Research and innovation

Report 2019 – 2021

Austrian Power Grid

What is the biggest challenge of our time?

The energy transition towards climate neutrality requires a complete transformation of the energy system – there is no greater or more important task facing us today.

As a key player in the energy industry, APG, with its electricity infrastructure, is paving the way for the integration of renewable energy. Along with grid expansion, research and innovation are the key to success. Answers must be found to new challenges in connection with the integration of volatile energy production, the increased electrification of society, business and industry, and sector coupling. Ensuring security of supply remains the top priority during transformation of the energy system.

Contents

Preface

The directors: Gerhard Christiner (CTO) & Thomas Karall (CFO) of Austrian Power Grid

Everyday, Austrian Power Grid fulfils the social mandate of securely transmitting electricity and reliably providing it to Austrian customers at all times.

To continue to safeguard this for the electricity system of the future and to ensure that the transformation can safely be achieved, we have to start today to prepare all corporate divisions for the energy world of tomorrow.

Thomas Karall, CFO of APG and Gerhard Christiner, CTO of APG

As a key player in the energy industry, APG is paving the way for the integration of renewable energy and the electrification of society, business and industry. This is the prerequisite for achieving climate and energy goals. With an annual investment volume of 350 million euros for expanding and converting the electricity grid, APG delivers a strong boost to domestic industry. In total, APG will invest around 3.5 billion euros in the network infrastructure over the next ten years. With investments in research and development, APG is joining forces with strong partners to find innovative, efficient ways to make the digital, sustainable and secure electricity world of the future a reality.

The new APG strategy focuses on increasingly making use of new technologies and thus helping to achieve climate change goals. This means that we have to completely restructure our entire energy system. This requires intelligent solutions and consistent implementation of research projects.

The customer is at the core of the future energy system. The key task is to digitally integrate the customer into the overall system. This is essential for enabling the customer to help balance out the volatility of renewable energy sources. At the same time, all measures require close coordination with our European partners, from infrastructure providers to business and industry.

In the current regulatory system, grid operators like APG are financed by the interest received on longer-term assets (CAPEX), while the expenses for new, innovative solution approaches (mostly OPEX) does not yield any additional profit.

In a world that is becoming more and more digital, this prevents higher investment in research and innovation. The new challenges and conditions should, however, be taken into account in the future regulatory system. To achieve the transition to 100 percent renewable energy in the electricity system by 2030, each step of the journey is a goal in itself. As a responsible manager of the energy system, APG is securing the power supply for Austria's industry, business sector and society, both today and tomorrow.

Research and innovation

in response to new challenges

The European electricity system of the future has to be more closely interconnected, better protected against blackouts and more sustainable. In Austria, the goal is to have 100 percent of power consumption covered by domestic renewable energy sources by 2030. The next goal, a decade later, is to be climate neutral across the entire Austrian energy system, which includes not only electricity but also heat generation and the transportation sector.

For transmission system operators, aspects such as sector coupling, the growing percentage of volatile, renewable energy sources and the increasingly integrated European electricity market create new challenges which require new answers. The purpose of research and innovation projects is to obtain these answers and to initiate the required changes, while the main focus still lies on security of supply, cost efficiency and direct added value for grid users.

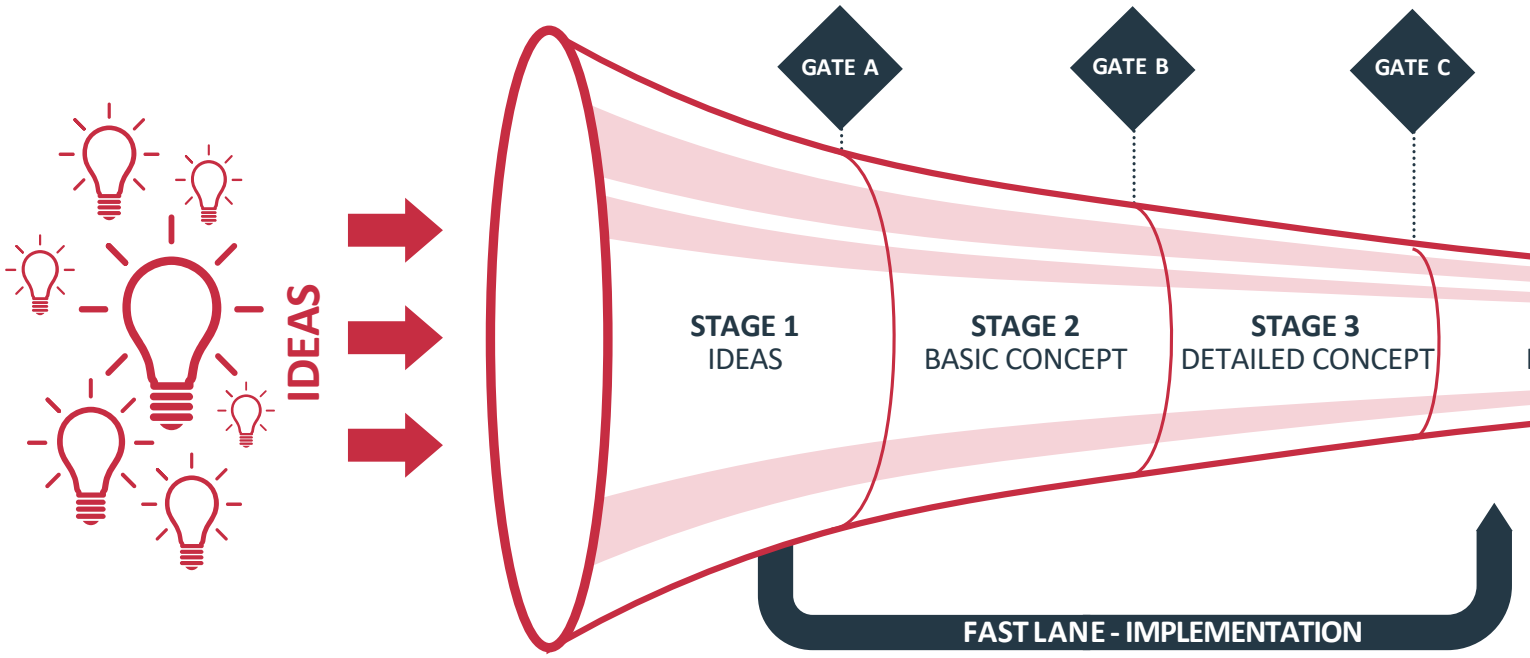
> We won't have a second chance to transform our energy systems.
> Gerhard Christiner, CTO of APG

