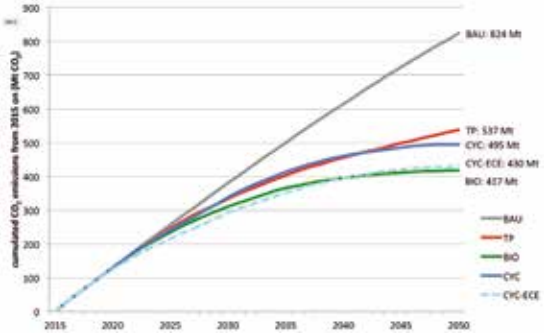


Figure 2: Comparison of cumulative net CO_2 emissions of the port's industrial cluster in the four scenarios and a scenario variant

CONTACT DETAILS

Sascha Samadi
sascha.samadi@wupperinst.org
Wuppertal Institute for Climate,
Environment and Energy
Wuppertal, Germany

For more information
https://wupperinst.org/en/p/wi/p/s/pd/628/

EUREC MEMBER

Wuppertal Institut

IGREENGRID - INTEGRATING RENEWABLES IN THE EUROPEAN ELECTRICITY GRID

www.igreengrid-fp7.eu

CHALLENGES

Distributed Renewable Energy Sources (DRES s) are increasing rapidly in distribution grids, and their integration into the electricity system is one of the most relevant problems these networks are facing.

The standard long-term solution to increase the capacity of electricity networks to host additional generation is grid reinforcement, but this kind of approach can be too slow and costly to respond effectively to the DRES developments. Several alternative solutions have been developed and demonstrated, including controlling DRES active and reactive power generation, managing flexible demand, and smart charging of electric vehicles.

MAIN FEATURES OF THE PROJECT

The objective of the project iGREENGrid was to analyze and select the most promising research and development (R&D) solutions to this problem. For this purpose, four research institutions (Institute of Communications and Computer Systems of the National Technical University of Athens - NTUA, Ricerca sul Sistema Energetico - RSE, Austrian Institute of Technology- AIT, and Tecnalia) and eight European distribution system operators studied six large demonstration projects: Eberstalzell and Koestendorf (Netz Oberösterreich GmbH and Salzburg Netz GmbH) in Austria; Proyecto de Redes Inteligentes del Corredor del HenarE in Spain, known as PRICE (Iberdrola Distribución Eléctrica and Gas Natural Fenosa); Sperchiada in Greece (Hellenic Electricity Distribution Network Operator - HEDNO); Isernia in Italy (enel-distribuzione); Zukunftsnetze in Germany (Innogy SE); and Venteea in France (Enedis). IGREENGrid had a budget of €6.6 million, partially funded by the European Commission, and was in development for almost four years.

Numerous smart grid solutions have been developed to address some of these resiliency challenges and to avoid disruptions to the grid. IGREENGrid focused on identifying the best practices regarding DRES integration issues by analyzing a large number of projects. In six successful large-scale demonstration projects, IGREENGrid has found practical implementations of solutions based on the following functionalities:

- voltage control systems
- storage management
- generation forecasting, management, and curtailment
- load/demand management
- network reconfiguration
- islanding solutions
- anti-islanding systems
- network state estimation and network monitoring.

Based on the results of the analysis, there is common agreement that the main type of disruptions in distribution grids caused by a large penetration of DRESs are as follows:

- ✔ The violation of voltage limits on medium- and low voltage (LV) networks are usually addressed through a diverse range of voltage control systems.
- ✔ The unpredictability of generation profiles of RESs and the need for local balancing between distributed generation (DG) and local demand can be addressed using storage technologies and generation forecasting and management, including curtailment and active demand solutions.
- ✔ Network faults require grid systems to have specific intelligence to isolate the problem and recover service as soon as possible. Network reconfiguration and islanded operations have been addressed by many research projects. Moreover, the topic of anti-islanding has received increased attention in the last years due to the large penetration of distributed generation in some network areas and to

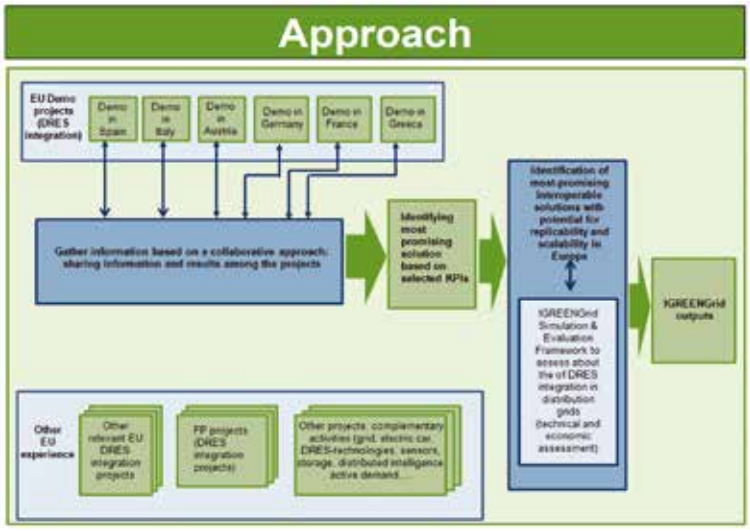
the fact that most generators are fitted with network support functions which can impact islanding protections.

- ✔ Finally, in a more general approach, grid resiliency can be improved by deploying monitoring and automation systems, reliable "analysis functions" such as state estimation, and congestion forecasting solutions as well as enhanced controllability including optimal power flows to predict and solve the problems before they have an impact in the most efficient way.

RESULTS

The final results can be clustered in the following thematic:

- Barriers identified to the massive integration of DRES
- Key Performance Indicators for the evaluation of the solutions
- Most Promising Solutions
- Replicability and Scalability Analysis
- Guidelines addressed to the European Commission for making possible the implementation of the solutions



CONTACT DETAILS

Helfried Brunner

AIT Austrian Institute of Technology GmbH
Phone: +43 50550 6382
helfried.brunner@ait.ac.at

Further information
http://www.igreengrid-fp7.eu/

EUREC MEMBER

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 308864.

"In the initial phase it was quite challenging to find a common language between all partners coming from different countries with different technical, institutional and regulatory frameworks. Nevertheless, the EU funding allowed to exchange experiences, draw conclusion and assess the scalability and replicability of nationally developed solutions at EU level, including the definition of related key performance indicators. Eventually, it was a great benefit for all involved partners.

