energy innovation austria

1/2022

Current developments and examples of sustainable energy technologies

klima+ energie fonds

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

Digital technologies

in order to make the most out of renewable energy sources

Digitalisation is an enabler and driver of the energy transition and is playing a key role in our efforts to make our energy system climate-neutral by 2040. Digital solutions are helping to save energy and use it efficiently in all areas of the economy and are allowing renewable energy from wind, solar and hydropower to be integrated and used sustainably.

Photo: Climate and Energy Fund/Ringhofer

Digitalisation

A driver and enabler for the energy transition

The European and national climate targets – climate neutrality by 2050 in the EU and by 2040 in Austria – are necessitating a root-and-branch transformation of the energy system. All available potential for saving energy and increasing energy efficiency must be leveraged while mastering the switch to renewable energy sources. Efforts to use more of these sources and integrate them into the energy system will need to be stepped up further if we are to make our energy supply sustainable and fit for the future.

Digitalisation is supporting this transformation of the energy industry and has the potential to become an enabler and driver of the energy transition. Digital technologies have a key role to play in innovative solutions for making the energy system less centralised and more flexible and for using energy and resources efficiently. They help to integrate renewable energy and deploy it in the best possible way, make use of surpluses and control energy consumption intelligently. Information and communication technologies also form the basis for connecting the various components of the energy system and for coupling power, heat, mobility and industrial production sectors.

SMART SOLUTIONS FOR THE ENERGY SYSTEM

All sectors of the economy harbour potential for using digital technologies to integrate renewable energy, save energy and increase energy efficiency. The methods and possible applications for digitalisation span across all areas of energy supply, from generation and grids to trading, sales, consumption and production. The Internet of Things (IoT), artificial intelligence, robotics, clouds and networks are all driving the energy value chain forward, from energy generation to intelligent distribution. Whether they are used to create smart grids, digitally interconnected buildings and residential districts, intelligent solutions for industrial processes or concepts for integrating electric mobility, digital technologies form the basis for an increasingly energy-efficient, decentralised, flexible and reliable energy infrastructure. Digitalisation is an "enabler" of a sustainable energy system because it offers solutions for mastering the complex interactions between numerous technical components and many different market players. At the same time, it is a "driver" of the energy transition as it is paving the way for new technical applications, services and innovative business models.

DIGITALISATION AND RENEWABLE ENERGY

Digital technologies are playing an increasingly important role in generating electricity and heat from renewable sources. Applications such as digital twins, big data, machine learning and artificial intelligence are opening up new opportunities for the simulation, design, quality assurance, data-based monitoring, maintenance and optimisation of installations and other facilities. In the future, the production and consumption of renewable energy sources will need to be better aligned with each other with the aid of digital technology. Intelligent solutions are required in order to incorporate renewables into the energy system, balance fluctuations in the grid and store energy. Digital applications will help to utilise grid and generation capacity much more efficiently.

Intensive research is being done in Austria into how digital applications can be used in the energy system of the future. In this issue, we present a number of projects from the areas of wind power, photovoltaics, heat pumps and hydropower in which digital solutions are being developed and tested for, amongst other things, controlling and performing predictive maintenance on installations, optimising them and making them more cost-effective.

Photos: Waldhör KG, ecop, stock.adobe.com

STUDY

DIGAT-2040
IMPACT OF DIGITALISATION ON ENERGY CONSUMPTION AND THE CLIMATE IN AUSTRIA

There are several aims to this study, which is being conducted by the Austrian Energy Agency (AEA) and the Association of the Austrian Electrical and Electronics Industries (FEEI) on behalf of the Climate and Energy Fund (KLIEN). One is to quantify how the onward march of digitalisation may impact energy consumption and greenhouse gas emissions in Austria in the years up until 2040, taking account of various digitalisation approaches in five sectors: industry, households, transport, services and agriculture. The potential for reducing energy consumption and greenhouse gas emissions is being analysed in conjunction with the corresponding digitalisation technologies and applications and the associated rebound effects in various scenarios.