Grid expansion will remain key for the integration of renewable energy sources in the future. However, currently this is slowed down by long approval processes that frequently cause years of delays. Thus solutions are needed that offer innovative approaches for utilising the maximum capacity that is physically possible with the existing infrastructure, while at the same time ensuring security of supply.

In recent years, the new realities in the energy system have multiplied the costs for short-term interventions of APG in power station's dispatch plans (redispatch), causing an additional burden of around 100 million euros to grid users. Due to the increasing integration of the European electricity market and the fast-growing percentage of volatile energy sources, no end to this development is in sight. To cope with these costs, new approaches for using existing capacities and creating new flexibility are required.

Through the key role APG plays in the energy transition, contributes significantly to overcoming the climate crisis. However, some of the consequences of climate change are irreversible, which means that the resilience of the electricity infrastructure against increasingly frequent extreme weather conditions, floods, mudslides and forest fires has to be safeguarded. This is another area where state-of-the-art technologies for data acquisition and evaluation are used in innovative ways.

The lessons learned from R&I activities contribute to achieving secure grid operation and thus support the high security of supply achieved in Austria. The presented research and innovations therefore provide direct added value for Austrian grid users, domestic industry and the research community.



Stage gate process for coordination
of R&I initiatives

Innovation culture and partnerships

as drivers of effective research and innovation

There will be no second chance to overcome today's challenges, therefore effective coordination and cost-effective implementation of research and innovation projects are essential. To this end, all of APG's initiatives are coordinated centrally. Experts in the technical departments are networked with each other and with external partners and are provided with support, for example with drafting funding applications and the methodical execution of R&I initiatives.

To effectively coordinate the multitude of R&I initiatives, a stage gate process is followed. In this key element of APG's R&I controlling, decision-making and resource allocation are defined. The project systematically goes through the various phases up to completion: idea, rough concept, detailed concept and implementation.