***Helfried Brunner,** AIT*

NOBEL GRID - NEW COST-EFFICIENT BUSINESS MODELS FOR FLEXIBLE SMART GRIDS

www.nobelgrid.eu

CHALLENGES

The H2020 project NOBEL GRID started in January 2015 as an integrating activity. Focusing on empowering end customers and prosumers to actively take part in the unbundled energy market, a consortium of 21 partners has the objectives to develop and demonstrate the next level of smart grid tools and IT services. NOBEL GRID defines an architecture including all domains of the smart grid reference architecture model (SGAM) from CEN-CENELEC-ETSI by a use case driven approach as proposed by the European Mandate M/490. It involves grid operators, energy service companies, energy providers and retailers, renewable cooperatives and aggregators. They all are interacting and actively using the flexibilities of customer-side electric loads and generators for optimising their business on the unbundled market.

MAIN FEATURES OF THE PROJECT

At the prosumer side, the design relies on smart meters, which are able to measure power in the range of seconds of temporal resolution, and are extended by software driven services placed on a modular and flexible embedded system, the "Smart Meter eXtension" (SMX). The SMX acts as a firewall for the prosumer and exposes grid support and flexibility capabilities of smart home appliances and inverter-coupled generators towards the key market actors, which are equipped with three central services:

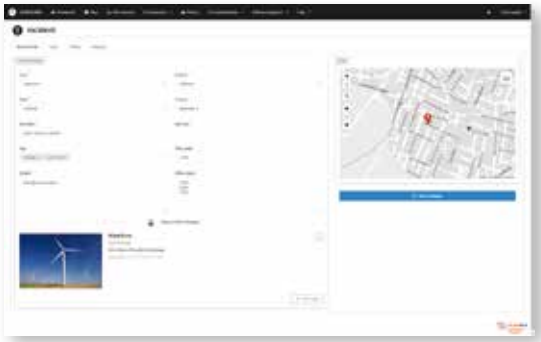
- The Energy Management and Analysis App (EMA App) for ESCOs and prosumers visualises and analyses the client's energy usage, and also allows for manual demand response campaigns and user interaction.
- The Demand Response Flexible Market Cockpit (DRFM) allows aggregators, ESCOs and retailers to manage demand response (DR) programs through a single, integrated system. It is a decision support system bridging the flexibility brought by controllable loads and generators at the prosumer premises with distribution grid actors.
- The Grid Management and Maintenance Master Framework (G3M) is the access point for the distribution grid operator to the set of functionalities and services offered by NOBEL GRID. It allows for detailed supervision and control of the energy system down into the low-voltage level. It integrates into and extends existing SCADA systems.

The technical components all work together in order to technically, economically and ecologically optimise operation of the energy system. An example is the avoidance of grid congestions. Here, the G3M exchanges standardised data with the DRFM, which in turn carries out demand response campaigns with automatic management of customer loads carried out by the SMX.

NOBEL GRID Consortium

Smart Low-Cost advanced meter prototype

DRFM cockpit screenshot



G3M screenshot

RESULTS

In the first 2 ½ years of the project all of the components named above were developed and individually tested in project partner's smart grid laboratories. Close-to-market solutions, modern standards and methodologies and open source solutions were used in order to ensure cost efficiency. For example, off-the-shelf embedded systems like the BeagleBone Black Industrial are used as core component of the SMX. The project succeeded in extending various types of smart metrology meters available on the market with an SMX extension. Also, a device was developed which combines SMX and high-precision metrology meter in a single housing, the so-called "Smart Low-Cost advanced meter" (SLAM). This device is currently undergoing a full class B meter certification process. With the last project year, NOBEL GRID has reached its final integration and demonstration phase. Currently, solutions are rolled-out at five pilot sites in Italy, England, Spain, Belgium and Greece with the goal of connecting a total of about 1000 customers with the NOBEL GRID infrastructure. The pilot tests will demonstrate practical integration of all the solutions in real-life environments across Europe.

Nobel Grid
Smart energy for people

CONTACT DETAILS

Fraunhofer IWES, Kassel, Germany

jan.ringelstein@iwes.fraunhofer.de

More Information: www.nobelgrid.eu

EUREC MEMBER

Fraunhofer IWES

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 646184

> *"Working with international partners in a great consortium striving for a common innovative goal is what I really enjoy about it. The project greatly supports the vision of creating a smart grid with downloadable functionality for the end customer, enabling them to actively work with energy in their social community instead of just passively using it."*
>
> ***Jan Ringelstein,*** *Franuhofer IWES*

ORPHEUS - OPTIMIZING HYBRID ENERGY GRIDS FOR SMART CITIES

www.orpheus-project.eu

CHALLENGES

Bringing together nine partner organizations from Germany, Austria, and Sweden, the European research project OrPHEuS was active from 2013 to 2016. It investigated the concept of hybrid energy grids as a way to increase the usage of renewable energy in urban areas in a resilient, flexible and cost-effective manner.

By enabling the interconnection of existing individual grids (typically electricity, district heating and gas) and their collaborative operation, hybrid energy grids can increase the use of locally produced renewable energy and improve overall energy efficiency through synergy effects and cross-grid storage capabilities. But this disruptive approach requires a number of adaptations to fully come into fruition. While technical solutions to transfer energy from one grid to another already exist, there is a need for an overarching monitoring and controlling infrastructure able to collect information from the various grids involved and apply an optimal collaborative control strategy to the coupling points. New business models must also be developed and implemented to ensure socio-economic benefits for all actors involved.

MAIN FEATURES OF THE PROJECT

The project activities focused on two real-life demonstration sites in Ulm (Germany) and Skellefteå (Sweden), representing typical use cases. In Ulm, the objective was to increase local PV penetration in neighbourhoods through power-to-heat, reducing PV curtailment and avoiding the need for electric grid reinforcement in the process. In Skellefteå, the aim was to make the city's energy supply more flexible to better benefit from cheap renewable electricity production and to phase out oil boilers for the provision of peak district heating.

One of the demonstration sites in Ulm (Germany), where grid hybridization can support increasing levels of PV penetration.

A thorough assessment of the potential for technical and socio-economic benefits brought by the hybrid energy concept was conducted for these locations, by considering both the hybridization options feasible in the immediate context and more advanced concepts for future scenarios. An ICT architecture able to transmit and process information about the various system components was developed. These data flows can become very large when implementing fine-grained centralized control strategies relying on numerous sensors, requiring an expensive and energy-intensive infrastructure by itself. Several solutions to this issue were investigated, ranging from the development of a new machine-to-machine data filtering algorithm to the consideration of different control architectures, with varying levels of centralization and data input (number of sensors). The control strategies were evaluated and validated with advanced co-simulations of the demonstration sites across the electrical and thermal domains. The use of meteorological data sourced from ground and satellite measurements was also considered as a way to reduce the number of required physical sensors.