Another objective of the project is to recommend RTI policy measures for developing digital technologies and applications further in Austria. The study is being run in close dialogue with stakeholders from research, technology, industry, commerce and the private sector.

www.energyagency.at/digat-2040

Example from scenario workshop – building automation; source: (AEA, 2022)

Service – building automation

Impact	Reference energy cons.	Potential reduction	Current market penetration	Market penetration 2040		
				MIN	MID	MAX
Increase in energy efficiency through optimised usage times and setpoints (in buildings used for commercial and public purposes)	Room heating and cooling	30% reduction in relevant energy consumption	20%	50%	60%	75%
	ICT, lighting, equipment EC	10% reduction in relevant energy consumption	20%	50%	60%	75%

Definition

Networked and automated buildings use digital technologies to monitor, analyse, control, automate and optimise building control systems such as heating, ventilation, air conditioning and lighting.

Most important technologies

- Building automation system (BAS)
- Building automation and control system (BACS)
- Energy management system (EMS)
- Sensors, actuators and microcontrollers
- Smart meters
- Internet of Things (IoT)
- Apps, data analytics, digital twins
- Big data, artificial intelligence/machine learning

More information

*Market penetration relates to the percentage of buildings equipped with smart building technology

Sources:
(IEA 2019a), (JRC 2019), (Accenture 2021)

DIGI-HYDRO

Digitalisation and data analysis as the basis for new strategies in hydropower

Reservoir in the Alps, photo: TU Wien

View inside a hydropower plant, photo: TU Wien

Hydropower is a key pillar of the energy supply in Austria, which generates around 60 per cent of its electricity from hydroelectric power plants. There are currently a few hundred large-scale hydropower plants and thousands of smaller ones in operation, some of which have been running for over 40 years now. Being very investment-intensive, hydroelectric power plants are planned and designed with very long operating lives in mind. The advanced age of many plants is one of the main reasons why digitalisation is only making slow progress in the hydropower sector.

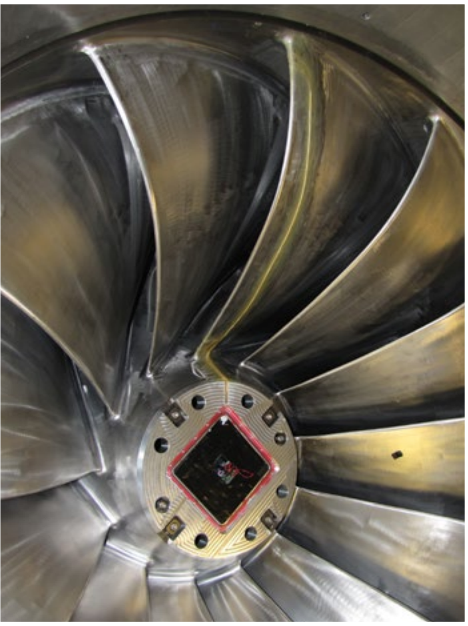
The DIGI-Hydro project is geared towards injecting new momentum into research on digitalisation in hydropower and thus laying the foundations for developing new concepts for operating hydropower plants digitally and assessing their condition automatically.