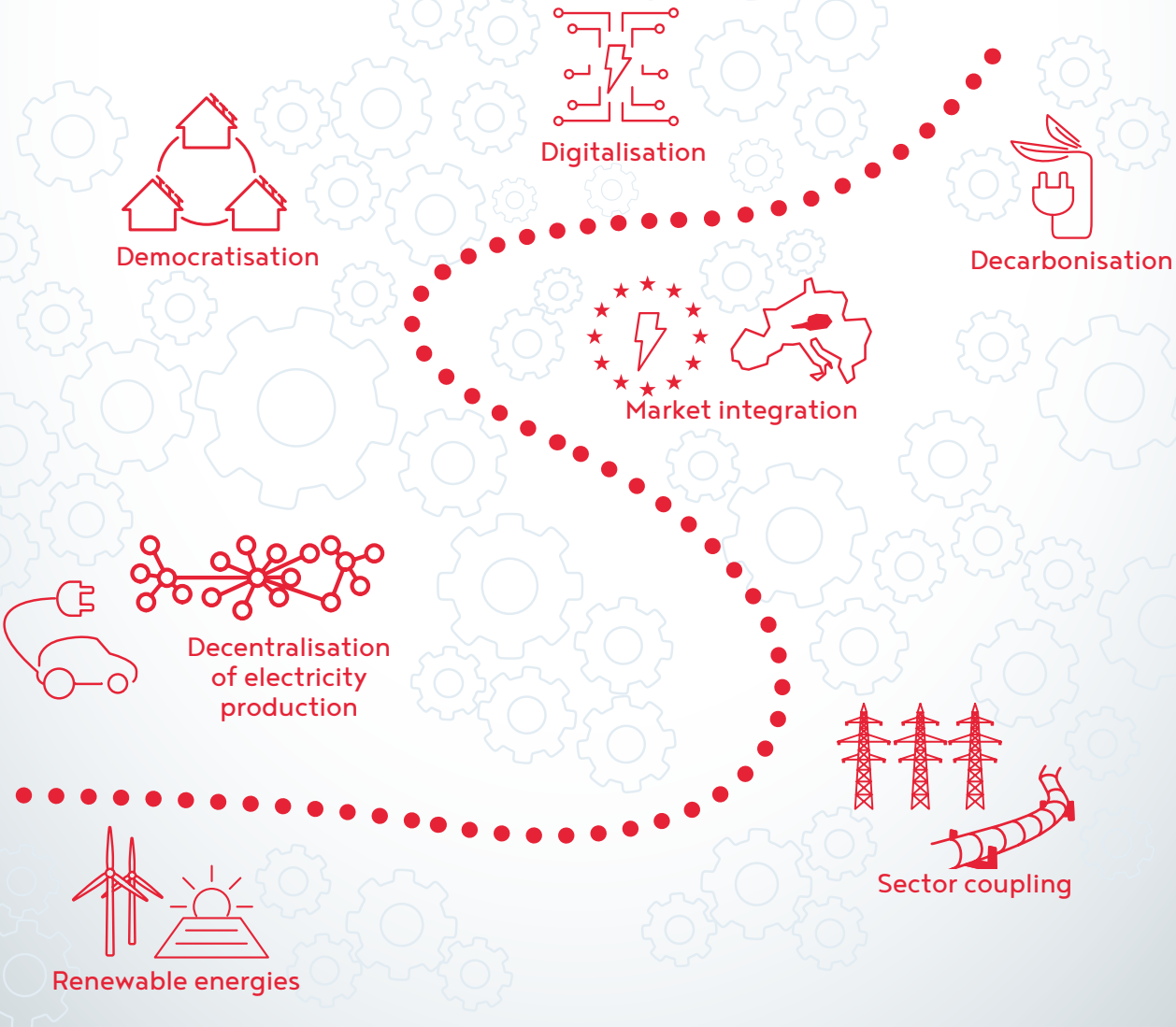
For APG, both the utilisation of all internal potential and coordination and cooperation with external partners are of essential importance. A large number of research projects are jointly conducted with universities of technology (e.g. TU Vienna, TU Graz) and research institutes (e.g. Austrian Institute of Technology). In some project consortia, APG cooperates with distribution system operators, energy providers and industrial companies. International involvement in the RDIC (Research Development and Innovation Committee) of the ENTSO-E (European Network of Transmission System Operators for Electricity) ensures coordination with other European transmission system operators. This results in joint research projects funded within the framework of the EU's Horizon Europe funding programme.

R&I initiatives pursue strategic goals and yield add value

Placing grid users centre stage

The transformation of the energy system is a Herculean task. Due to progressive decarbonisation, transportation and heat generation, which are currently largely dependent on fossil fuels, are also increasingly electrified. In the future, steel manufacturing will also have to be electricity-based to a much larger degree than it is today. Electricity is therefore at the centre of the energy system.

8 R&I directions of focus of APG



Due to APG's expertise in the electricity sector and its new, neutral position, our vision is follows:

> We manage the energy system of the future.

To live up to this vision, we will:

- Continue to guarantee a secure and stable power supply, in our role as system manager of the sustainable energy system.
- Ensure that 100 percent renewable energies can be integrated into the grid.
- Design and develop the electricity market for a flexible, intelligent grid.

In the pursuit of this vision, security will remain the top priority, while necessary new approaches will be implemented according to the motto:

> Performing while transforming.

The only way to identify and establish the necessary approaches is extensive research and innovation initiatives. To ensure that these are aligned with the corporate strategy and provide clear added value to grid users, three strategic R&I dimensions have been identified:

1. OPTIMISATION OF THE EXISTING GRID
   Optimum grid operation is to be guaranteed through strategic use of new technologies.
2. NEW FLEXIBILITY
   For successful integration of renewable energy sources, grid users have to be integrated into the electricity system to a larger extent.
3. NETWORK DEVELOPMENT
   New infrastructure has to be created to cope with the comprehensive integration of renewable energy sources and the increased convergence with other sectors.

In the presentations of selected R&I initiatives on the following pages, these three strategic R&I dimensions are used as the chapter structure and described in detail at the beginning of each chapter.

To support the research and innovation work with more fine-grained goals, eight key directions of focus were defined following a comprehensive review. The respective direction of focus is stated for each presented project.

The eight R&I directions of focus

1. Development and utilisation of decentralised flexibility potential
2. Intensification of cross-sectoral activities
3. Sustainable safeguarding of the infrastructure
4. Continuous search for, evaluation and utilisation of new technologies
5. Widespread use of sensor systems and the Internet of Things
6. Increased greening through sustainable innovation
7. Expansion of condition-based asset management
8. Development and implementation of support systems in grid operation

- Creating technical, procedural and organisational PRINCIPLES THAT ENABLE APG TO UTILISE DECENTRALISED FLEXIBILITY POTENTIAL
- *Examples of activities: ABS4TSO, PICASSO & MARI*

- Establishing CROSS-SECTORAL SOLUTIONS, in particular COORDINATION OF THE ELECTRICITY AND GAS SECTORS
- Analysing possible POTENTIAL IN CONNECTION WITH SECTOR COUPLING
- *Examples of activities: Power-to-gas pilot plant, APG market model VAMOS*