The present and future scenarios for the demonstration sites of Ulm and Skellefteå were evaluated in terms of costs and benefits for the different participating actors. With the conduction of sensitivity analyses and robustness tests, the consortium could issue recommendations for new collaborative business models offering an optimal allocation of costs and profits according to the Pareto criterion.

RESULTS

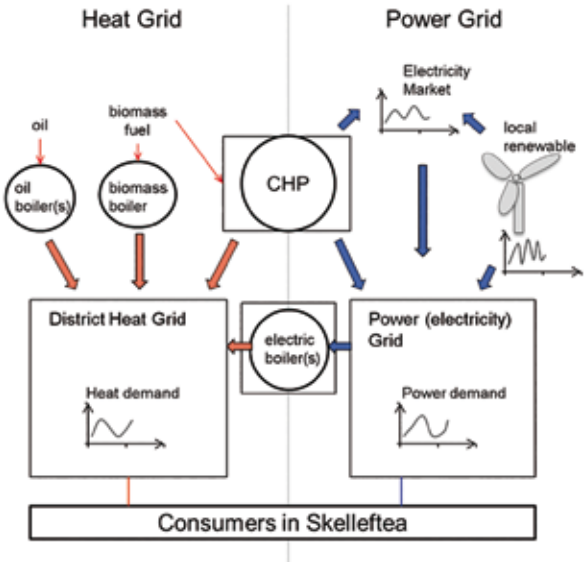
In both demonstration sites it was conceptually shown that a hybridization of the energy supply chain and a stronger coupling of the energy distribution networks can significantly reduce the usage of fossil fuels in a cost-efficient manner. The usage of hybrid coupling points provides more flexibility – especially for the electricity network – and, thus, can be an important tool to further increase the share of renewable energy sources in Europe's energy system.

In Ulm, the conversion of surplus PV production into heating with electric boilers for local households can easily lead to a yearly reduction of PV curtailment of 35% while slashing fossil fuel consumption by 60%. In Skellefteå, the use of oil boilers to provide peak district heating in the winter can be completely avoided by the implementation of a large electric boiler and new control strategy, thus making heat supply for the city completely CO_2 neutral.

In terms of control infrastructure, the results show that centralized control strategies are preferable to decentralized ones in terms of almost all key performance indicators, which can be explained by a more holistic overview of the hybrid grids' states. Decentralized strategies are still attractive because of their scalability and simplicity but require very careful control design in order to not perform sub-optimally.

In all cases the technical results can be accompanied by positive socio-economic developments for all involved stakeholders if new business models are established. Regulatory barriers to these business models were however identified in the current context, such as network charges and electricity taxes for power-to-heat technologies.

The applicability and scalability of the developed control strategies and results to cities in other regions, with different energy networks, different means of energy exchange, and different supply and demand patterns was further analysed. The OrPHEuS consortium published a series of reports and practical recommendations to guide energy utilities, DSOs, municipalities and actors of the ICT sector.



Overview of energy interactions in the present hybridization scenario for Skellefteå (Sweden)

CONTACT DETAILS

Ingrid Weiss
Ingrid.weiss@wip-munich.de

Silvia Caneva
silvia.caneva@wip-munich.de

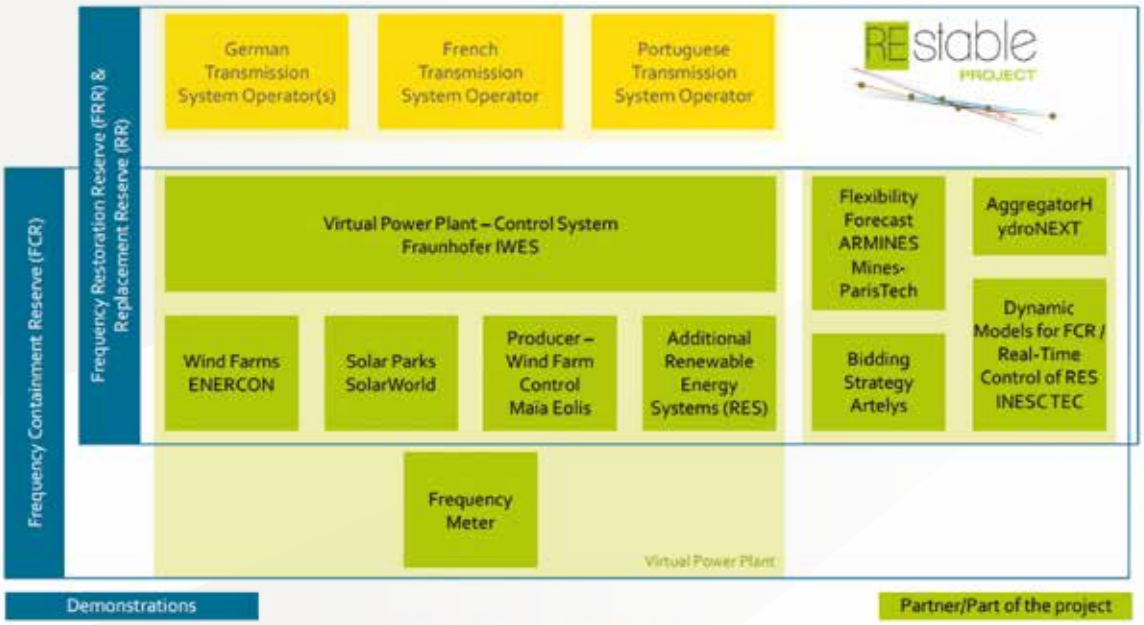
Simon Challet
simon.challet@wip-munich.de

EUREC MEMBER

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 608930.

RESTABLE - IMPROVEMENT OF RENEWABLES-BASED SYSTEM SERVICES THROUGH BETTER INTER-ACTION OF EUROPEAN CONTROL ZONES

www.restable-project.eu



Example of FCR provided by renewables

Duration: 01.04.2016 - 31.03.2019

Budget
Total Budget: € 3,500,400
Funding: € 1.817.300

REstable is a collaborative European research and develop-ment project. Its objective is to develop the technology in order to allow renewable resources to provide ancillary ser-vices to the grid without the need of storage or other invest-ments. It is based on the results of the project "Kombikraft-werk II" and based on the idea of a Virtual Power Plant (VPP) able to control diverse renewable resources (photovoltaic, wind) in several regions (atlantic, continental, mediterranean) in order to exploit their variability.

Ancillary services are those services necessary to support the transmission of electric power. They are provided by qualified network users (in general large power plants) to the trans-mis-sion system operator. Currently renewables generally don't qualify to provide them forcing conventional power plant to turn in order to provide the necessary ancillary services with the following negative consequences:

1. There is a technical limit to the share of renewable connected to the network
2. renewable producers miss a source of revenue where ancillary services are rewarded

MAIN OBJECTIVES

The project will test the ability of a Virtual Power Plant (VPP) to provide the following five ancillary services:

1. Frequency Containment Reserve (FCR)
2. Automatic Frequency Restoration Reserve (aFRR)
3. Manual Frequency Restoration Reserve (mFRR)
4. Replacement reserve (RR)
5. Voltage Support.