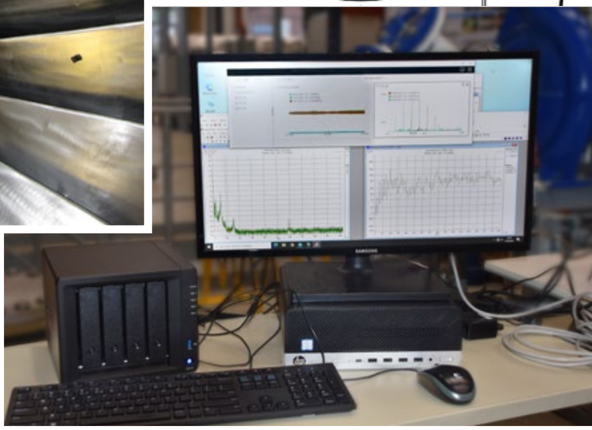
SECURING FUTURE SUPPLIES

The energy transition is bringing about major changes in the electricity market and posing new challenges to the operation of power plants. Increased electricity generation from renewable sources is causing greater fluctuation in the power grid. These have to be balanced out in order to guarantee security of supply. Hydropower plants were originally designed for a constant energy supply, i.e. for working in an efficient mode in which the wear and tear of machine parts is kept to a minimum. If more use is made of such plants to regulate the grid in the future, they will invariably be run more often in far-from-ideal operating conditions for which they were neither designed nor built. The impact of these new operating conditions on operation and the expected life of the plants has thus become a key topic for research.

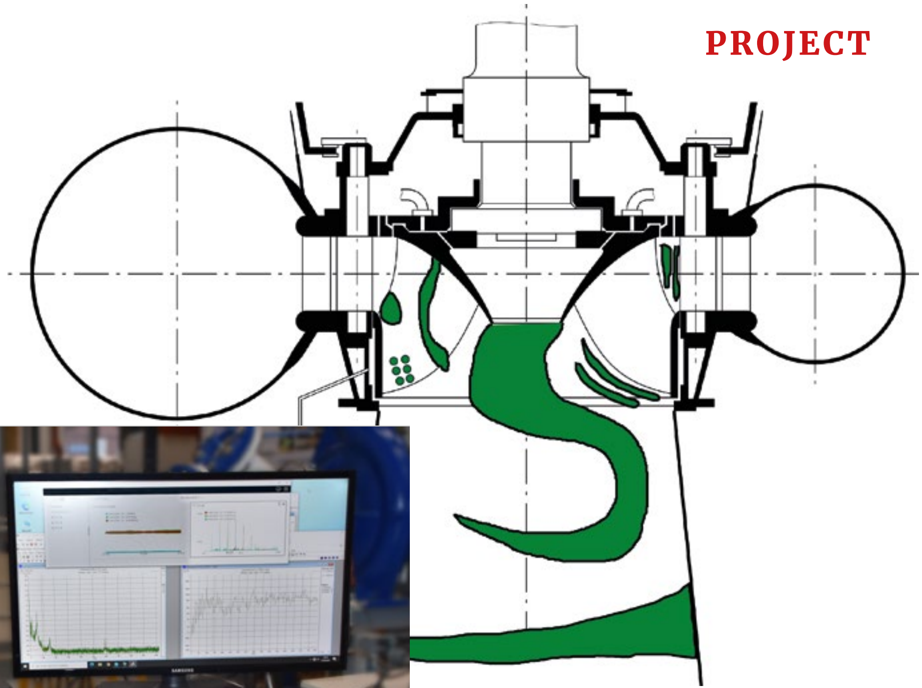
> **"Although we've got resources and expertise for doing sensor measurements, we need new methods for storing, merging, illustrating and validating the data. This is the only way we can find out how a plant can be operated in a digitalised, data-driven way. In the future, this will help us to use the available resources better and also for longer."**
>
> EDUARD DOUJAK
> INSTITUTE FOR ENERGY SYSTEMS AND THERMODYNAMICS, TU WIEN

Photo: TU Wien





Francis turbine (top), taking measurements in the lab (right), photos: TU Wien



Damaging flow phenomena, image: TU Wien

DIGITALISATION IN THE HYDROPOWER SECTOR

In the DIGI-Hydro project, an interdisciplinary team led by the Institute for Energy Systems and Thermodynamics at TU Wien[1] is working on formulating a digitalisation strategy for hydroelectric power plants to enable data-driven predictions of the lifespan of water turbines, i.e. the mechanical parts of the plant. Their work is divided into the following packages:

- **A concept for monitoring hydropower plants using sensors**
  What kind of sensors are suitable for assessing the condition of hydropower plants automatically is not known at present, and further it is to be investigated how detailed the data needs to be or what sort of data volumes are to be expected.

- **New methods for storing and analysing data**
  The measurements being planned are likely to generate a great deal of data, which poses questions about how to store it efficiently and analyse it further down the line.