- Promoting comprehensive solutions for monitoring, analysing and reducing ENVIRONMENTAL INFLUENCES ON APG INFRASTRUCTURE
- *Examples of activities: QR codes on pylon number plates, lightning research in the Alpine region*

- Continuously IDENTIFYING new technologies and ASSESSING THEIR POTENTIAL for APG
- CONSISTENTLY EXPANDING THE USE of suitable and tested technologies (in particular where added value is created)
- *Example of an activity: Smart Wires – innovative load flow management*

- IMPLEMENTING widespread use of sensors and IoT applications for efficient and safe plant and grid operation
- Creating the TECHNICAL PREREQUISITES for company-wide innovation projects
- *Example of an activity: Ice monitoring+*

- Focusing on the ECOLOGICAL ADDED VALUE of R&I activities (energy transition and climate goals)
- Improving APG'S CARBON FOOTPRINT through targeted measures
- *Example of an activity: Life Eurokite – red kite protection*

- Expanding the technical infrastructure for TECHNOLOGY-BASED STATUS LOGGING for APG assets
- Developing and using procedures for AUTOMATED STATUS ANALYSIS
- *Examples of activities: Innovation partnership for disconnector monitoring, the digital transformer substation and 3DS*

- Expanding the use of INTELLIGENT SYSTEMS FOR SUPPORTING operational DECISION-MAKING AND CONTROL PROCESSES
- *Example of an activity: Monitoring of icing on wind turbines*

2 Optimisation of existing grids

APG's assets, which range from individual components in substations to many kilometres of line sections, were designed for decades of use. This reliable longevity is essential for both profitability and security of supply. Simultaneously, rapid technological progress, for example in the fields of sensor systems and data processing, is opening up new applications.

For this reason, it is one of APG's objectives to implement technology and process innovations that optimise operation of the existing infrastructure. The functioning interaction of existing plants and systems with new technologies and processes has to be well coordinated.

The use of new technologies and approaches in existing grids maintains a very high level of security of supply, even in the face of the new challenges posed by the energy transition. Cost optimisation resulting from data-supported maintenance and investment decisions can be passed on to grid users directly.

BVLOS – use of drones

for rapid fault inspection

> Project type: Innovation
> Contact persons: Paul Zachoval
> Project period: 01.2018 – ongoing
> Project partners: Smart Digital, Austro Control

R&I direction of focus **8**

Development and implementation of support systems in grid operation

Project description

Unusual weather events, earth faults resulting from fallen trees or other causes can lead to short-term interruptions in the operation of high-voltage and extra-high-voltage lines. Obligatory redundancies in the transmission grid according to the N-1 security criterion ensure, that a temporary line failure does not cause a blackout. Fast fault detection and repair is important nevertheless to ensure the continuation of reliable network operation.

Prior to recommissioning, it has to be ascertained that there is no damage and no foreign objects on the lines. Although service teams can reach all points of the approx. 7,000 km long Austrian transmission grid around the clock within a period of one-and-a-half hours, weather conditions or acute danger (e.g. risk of avalanches) can temporarily make some points impossible to reach in the customary ways. Here, new technologies can further reduce the time and staff required for inspection and identification of the fault location.

Together with the technology company SmartDigital and the Austrian aviation regulatory authority Austro Control, a solution has been developed for inspecting up to 100 km long line sections within a short period of time. A propeller-driven fixed-wing drone with a wingspan of more than three metres flies along the line route. With a ground-facing camera, it collects high-resolution images that the APG experts can evaluate. What's special about this solution is that the flight is automated, beyond the visual line of sight of a pilot (BVLOS). With the first flight of this kind, APG made European aviation history.

Achieved goals and results

In 2021, testing of this new inspection application continued, for example with two automated 100 km flights over 380 kV extra-high-voltage lines. These flights were monitored in the operation centre by means of live view and live radar. Flights by night were another first.

Following the successful trial, routine inspections are also to be supplemented with image data from fixed-wing drones. In addition to proving the technical feasibility, details regarding the operationalisation and flight permits still have to be clarified.

Backstory

In 2012, when the idea of using drones for rapid inspection of faults was first proposed, it was ahead of its time. Neither technology providers nor regulatory frameworks were prepared for the professional use of unmanned aerial vehicles. This did not stop Paul Zachoval, an employee in operations, from presenting the potential of remote-controlled multicopters equipped with a camera in a board meeting. To visualise the potential of the technology, he used his private drone, which he had received as a Christmas present.

The board quickly made the bold decision to buy a drone. Thereafter, questions regarding the economic efficiency had to be clarified: Is it just a gimmick or can it actually increase efficiency in maintenance and operation?

Paul Zachoval also proved this, with a high degree of practicability. Around this time, a radar warning sphere on an extra-high-voltage line had to be inspected. The problem was its position high above the Danube river. Normally, such an inspection would involve switching off the entire line section and interrupting shipping traffic on the Danube, so that a person can reach the location and inspect the radar warning sphere. Using a drone and subsequently evaluating the high-resolution camera images was a promising idea: It would be possible to avoid all interruptions to operation, which meant cost savings of many thousands of euros.