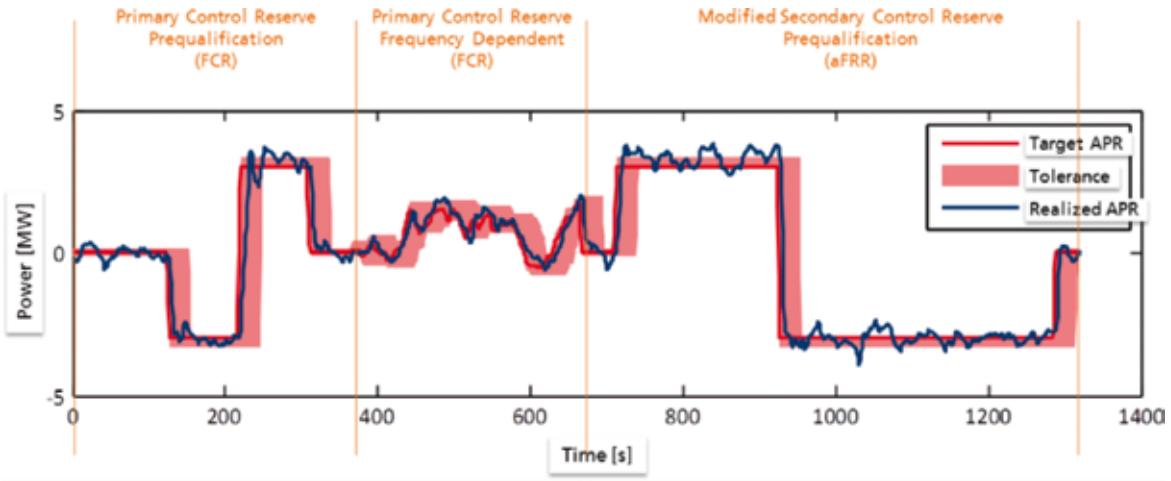
For each service a meaningful number of tests will be carried out. In each test it will be repeated the procedure which is similar to the one requested by the TSOs for the pre-qualification of a provider for the provision of each ancillary service. In the case of FCR there will also be a test with reac-tion of the VPP to a real frequency deviation signal. The results will be evaluated according to the most stringent criteria found in the regulation of the three participant countries. Other objectives involves: the development of an approach to accelerate the response of the VPP, the development of strat-egies for multiple bidding in energy and ancillary services markets, the forecast of the capacity of renewable plants to provide ancillary services and the study of the needs of ancil-lary services on the European grid at a medium long horizon.

MAIN RESULTS

For each test, a number of metrics used to carachterise the quality of the ancillary services provided by the VPP will be recorded. These metrics include, but are not limited to:

1. Number of under and over fulfilments
2. Maximum under and over fulfilment
3. Total energy of the under and over fulfilment
4. Amount of the service provided

An example of a test, with the allowed tolerance band and the real under and over fulfilments is shown in the picure below.



RE stable PROJECT

CONTACT DETAILS

Coordinator:

Andrea MICHIORRI
ARMINES (France)

EUREC MEMBER

MINES ParisTech

SOSTURMAC - SUSTAINABLE REVALUATION OF NATURAL AND ARCHITECTURAL HERITAGE AND DEVELOPMENT OF LOW CARBON TOURISM INITIATIVES IN THE CANARY ISLANDS AND CAPE VERDE

sosturmac.iter.es

CHALLENGES

SOSTURMAC main challenge is to promote sustainable actions based on renewable energies and energy efficiency that put in value the natural and architectural heritage of the Canary Islands and Cape Verde, favouring its conservation and providing added values to its sustainable and cultural tourism offer. Its activities will promote a new tourism approach based on energy efficiency and renewable energies as a way to enhance economic competitiveness and to reduce energy dependency. The project will enhance the integration of the new values and products developed in the tourism dynamics of the Canary Islands and Cape Verde, in order to diversify its tourist offer and to promote its position as innovative, cultural and natural tourist destinations.

MAIN FEATURES OF THE PROJECT

The project SOSTURMAC (2017 – 2019), co-financed by the European Programme PCT-MAC 2014 - 2020, aims to provide added value to the tourism offer of the Canary Islands and Cape Verde by orienting it to the new trends of the market with scientific and nature tourism. The aim is to make ecotourism an opportunity for socio-economic improvement and conservation of the environment in the area of cooperation. SOSTURMAC will identify the key natural and architectural heritage elements in terms of their conservation and their potential as a tourist attraction, and will propose actions that contribute to its sustainability.

The Institute of Technology and Renewable Energies (ITER) leads this Project, transferring its experience and knowledge both in the development of low carbon technologies and in the management of a Zero CO_2 tourist accommodation: ITER's bioclimatic houses "Casas ITER" (Tenerife Island - http://casas.iter.es/). The other project's partners are the International Foundation for Heritage Conservation (CICOP) and the Tenerife Energy Agency (AIET), from the Canary Islands; and the National Directorate for the Environment (DNA), the National Agricultural Research and Development Institute (INIDA), the Cape Verde University, the City Council of São Filipe (Fogo Island) and the Natural Park of Fogo, from Cape Verde.

The SOSTURMAC project will define and propose the guidelines to integrate renewable energy and energy efficiency systems in key architectural heritage, respecting its conservation. These criteria will be implemented in the historic centre of the São Filipe municipality (Fogo Island, in Cape Verde), as a pilot initiative to study how these sustainable criteria can revitalize the tourism in an historical city. Furthermore, based on ITER's experience with its Living-Lab "Casas ITER", the project will propose a "Zero CO_2 Modular tourist accommodation" (with PV and energy efficiency systems), suitable to be implemented in areas with a high value of natural heritage. As a concrete result, the project will design and implement a "Zero CO_2 Modular Information Point" within the Fogo Natural Park (Cape Verde) boundaries.

RESULTS

- ICT tools "Canary Islands heritage Manager" and "Cape Verde heritage Manager "
- Guidelines to integrate renewable energy and energy efficiency systems in key architectural heritage
- Consolidation of ITER's bioclimatic houses "Casas ITER" as Living Lab and tourist product
- Sustainable intervention Pilot action in the city of São Filipe (Fogo Island)
- Design of a "Zero CO_2 Modular tourist accommodation" together with ICT tools suitable for management and marketing
- Installation of a "Zero CO_2 Modular Tourist information and natural heritage interpretation point" in the Natural Park of Fogo
- Complementary activities and materials for the touristic promotion of the products developed
- Dissemination and training actions (courses, training sessions, awareness raising campaigns, etc.)