- **A platform for automatic condition assessment**
  The project is using findings from extensive measurements and data analyses to develop models for assessing the condition of hydropower plants in an automated and data-driven way.

MEASUREMENT SETUP AND INSTALLATION OF SENSORS

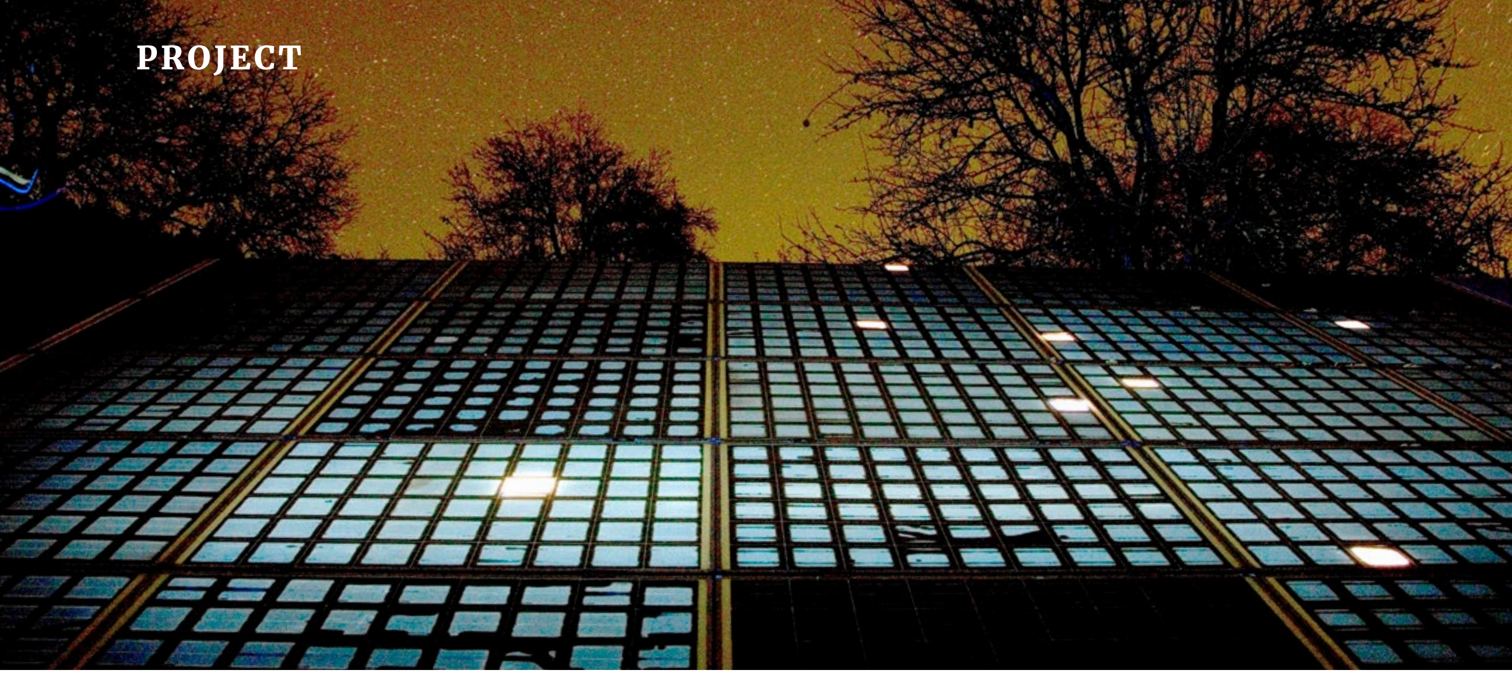
A key part of DIGI-Hydro concerns installing measuring sensors in operational hydropower plants. Following laboratory tests at TU Wien, the first sensor measurements have now begun on an active plant in Austria. The ongoing measurements will supply data on the plant's operation continuously over a six-month period. At the same time, data storage methods and analytical algorithms are being trialled so that the large volumes of data can be analysed.