With this and many other steps, an idea that was first presented by flying a toy drone in a meeting room developed into a technology that today has become indispensable in many areas of application at APG. Zachoval's vision: In the future, imagines Paul Zachoval, drones could be deployed from "drone hubs" semi-automatically, to rapidly detect damages to the transmission grid and to sections of the distribution grids. Furthermore, new technological developments aim to enable use during highly adverse weather conditions, to facilitate provision of these services at all times.

The digital substation and 3DS

the digital inventory

- Project type: Innovation
- Contact persons: Johannes Futschek
- Project period: 12.2019 – ongoing
- Project partners: ARGE Vermessungs Zivilgeometer, EKG Baukultur, Laserdata GmbH, Vermessung AVT ZT GmbH, ODE Informationstechnik GesmbH

R&I direction of focus **7**

Expansion of condition-based asset management

Project description

The energy system of the future is increasingly interconnected. The electricity system always had to be viewed as a European system and the cross-border dependencies are constantly increasing. At the same time, essential system components, for example generating plants or flexibility resources, are increasingly becoming decentralised and democratised, yet still have to have the ability to be optimally integrated into the overall system. As the electricity system and other sectors – gas, heat and transportation – converge, the need for networking further increases. Therefore digitalisation at all levels is essential for mastering communication and data management.

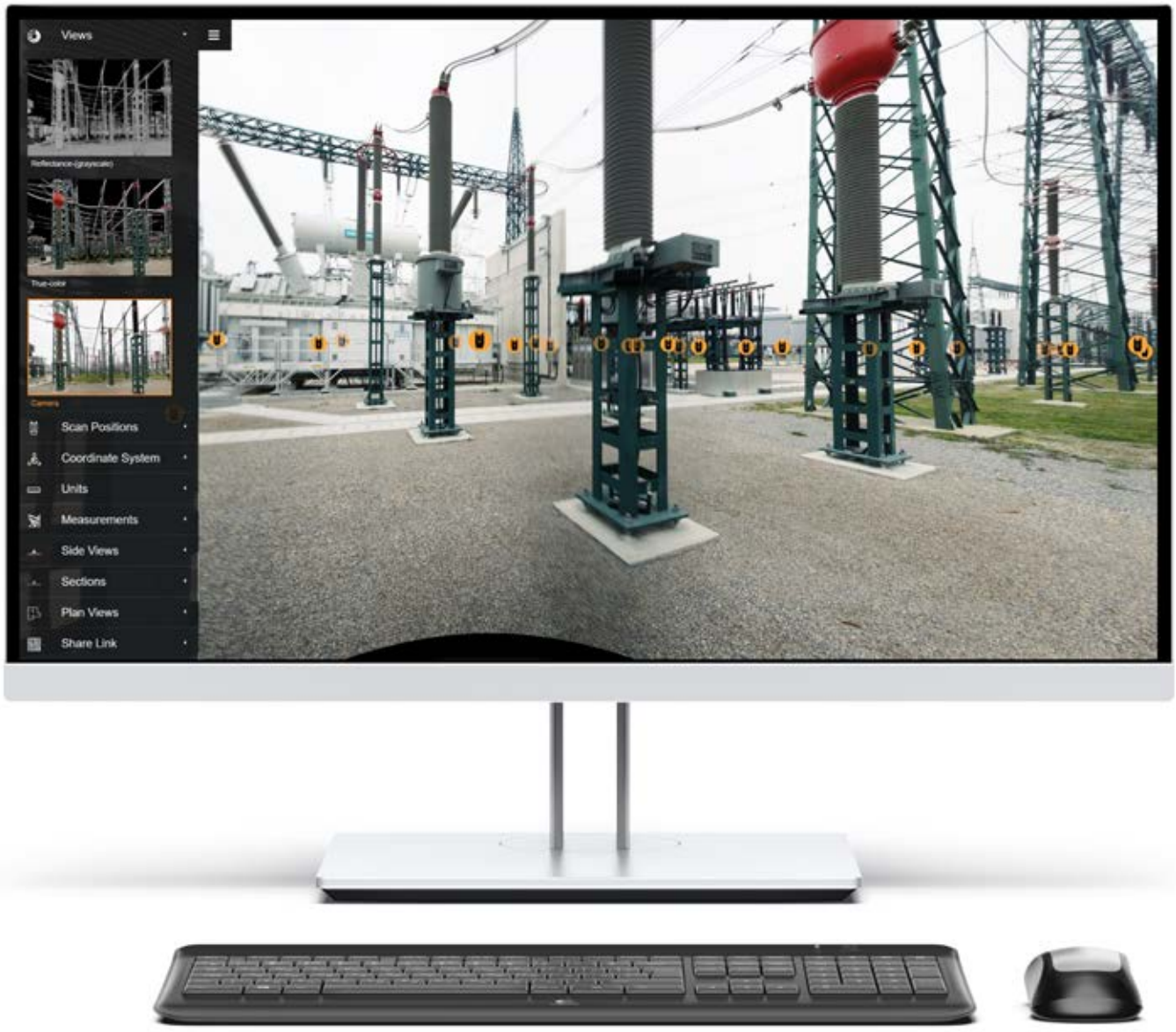
The "Digital Substation" initiative investigates how this trend is affecting the nodes of the APG grid – the substations – and how digitalisation potential can best be used in this context. The aim is to obtain as accurate an image as possible of the substation and the components contained therein, such as transformers and disconnectors, through the use of sensors. This leads to the optimisation of planning and decision-making processes, from operation to strategic level. Additionally, status monitoring of the most important components, combined with the highest safety standards, makes a significant contribution to ensuring security of supply.