CONTACT DETAILS

Mónica Alonso López

Instituto Tecnológico y de Energías Renovables – ITER
Agencia Insular de Energía de Tenerife - AIET

sosturmac@iter.es
www.sosturmac.iter.es
www.facebook.com/SOSTURMAC

EUREC MEMBER

"The EU Programme INTERREG MAC is of huge interest for outermost regions such as the Canary Islands, since it allows us to transfer technology and strengthen our position as a connecting link between Europe and Africa".

Mónica Alonso López, ITER

SYNTHESIZING RESIDENTIAL LOAD PROFILES USING BEHAVIOUR SIMULATION

www.loadprofilegenerator.ch

CHALLENGES

Many applications and research projects need residential load profiles for doing simulations, testing algorithms or performing system analysis. Frequently such profiles are not available, for reasons of privacy, lack of money for a monitoring project or because the situation simply does not exist yet. Then the only option is synthesizing the needed profiles. Many approaches exist to do this. But 70-80% of all residential energy use depends directly on human behavior, and for a realistic load profile many different details have to be modelled. This includes, but is not limited to factors such as vacations, illnesses, changing working times and different device ownership.

MAIN FEATURES OF THE PROJECT

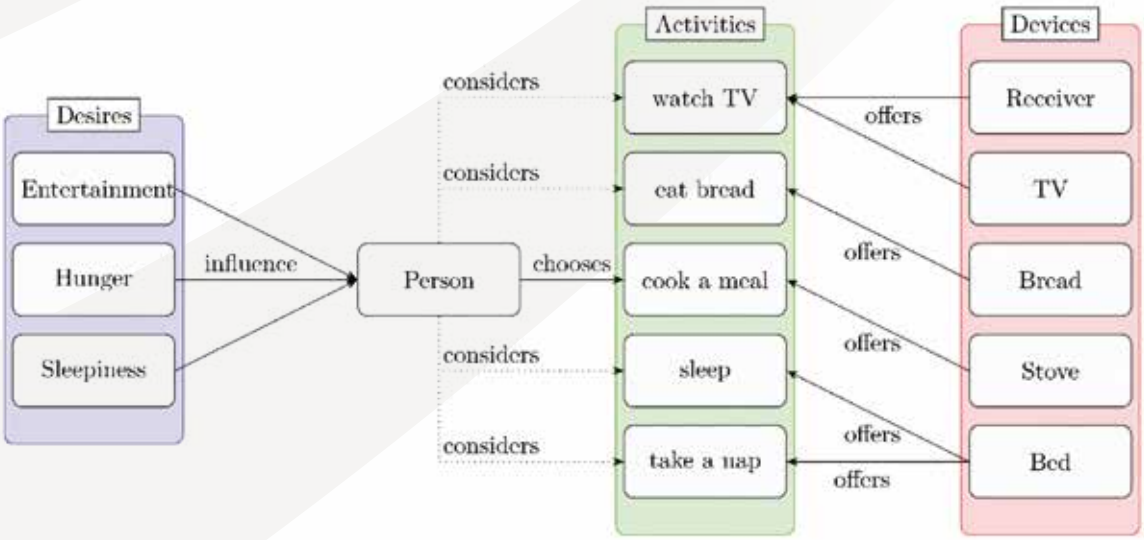
In this project, a behavior-based load profile generator was developed. This was implemented by modelling the residents as independent, desire-driven software agents that chose their next activity based on their current desire. This basic idea is shown in Figure 1

This is used to generated realistic activity profiles. Those are then transformed into load profiles by combining individual measured device profiles into a household profile.

The model was then extended to include flexible time limit definitions for activities, tracking for things such as dirty laundry and dirty dishes to enable realistic dishwasher and laundry activation frequencies, joint activities such as eating a meal together, shared responsibilities for example for cleaning, vacations, illness and many more details and turned into an universal behavior modelling tool.

Additionally, the program includes templating features for the easy creation of large numbers of new households, settlement templates for the easy creation of entire districts, a basic model for house infrastructure including heating and many more features.

Figure 1: Basic idea behind the load profile generator



RESULTS

One application is research into the impact of technological progress on the load profile. Figure 2 shows the result of one such study on a small example district of 100 households after switching all incandescent light bulbs for LEDs.

The software is freely available from www.loadprofilegenerator.ch. To enable the widespread use of the model, it was implemented as a Windows program in C#. It offers the user a flexible interface to model their household of choice. The program contains 60 validated, predefined households for Germany based on German statistical data, measurements and a small survey.

The program has been downloaded over 2000 times already and has been used in various Bachelor, Master and PhD-Thesis, research articles and projects.

Development is ongoing. The next steps planned steps in the development are to include electromobility and aging of residents to be able to create more realistic long-term load profiles over for example the entire life time of a system instead of every year repeating the same pattern.

LoadProfileGenerator

CONTACT DETAILS

Dr. Noah Pflugradt

Jlcoweg 1, CH-3400 Burgdorf
Phone +41 344 266 927
Noah.Pflugradt@bfh.ch

Urs Muntwyler
urs.muntwyler@bfh.ch
http://www.loadprofilegenerator.ch

EUREC MEMBER

Berner Fachhochschule
Haute école spécialisée bernoise

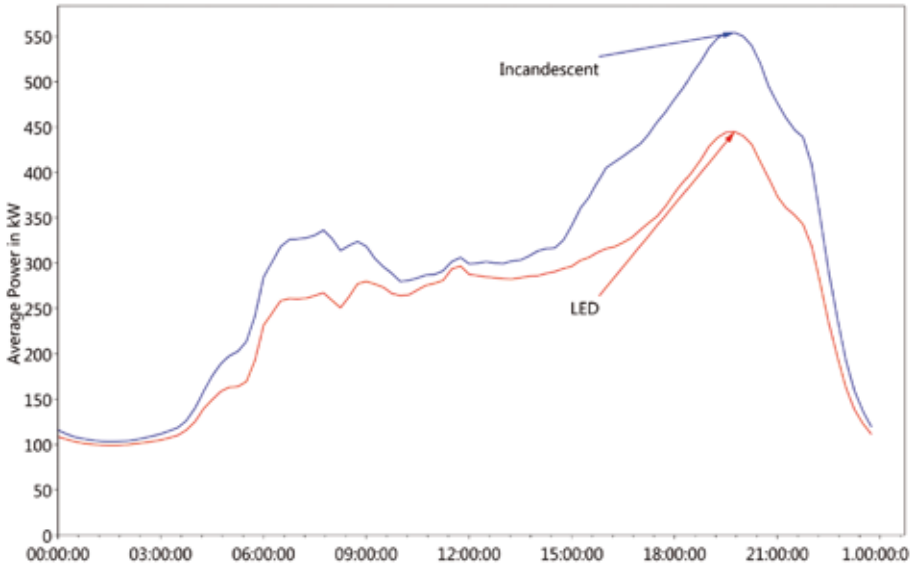


Figure 2: Impact on the load profile for a small district with a 100 households if all residents switch from incandescent light bulbs to LED lights