NEW INSIGHTS

Automated condition assessment, combined with data-based access to remote monitoring, is opening up a new avenue towards giving hydropower plants digital twins. The DIGI-Hydro project is enabling the devlopment of a strategy for collecting and analysing real-time data on hydropower plants, a major step towards making hydropower digital.

www.digi-hydro.com

[1] **PROJECT PARTNERS:** Institute for Energy Systems and Thermodynamics at TU Wien (project management), VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, HAKOM Time Series GmbH and VibroConcept GmbH



*PV modules lit with ultraviolet light/
UV fluorescence (UVF) method for detecting effects of ageing,
photo: AIT/B. Kubicek*

ADVANCE!

Models for forecasting the ageing of PV systems

Reliability tests and modelling to analyse new combinations of materials in PV systems have become increasingly important in order to prevent photovoltaic power plants from suffering over extended periods of downtime. ADVANCE! is an interdisciplinary research project led by AIT Austrian Institute of Technology in cooperation with research and corporate partners.[1] It is opening up new paths for analysing the long-term and degradation behaviour of PV modules using digital means.

To this end, innovative, complex statistical data processing models and machine learning algorithms are being developed and used to analyse how the behaviour of PV modules changes over time and in response to stress. The project team uses extensive measurements and characterisation data taken from artificially aged PV modules from the INFINITY[2] flagship project, which have been subjected to precisely defined, accelerated ageing scenarios.

PREVENTIVE MAINTENANCE FOR PV MODULES

In the PV sector, maintenance is usually done based on condition. This means that the condition of the PV facility is checked, either regularly or continuously. Maintenance actions are often started late, i.e. after a fault occurs. New digital technologies are opening the door to so-called predictive maintenance, thus enabling additional improvements and greater efficiency. Predictive maintenance makes use of innovative characterisation methods and digital sensors combined with data science/mining methods that have only recently become available.

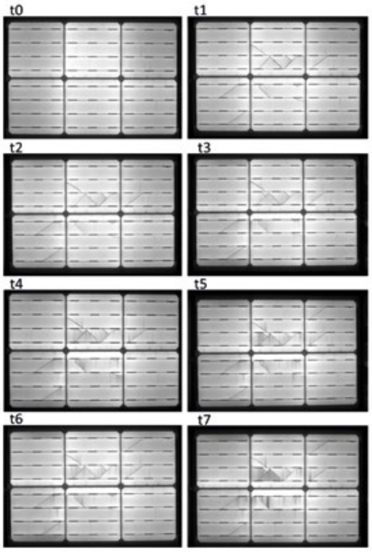
The PV system's current condition is compared to how it is predicted to age. Using this modelling, the ideal timing and measures for maintenance can be planned in advance and arranged in an economically efficient way.

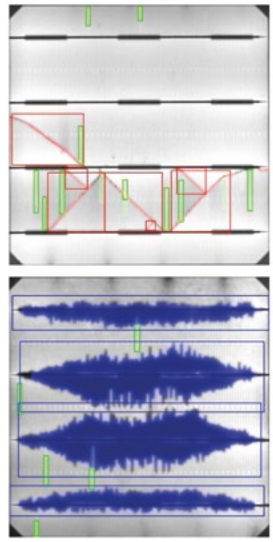
MODELLING AGEING PROCESSES

Various modelling approaches are being developed and applied as part of the project. The research is geared towards identifying the links between the drop in performance suffered by operational PV modules and the specific degradation behaviour of the materials used as well as analysing the effects of stress.