Following a closer look is taken at an example project from the overarching digital substation initiative: 3D Scan ("3DS") of substations. To get a digital image, and potentially even a "digital twin", the spatial characteristics of the entire substation are also relevant. Due to missing or incomplete documentation for various APG substations, for example after takeovers, it was necessary to develop a system with which the substations could be measured in a short period of time and without switching off any parts of the stations.

Achieved goals and results

Intensive market research has shown that a combined application of terrestrial (from close to the ground) and airborne (from the air, with drones) laser scan recordings is the most cost- and time-efficient solution. The result of the scan is a multi-use, digital point cloud, which in turn forms the basis for creating CAD plans and virtual systems, but also provides information for workforce management and the systems plant database.

Online access to the 3DS data provides immediate information about plant components and even makes it possible to take a virtual tour of the plant. With this systematic approach, it is possible to perform measurements and virtual plant inspections in a short period of time and without any shutdowns. The aim is to use this method to digitise all existing plants, as well as any new or converted plants, by 2026. An international tender will ensure cost-efficient rollout of this application.


Views
Reflectance (grayscale)
True-color
Camera
Scan Positions
Coordinate System
Units
Measurements
Side Views
Sections
Plan Views
Share Link

Rust detection

through the use of artificial intelligence (AI)

- Project type: Research
- Contact persons: Stevica Rakic, Paul Japek
- Project period: 07.2021 - ongoing
- Project partners: Know-Center GmbH

R&I direction of focus 8

Development and implementation of support systems in grid operation

Project description

To ensure that internal processes are fit for the future and that the large amounts of generated data can be processed efficiently and in a way that adds value, strategic focus areas of the digital transformation have been defined. One of the resulting programmes is "Data Driven Utility" (DDU), with the aim of professionalising data management and implementing improvements in data-based control. In addition to data preparation, creation of the required system architecture and definition of data processes and role assignments, one of the main focal points is the application of artificial intelligence (AI).

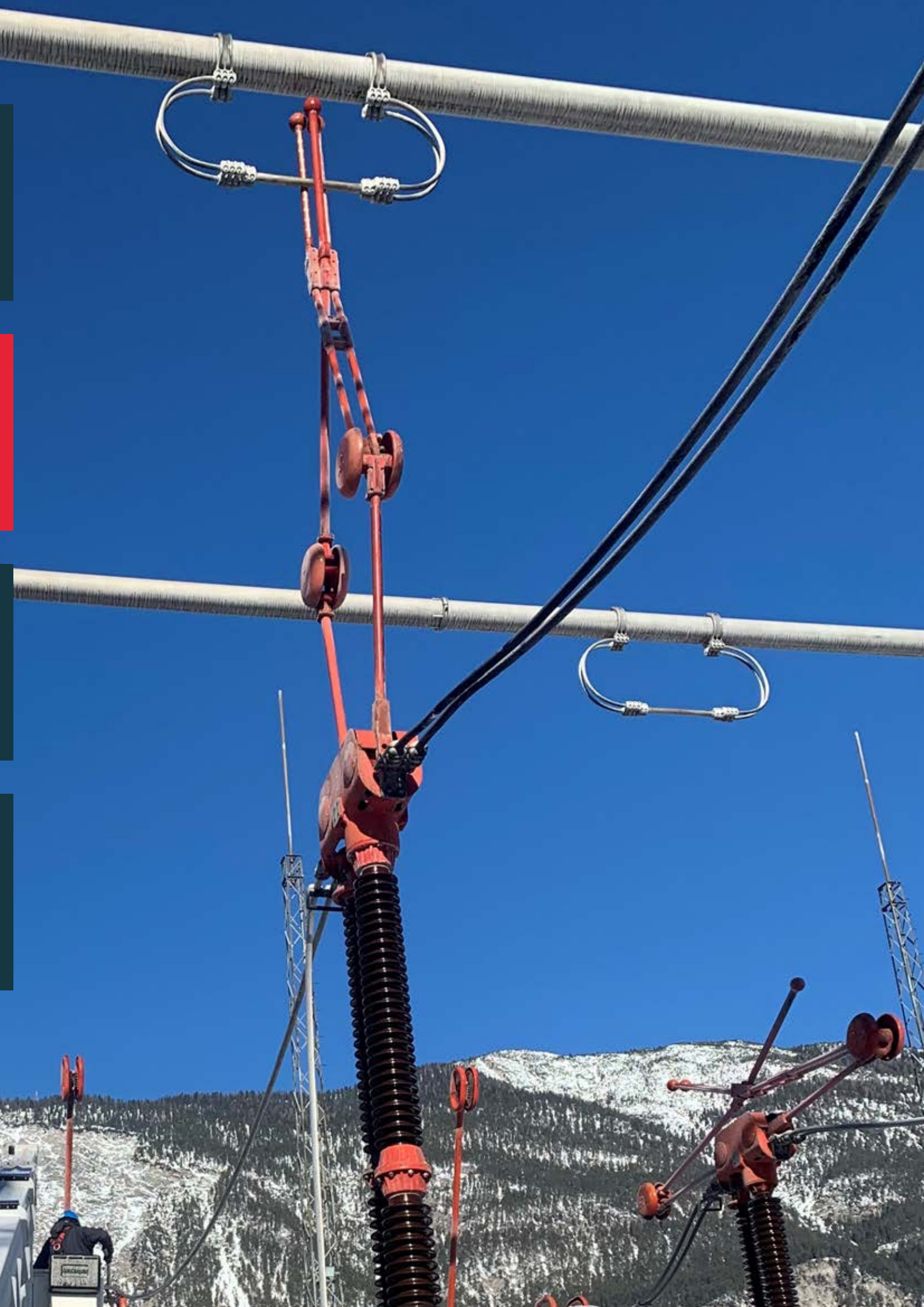
Within APG, a large number of potential use cases for AI have already been identified and prioritised. These originate from the market, operations and asset divisions. A use case from the asset division is presented as an example: AI-based detection of rust on pylons.