TWINPV - STIMULATING SCIENTIFIC EXCELLENCE THROUGH TWINNING IN THE QUEST FOR SUSTAINABLE ENERGY

www.twinpv.eu

CHALLENGES

Bringing Members together for collaboration aiming for industrial success and scientific excellence is of primary importance to EUREC and this is the prime objective of the TwinPV project. Two Members of EUREC, FOSS the research centre for sustainable energy at the University of Cyprus (UCY) and AIT the Austrian Institute of Technology, have joined forces with the Technical University of Denmark (DTU) for creating sustainable collaboration through the Twinning initiative of Horizon 2020.

The main challenge addressed in Twinning is collaboration in scientific and technological programs between institutions from countries with high research and innovation (R&I) index and institutions from countries with below average R&I index. Twinning comes to close that gap, widen the participation and create a more collaborative and inclusive Europe. In the case of TwinPV, FOSS is the widening partner and is paired with two internationally leading research institutions, AIT and DTU. The **aim** is to stimulate **excellence and innovation capacity** at UCY primarily in the field of photovoltaics (PV) and grid integration in smart grids and to develop **long term and sustainable collaboration** between the partners. This consortium has expertise in the entire lifecycle of PV power ranging from PV cells/modules to grid integration/smart grids to socioeconomic impact of high penetration of renewable energy. This expertise is available to the Cypriot and international industry and is expected to play a big role as PV energy becomes more prevalent. The importance of TwinPV for Cyprus is substantial. It brings technical know-how from advanced institutions that will strengthen the scientific capabilities of UCY and in extent those of the Cypriot PV industry. This is compounded by the fact that the energy industry is of strategic importance for Cyprus. For the non-widening partners (AIT and DTU) TwinPV gives them the opportunity to see first-hand the challenges of providing power to an island, and access to the extended Mediterranean region, which includes the Middle East North Africa (MENA) region. The importance for Europe is that it brings unity and cohesion among the European countries, it allows for the increase in innovation and it helps educate future researchers and innovators that will act as economic and job creation engines for their countries.

MAIN FEATURES OF THE PROJECT

The core of the TwinPV project is the collaborative and support actions (CSA) between the three partners that allow them to achieve the objectives of TwinPV. Those actions include:

- A scientific audit of UCY and sharing of best practices for excellent research between the partners.
- A total of eight intensive week -long trainings based on case studies in the field of PV and grid integration developed at the beginning of the project. Researchers from all three institutions participate and have the opportunity to learn from each other and to plant the seeds for future research joint projects. These trainings lead to the enhancement of the scientific and technological capacity of the partners.
- Multiple networking events with international (European and from MENA countries) and Cypriot industry. These events bridge the gap between academia and industry and create the networks for future projects. They also strengthen the relevant research links between EU and the extended Mediterranean region and the MENA countries.
- The development of joint PhD programs and a long term flow of scholars between the TwinPV partners. These programs will act as catalyst for sustainable collaboration and infrastructure sharing.

RESULTS

The project started with a scientific audit of FOSS from AIT and DTY. This led to the development of a comprehensive strategy for FOSS that covers personnel, research, education and service. This set the framework for the collaboration that is already producing results, such as the fourteen joint funding proposals. In addition, three of the week-long trainings have been completed with one at each partner. The trainings were the catalyst for further research with the results presented at two international conferences (the sixth solar integration workshop in Vienna and the 2017 International Renewable Energy Storage Conference in Dusseldorf). The first training was completed in May 2016 at AIT on the topic of PV module performance and degradation.

The intensive two-day workshop and networking with the Cypriot industry was completed in December of 2016 with great success. Topics at the workshop ranged from fundamentals, emerging technologies, smart grids, network integration to funding and investment opportunities. The workshop looked at how new developments apply and affect the Cyprus PV industry. The close collaboration and interaction with industry continues. In May 2017, the consortium visited the transmission system operator (TSO) control centre in Cyprus. The discussions on how PV inverters can be controlled for better grid performance will be further analysed in the upcoming training of TwinPV (October 2017) at AIT for which engineers from the TSO and DSO of Cyprus as well as MENA colleagues will participate.

WinPV

CONTACT DETAILS

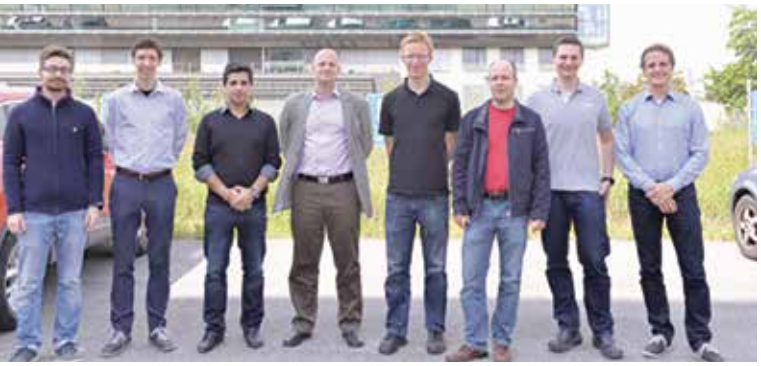
Eliza Pafiti
FOSS Research Centre,
University of Cyprus, Aglantzia, Cyprus
paphtiti.elisavet@ucy.ac.cy

For more information
www.twinpv.eu

EUREC MEMBER

FOSS
Research Centre for Sustainable Energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 608930



NEO-CARBON ENERGY

http://www.neocarbonenergy.fi/internetofenergy/

CHALLENGES

According to the Paris Accord the world needs to turn carbon neutral by around the mid of the century. Regarding the energy sector, the main solution seems to be electrification. In "great electrification" electricity takes the role of primary energy. All end use of energy, with the exception of sustainable use of biomass, is turned to use electricity as the primary energy source: transport, industry, heating, cooling.

One option to produce carbon neutral power is renewable energy. These sources, primarily solar and wind, are variable even intermittent that pose a challenge for the energy system and energy transition.

MAIN FEATURES OF THE PROJECT

In the Neo-Carbon Energy project the aim is to create foundations for 100 percent renewable energy system by futures, energy system and modelling research. The project is the first in the world to simulate 100 percent renewable electricity generation globally in hourly resolution, see http://www.neocarbonenergy.fi/internetofenergy/#. The model is being expanded to cover the whole energy sector.