These findings will then be used to develop forecasting models that are also to be evaluated in real-life settings. This work aims to lay important foundations for developing highly efficient materials in the future and formulating specifications for predictive maintenance.

projekte.ffg.at/projekt/3862073





Electroluminescence image and time series of an accelerated ageing process for a specific climatic stress scenario, image: AIT

Electroluminescence image analysis – indications of predicted "cracks" (red), "finger faults" (green) and "corrosion" (blue) and corresponding limit ranges, image: SAL/Lukas Neumaier

WORK PACKAGES

> Automated data preparation: feature selection, image analysis (neural networks – machine learning), data reduction (converting digital information obtained from experiments into a corrected, ordered and simplified form)

> Statistical modelling of links between data and measurements from an extensive pool of existing data (multiple sets of time-resolved characterisation data on PV modules during various accelerated ageing tests)

> Creating a predictive model (chemical/physical/electrical) for the longevity and reliability of PV materials and PV modules

> Validated degradation models for PV materials and PV models for spotting the signs of ageing early and producing optimised, accelerated ageing tests and specifications for predictive maintenance

Large-scale PV facility, photo: AIT/T. Krametz

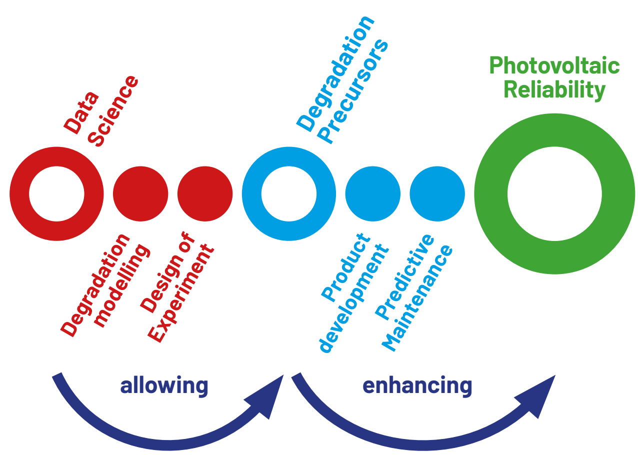
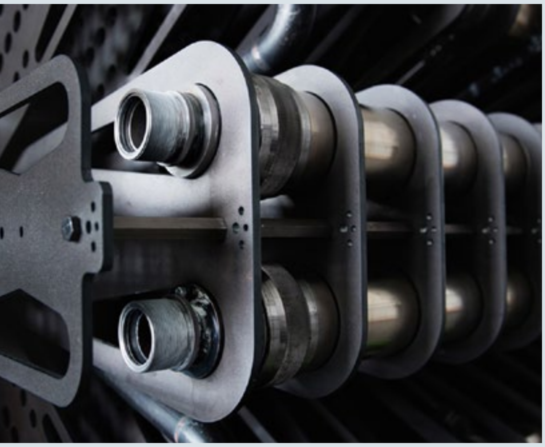


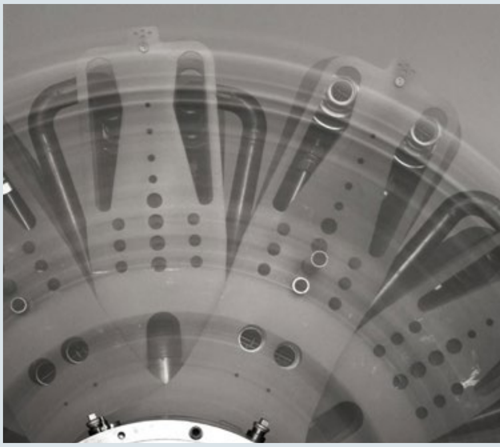
Diagram of the project, image: PCCL/Gernot Oreski

[1] **PROJECT PARTNERS:** AIT – Austrian Institute of Technology GmbH, Applied Statistics GmbH, SAL – Silicon Austria Labs GmbH, OFI – Austrian Research Institute for Chemistry and Technology, PCCL – Polymer Competence Center Leoben GmbH, KIOTO Photovoltaics GmbH, FHTW – University of Applied Sciences Technikum Wien
[2] See energy innovation austria 2/2017 for details of the INFINITY lead project www.energy-innovation-austria.at/article/infinity/

ROHAN

Digital twin for optimising technical control of a rotation heat pump





Detailed views of the rotation heat pump, photos: ecop

Conventional compression heat pumps have been little used in industry up until now because their thermodynamic properties significantly limit their usefulness in industrial processes. Rotation heat pumps from the Austrian company ecop Technologies GmbH are a new development. These harness an innovative technology and were specifically designed for industrial use. Unlike compression heat pumps, they can handle flexible processes and temperatures ranging from -20°C to +150°C and work with a non-flammable, environmentally friendly gas. The technology has already been successfully demonstrated on prototypes and in the operation of a reference system. So far, however, it has only been possible to control the rotation heat pump manually.