All of APG's roughly 12,000 pylons are inspected for damage annually. The purpose of this is to help ensure security of supply and to optimise maintenance costs at the same time. During on-site surveys by APG staff, the pylons are visually inspected and photos are taken of problem areas, including cases of rust formation. Currently, this image material is evaluated manually and maintenance measures are derived from it. In the future, this procedure is to be significantly supported by the use of innovative technology.

Achieved goals and results

An AI application developed in collaboration with the research institute Know-Center GmbH is already capable of detecting rust in images with a high degree of accuracy. In the subsequent manual evaluation, this saves valuable time, which can in turn be invested in the improvement of maintenance measures.

In the future, the entire inspection process could be redesigned: For example, photos could semi-automatically be taken by a drone that flies around a pylon in a preprogrammed spiral. Subsequently, the image data could be evaluated digitally and then manually checked in the final step. Over time, an image time series would thus be produced. With this, it would be possible to compare the condition of the pylons over a number of years.



Innovation partnership

for disconnector monitoring

- Project type: Innovation
- Contact persons: Georg Achleitner, Brigitte Bernhardt
- Project period: 2019 – ongoing
- Project partners: TU Graz, ARTEMES, FSM law firm, other companies

R&I direction of focus 7

Expansion of condition-based asset management

Project description

As "sectoral contracting entity", APG is subject to the Austrian Federal Public Procurement Act (Bundesvergabegesetz – BVergG), which stipulates that major procurements have to be put up for public tender. Since the legislation did not provide a suitable framework for innovative development cooperation, the "innovation partnership" was included in the 2018 amendment of the BVergG. It regulates the tendering process for a co-development and the subsequent procurement of a deliverable that is not yet available on the market. If the predefined performance and cost targets are met, the procurement does not require a tendering process after the co-development has been completed. APG was one of the first Austrian companies to make use of this new procedure.

In this specific case, the co-development is based on a patent that was developed in collaboration with TU Graz after an internal idea of APG. With this new approach, it is possible to detect faults in disconnect switches (disconnectors) reliably and with minimal use of sensors. – A centralised measurement is all that is needed. Disconnectors are components in substations that have a clearly distinguishable switch position, for connecting or disconnecting system components from the power supply. However, switching only takes place if the power supply has already been interrupted, for example by a circuit breaker.

Mechanical interference such as formation of ice or a broken porcelain isolator can prevent the disconnector from switching to the desired position. Such faults cause characteristic voltage and current flows in the actuator motor. It is possible to centrally record and monitor not only disconnectors, but also other assets.

Achieved goals and results

APG conducted the innovation partnership procedure in four phases:

01. From 2019: EU-wide tender to select the three best-suited innovation partners from around 20 interested parties
02. End of the procedure in accordance with the procurement legislation: Feasibility study with the three selected innovation partners
03. Until mid-2021: Prototype development with the two promising innovation partners
04. End of 2021: Selection of the winner of the tender, for development up to market-readiness and long-term cooperation

The winner was ARTEMES from southern Styria, with whom APG is currently working on the fixed installation and the suitability for series production. Previously, in the course of developing the prototype, an AI approach for error recognition was developed and tested in practice.

For APG, the procedure for entering into innovation partnerships harbours great potential for the procurement of innovative products as well as construction work and other services. In the course of this project, valuable experience was gained for conducting more such procedures in the future.

QR codes on pylon number plates

> Project type: Innovation
> Contact persons: Stevica Rakic
> Project period: 2018 – 2021
> Project partners: QR Planet

R&I direction of focus 3

Sustainable safeguarding of the infrastructure

Project description

APG's high-voltage and extra-high-voltage grid is supported by around 12,000 pylons. For many decades, they have been designated with pylon number plates. These provide the following information: pylon number, line number and an emergency phone number. This information is essential for reporting imminent danger and for assisting the emergency services.