Futures research deals with energy future as a part of societal change. The history shows all societal, organisational and economic changes have taken place as a result of the combination of new energy sources and new means of communication. It can be argued the past decade initiated new development and the result is a cloud type of Internet of Energy.

The name of the project originates from the concept of replacing fossil carbon with CO_2 as a carbon source. Instead of producing power from gas and emitting CO_2 in the air, the project produced gas from solar power and CO_2 captured from air.

RESULTS

The project has shown through simulation it is possible to build and operate 100 percent renewable electricity system. Also, it seems to be quite cost competitive due to fast development of technology. The project has identified new business opportunities and piloted some key technologies needed for 100 percent renewable system.

The project won the national Energy Globe Award on the 100 percent renewable world visualization.

As a spin-off from the project, fuels (http://soletair.fi/) and food (http://neocarbonfood.fi/) were produced from air with solar power.

With powerful process simulation tools the Neo-Carbon Energy research team was capable of demonstrating the balancing of the power grid in sub-second time resolution by using huge fuel and fertiliser factories to balance the grid.

The project's results have raised interest in all over the world, demonstrated by several hundred of media hits many of can be found in the project database, http://www.neocarbonenergy.fi/media/news/

NEO CARBON ENERGY

CONTACT DETAILS

Pasi Vainikka
VTT Technical research centre of Finland Ltd.
pasi.vainikka@vtt.fi, tel. +358 40 5825 987

Christian Breyer
Lappeenranta University of Technology
christian.breyer@lut.fi, tel. +358 50 443 1929

Jarmo Partanen
Lappeenranta University of Technology
jarmo.partanen@lut.fi, tel. +358 40 506 6564

Sirkka Heinonen
Futures Research Centre, University of Turku
sirkka.heinonen@utu.fi, tel. +358 40 581122

EUREC MEMBER

VTT

CONCLUSION

SUCCESSFUL PROJECTS DRIVE THE EU TO KEEP POWERING RENEWABLE ENERGY RESEARCH AND INNOVATION IN FP9

By Greg Arrowsmith, EUREC's Policy Adviser

"Why should we fund you and not them?" Decisions will be made in the European Commission in 2018 on the budget breakdown of Horizon's 2020 successor. This programme, provisionally known as FP9, will likely fund – as in the past – research and technology demonstration in areas such as transport, energy, health, bioeconomy, ICT, advanced materials but with changes to the funding distribution. Now is the time when the constituencies active in a particular field make a special effort to find projects that demonstrate the positive difference that European funding has made.

In this Catalogue, EUREC's members showcased their top EU-funded projects. Among the ones put forward for inclusion are:

Cheetah, which has managed to produce thinner photovoltaic cells. Researchers at CEA-INES have made a solar panel containing individual cells of half the normal thickness. The PV industry has been slow to embrace thinner cells but by showing that industrial equipment can handle them safely, the researchers hope that these, a tenth of a millimetre across, will be adopted widely. R2RCIGS concerns an alternative to silicon, CIGS. This project, funded under Horizon 2020's predecessor, stands out as a success. High efficiency CIGS cells on flexible foils were transferred from the lab to the fab – they are now being manufactured commercially at the Swiss firm Flisom.

Photosynthesis is nature's way of capturing energy from the sun, and in our space-constrained world, researchers have been looking to the sea as the place to "grow" a source of fuel. The Macrofuels project has seen two big harvests of seaweed in the year-and-a-half that it has run, and a journal article has been published with details of a highest-ever yield of alcohol from seaweed, at good concentration and with few contaminants.

Fuels are easy to store – renewable energy in other forms, less so. The COMTES project developed three different heat storage technologies suitable for a single family home. Such stores need to be compact – these scaled-down experimental systems took up around 2 cubic metres. A EUREC member designed and built a system that achieved record storage density using water vapour adsorbed to zeolites.

Storing electricity is harder still and it's often better to find a way to use it directly. The Orpheus project included an assessment of the advantages of using electricity for heating, focusing on Skellefteå (Sweden) and two districts in Ulm (Germany). In Skellefteå, researchers found a 35 MW electric boiler powered by electricity from a biomass-fired CHP plant was a cost-optimal alternative to meeting winter heating demand from an oil-fired boiler. It would also save 99% of CO_2 emissions. Distribution System Operators in Germany are keen to learn from the Ulm DSO how to use PV electricity to heat water when it would otherwise be wasted.

Bridge-building is often a feature of EU-funded projects. Eurosunmed brought together European and Moroccan/Egyptian research stakeholders. Staff exchanges were organised and scientists-in-training were given lectures by experts in photovoltaics, concentrating solar power (CSP) and grids. The partners also performed joint research, which saw the first CZTS/Si photovoltaic mini-modules fabricated, then tested in Morocco; protective coatings for heliostats assessed; rock-based thermal storage evaluated; innovative configurations for CSP power plants proposed; and grid codes for renewable energy implementation in Morocco and Egypt analysed. An official progress report is here.

SIGNALS FROM POLICYMAKERS

On June 6, the European Parliament called for a budget of 120 billion euros for FP9. A month later, the High Level Group on maximising impact of EU Research and Innovation Programmes, chaired by Pascal Lamy, released its report calling for a budget of 120-160 billion. It did this at a large conference hosted by the European Commission. At least two of Brussels's three main policy-setting institutions seem to be signed-up to giving research a boost in the post-2020 era.

For now, sustainable development seems to be as popular a theme for FP9 as it has been in Horizon 2020. The audience at the conference spontaneously reached for the word "sustainable" when asked "What should be the future mission of the EU in the R&I field" and Robert-Jan Smits, Director General of DG Research, speaking a few days earlier, said, "It's only logical that sustainable development will be the leitmotif of FP9's Societal Challenges", in part because of the COP21 Paris Agreement on climate change.

Clean energy, specifically, is well positioned for the upcoming negotiations. Since early 2017 the EU is proudly at the helm of Mission Innovation, an intergovernmental pledge to double public R&D spending on energy between 2015-2020. This creates the expectation that the EU will push the other members towards bold pledges after 2020, using its own research budget to set an example.

Follow us on Twitter, including for news about the launch of our Projects Catalogue 2018 (@EUREC_Info).