FUNCTIONAL CONTROL OF ROTATION HEAT PUMPS

Since rotation heat pumps have a fundamentally different design and operating principle to conventional ones, their control systems and strategies cannot be transferred from one to the other. As part of the ROHAN project and in partnership with AIT Austrian Institute of Technology,[1] the company is developing a concept for the functional control of rotation heat pumps that is to be implemented and trialled in real-life operation further down the line.

In the first step, the physical interrelationships between the various thermodynamic processes that components of the rotation heat pump undergo have to be identified and analysed. A digital twin of the system is then generated in a dynamic simulation environment based on these findings. This forms the basis for devising and designing a functional control system for the rotation heat pump. The control concept developed is to be tested on the controller hardware ("controller-in-the-loop") and then demonstrated on a real-life system at proof-of-concept stage.

In particular, ecop Technologie GmbH is contributing its expertise to the process, to simulating the components and to implementing the controller in the machine's control system. AIT Austrian Institute of Technology provides extensive knowledge of compression heat pumps and using dynamic simulation environments to design complex controllers.

[1] **PROJECT PARTNERS**: ecop Technologies GmbH (project management), AIT Austrian Institute of Technology GmbH

Rotation heat pump, photos: ecop

> "The ROHAN project is helping to bring the market launch of the rotation heat pump a lot closer. Having a digital twin allows us to study the control technology in our innovative rotation heat pump in great depth. In AIT, we've found the perfect project partner for turning our ideas into reality. The ability of our systems to withstand high temperatures means that we'll be able to provide a key technology for decarbonising heat generation in industry."

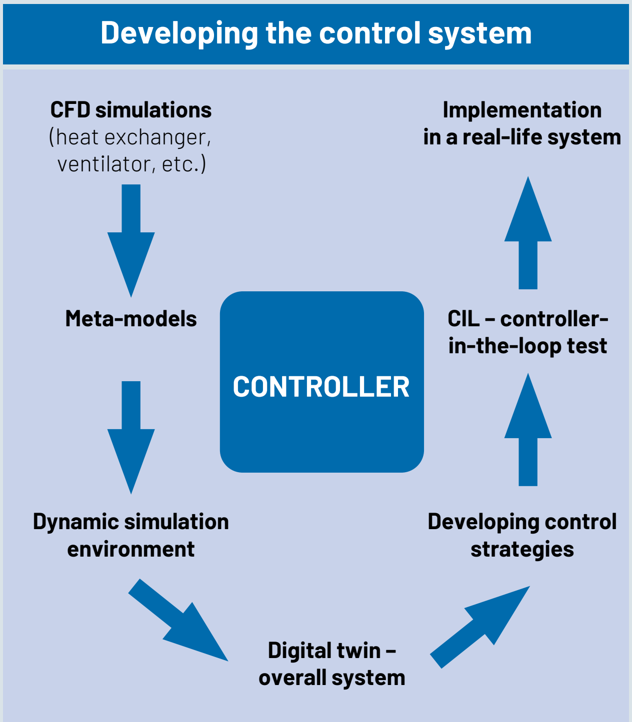
BERNHARD ADLER
CEO ECOP TECHNOLOGIES GMBH

Photo: ecop

INITIAL RESULTS

A number of models of individual components have already been created and simulated using computational fluid dynamics (CFD). These models were integrated into a dynamic simulation environment in initial tests and are now being studied in action. The results obtained to date are already indicating fundamental interrelationships between individual components. The team now wants to gain new insights into optimising the controller from a technical perspective by adding in more models and connecting them up in the dynamic simulation environment.

energieforschung.at/projekt/regelungstechnische-gesamtoptimierung-einer-rotationswaermepumpe-mittels-digitaltwins-rotation-heat-digital-twin



Source: ROHAN Project

Generating electricity efficiently from wind power even at freezing temperatures
Iced-up wind turbines result in high costs (left).
Wind turbines free of ice (right),
photos: VERBUND

SOWINDIC

Smart operation of rotor blade heating systems on wind turbines

Making up around 10 per cent of the electricity mix, wind power is an important source of renewable energy in Austria. In a project entitled SOWINDIC (Smart Operation of Wind Turbines under Icing Conditions), an interdisciplinary team[1] led by VERBUND is investigating the smart operation of rotor blade heating systems for wind turbines. Digital technologies are to be used to ensure efficient electricity production even at extremely low temperatures. Austria' s Alpine climate means that the rotor blades on wind turbines in many areas ice up in the winter months, in some cases severely.

ICE – THE ENEMY OF EFFICIENCY

The ice alters the aerodynamic properties of the rotor blades, making the wind turbine less efficient while also increasing mechanical wear. Once the degree of icing reaches a certain level, official regulations require the turbines to be switched off and the ice melted either naturally or using a heating system inside the rotor blades. Up until now, the rotor blades' heating function has primarily been used reactively, i.e. not predictively. The enforced downtime results in unexpected losses of production that in some cases can be significant. Faced with such a situation, producers are required to buy electricity from the balancing market to guarantee a stable supply of electricity.

[1] **PROJECT PARTNERS**: VERBUND (project management), AIT Austrian Institute of Technology GmbH, University of Vienna, Meteotest AG

RESEARCHING A PREVENTIVE MODE OF OPERATION

Minimising the production losses caused by the ice requires the development of a decision-making algorithm to heat the rotor blades preventively so that ice on the rotor blades can be prevented as it forms. This algorithm is based on meteorological data, weather forecasts, operating data and SCADA (supervisory control and data acquisition) data as well as up-to-date market data.

The SOWINDIC project is studying two initially separate approaches to optimising the operation of the rotor blade heating system. Later on, the two approaches are to be combined in a hybrid model. The "Angewandte Mathematik mit Schwerpunkt Optimierung" ("applied mathematics with a focus on optimisation") working group at the University of Vienna will investigate the suitability of existing machine learning strategies and develop them further. Meanwhile, Meteotest is studying an empirical approach based on physical models. Both strategies are geared towards forecasting production losses caused by iced-up wind turbines as accurately as possible.

Using a network component specially adapted by AIT Austrian Institute of Technology, data flows are to be captured as close to the wind turbine as possible and both algorithms are to be implemented on the turbine with real-time capability and used to control the rotor blade heating in an automated and optimised way. As an operator of wind turbines, VERBUND will focus particularly on validating the models developed and contribute its many years of operational knowledge to the project.

SOWINDIC MILESTONES

- Building a platform for generating, supplying and evaluating data
- Using physical models to optimise operation of the rotor blade heating system
- Developing and applying machine-learning methods
- Evaluating and combining the algorithms developed
- Validating the algorithms developed and implementing them in real time

BENEFITS OF DIGITAL CONTROLS

Regulating the rotor blade heating system efficiently will allow wind turbines that have not yet been realised for purely economic reasons to be operated cost-effectively in future, thus opening up new potential sites for wind turbine projects. Intelligent control also offers the advantage of removing the danger posed by shed or falling ice while a turbine is running. The lower mechanical load placed on the turbine also extends its operating life.

energieforschung.at/projekt/smart-operation-of-wind-turbines-under-icing-conditions

Photo: Waldhör KG

Photo: VERBUND

“Besides production losses, unexpected downtimes affecting a wind turbine also place additional strain on the power grid. Operating the rotor blade heating system smart and preventively can relieve some of this burden and stabilise production.”

SIMON KLOIBER,
TECHNICAL PROJECT MANAGER,
PERFORMANCE ANALYST WIND AND PV, VERBUND

INFORMATION

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

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