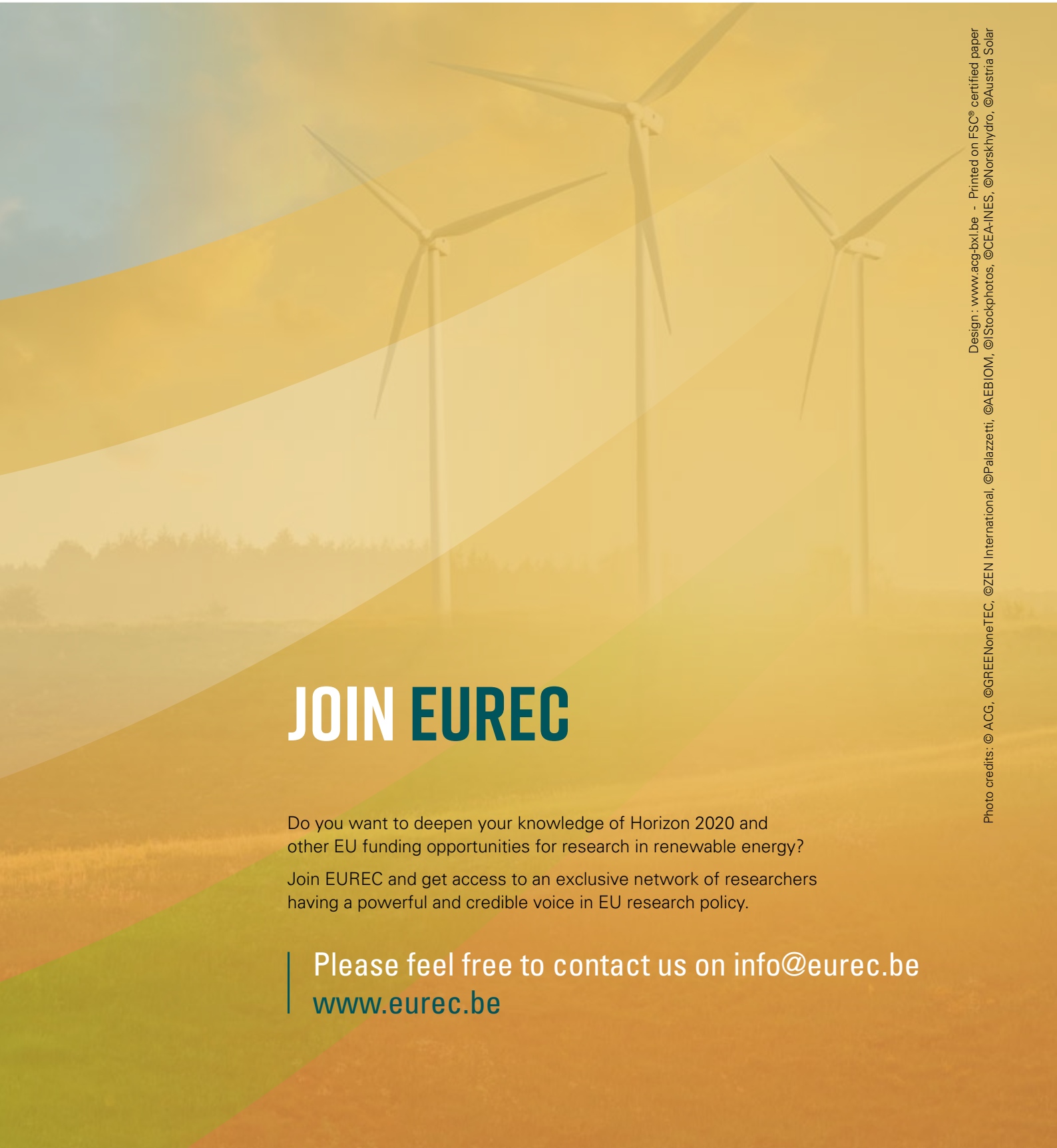
EUREC MEMBERS

- AEE Institute for Sustainable Energy, Austria
- Austrian Institute of Technology - Energy Department, Austria
- ARMINES/MinesParisTech, France
- Carl von Ossietzky Universität Oldenburg - Department of energy and Semiconductor Physics, Germany
- Centro Nacional de Energias Renovables (CENER), Spain
- CIEMAT - Renewable Energies Department, Spain
- CNR - Institute for Advanced Energy Technologies, Italy
- CNRS ICUBE, France
- CNRS Laboratoire PROMES, France
- Centre for Renewable Energy Sources (CRES), Greece
- German Aerospace Centre (DLR), Germany
- Energy Centre of the Netherlands (ECN), The Netherlands
- Ecole Polytechnique Federale de Lausanne (EPFL)
- Laboratoire d´Energie Solaire et de Physique du Batiment, Switzerland
- ERIC - Hanzehogeschool Groningen, The Netherlands
- EURAC - European Academy, Italy
- Forschungszentrum Jülich (FZJ), Germany
- FOSS Research Centre for Sustainable Energy, Cyprus
- Fraunhofer Institute for Solar Energy Systems (Fraunhofer-ISE), Germany
- Fraunhofer Institute for Wind Energy and Energy Systems Technology (Fraunhofer-IWES), Germany
- Fundacion CIRCE - University of Zaragoza, Spain
- Institut National d´Energie Solaire (CEA-INES), France
- Instituto Superior Técnico de Lisboa, Portugal
- Instituto Tecnológico Energias Renovables (ITER), Spain
- Interuniversity Microelectronics Center (IMEC), Belgium
- Loughborough University - Centre for Renewable Energy Systems Technology, UK
- National Technical University of Athens (NTUA), Greece
- NEXT ENERGY, Germany
- Offshore Renewable Energy Catapult, UK
- PV-Lab Berne University of Applied Sciences, Switzerland
- Research Institute for Analytical Instrumentation (ICIA), Romania
- RISE - The Swedish Research Institute, Sweden
- Tubitak MAM - Energy Institute, Turkey
- University of Northumbria - Newcastle Photovoltaics Application Centre (NPAC), UK
- Université de Perpignan - UFR des Sciences Exactes et Expérimentales, France
- Università di Pisa - Dipartimento di Ingegneria dell'Energia, dei Sistemi, del Territorio e delle Costruzioni (DESTEC), Italy
- VTT Energy, Finland
- WIP - Renewable Energies, Germany
- Wuppertal Institut for Climate, Environment, Energy, Germany
- ZSW - Centre for Solar Energy and Hydrogen Research, Germany

NOTES

NOTES

EUREC



JOIN EUREC

Do you want to deepen your knowledge of Horizon 2020 and other EU funding opportunities for research in renewable energy?

Join EUREC and get access to an exclusive network of researchers having a powerful and credible voice in EU research policy.

Please feel free to contact us on info@eurec.be
www.eurec.be

Design : www.acg-bxl.be - Printed on FSC® certified paper
Photo credits: © ACG, ©GREENoneTEC, ©ZEN International, ©Palazzetti, ©AEBIOM, ©IStockphotos, ©CEA-INES, ©Norskhydro, ©Austria Solar