Since the end of 2018, all these pylons additionally carry a QR code on their existing number plates. When the QR code is scanned with a smartphone, an emergency message can be sent. A telephone connection is established with the APG safety centre and additionally the data of the site (pylon coordinates, line data, etc.) is sent to the safety centre by e-mail. Messages and images can also be digitally sent in this way. If emergency personnel scan the QR code, they get access to the digital safety platform of APG.

In addition to reporting emergencies, the QR code can help to find relevant information, such as the data sheet with the safety distances that have to be observed in the vicinity of systems that conduct electricity. To preserve the option of reporting emergencies without having a smartphone with an Internet connection, the existing information is retained on the pylon number plate.

A demo version can be accessed using this QR code:

In addition to supporting more detailed emergency reporting, the QR code can also be used for digital support for the measures that are then initiated. The APG operations manager can immediately get an accurate status report for the respective pylon and can better prepare and coordinate deployments to the site. Thus digitalisation is used to achieve an immediate increase in safety.

Backstory

In the autumn of 2021, the project "QR codes on pylon number plates" won the science award of TÜV, the Austrian technical inspection authority – well-deserved recognition for the driving force behind the project, Stevica Rakic, project manager in line construction. Since 2015, he has been pulling out all the stops to develop this idea in more detail and implement it. Even though the project had an entire team working on it, he was the one who never let go and wanted to better understand the needs of the users, for which he attended countless meetings, for example at the APG safety centre or with the emergency services.

The first prototype, which he programmed himself, had a similar purpose: He wanted something tangible to show, with the goal of integrating suggestions for improvements into the next iteration. Thus the possibility of making contact by phone developed step-by-step into today's digital safety platform. "It is not a static product, it is constantly being adapted," emphasizes Rakic. This process is still continuing today, with the aim of further improving the processes for making contact, for example when local residents or companies are performing workings in close proximity to the lines. Additionally, it can help to achieve a faster and more effective chain of response in the event of an emergency.

With much of the preliminary work for this project done in addition to the day-to-day work, implementation picked up speed during an internal research and innovation event, at which the board of directors also recognised the potential of this idea. In the course of the next inspections of all APG pylons, which are performed twice a year, the QR codes were added to the existing pylon number plates. Today, the new pylon number plates that are delivered and installed are equipped with an integrated QR code.

Project manager Stevica Rakic believes there is still a lot more potential in the idea. While the QR codes on the 12,000 APG masts are weather-resistant and remain unaltered, the platform behind them can constantly be improved.

Lightning research in the Alpine region

- Project type: Research
- Contact persons: Christoph Karner, Georg Achleitner
- Project period: 01.2016 - 12.2020
- Project partners: ALDIS, TU Graz

R&I direction of focus 3

Sustainable safeguarding of the infrastructure

Project description

The Austrian Alpine region has always been among the areas with the highest incidence of lightning in Europe. Climate change and the accompanying meteorological changes may further increase the intensity of thunderstorms and the associated lightning discharge, and it is becoming increasingly difficult to predict their occurrence. The lightning location systems currently in use, such as ALDIS (Austrian Lightning Detection and Information System), can identify the position of the discharge with a certain amount of accuracy, but cannot predict it. These systems can only be used for decision-making and protective measures once the first strike has occurred. There is currently a high degree of uncertainty, both when issuing warnings and when giving the all-clear. This unpredictability in the development of storms presents challenges to our entire society, from our work-related activities to our private lives.

Of course, all essential infrastructure systems, such as the lines and substations of APG, are also subjected to these environmental influences. These phenomena have already been studied for many years in various research initiatives with scientific partners, with the goal of better understanding these discharges on and around the APG systems and preventing failures.

For example, APG has been engaged in the creation of ALDIS right from the start, together with the Austrian Electrotechnical Association (OVE). Experience has shown that the location of lightning is less precise in the Alpine regions. For this reason, several projects focused on improving location precision in this region.

Achieved goals and results

As part of the project "Wolke-Erde-Blitz im Alpenraum" (Cloud-to-ground lightning in the Alpine region), conducted together with TU Graz, a mobile system consisting of a high-resolution camera and a measuring system for electrical fields has been developed. By combining the data of the evaluations, together with the time-synchronised GPS data from ALDIS, and weather data from the Austrian Central Institute for Meteorology and Geodynamics (ZAMG), the types and characteristics of thunderstorms can now be much better documented. The lessons learned and the established systems are a significant step towards improved early detection of lightning and faster troubleshooting.

The improvement in the location precision of ALDIS is not the only result. The "Blitzstrom-Messung Gaisberg" project (Lightning current measurement in Gaisberg) shares the objective of conducting more detailed research into the formation of electrical pulses as a result of lightning, induction, long-term discharge and multiplicity. A special European aspect in this research project is direct current measurement using a shunt (low-impedance resistor). This provides valuable insights for the standardisation and future design of electrical infrastructure.

Ice monitoring+

- Project type: Research
- Contact persons: Oskar Oberzaucher, Michael Leonhardsberger
- Project period: 09.2020 – ongoing
- Project partners: Heimdall Power

R&I direction of focus 5

Widespread use of sensor systems and IoT

Project description

Unfavourable, wintry conditions can cause ice to form on overhead lines. Although all domestic overhead lines are designed to carry a certain ice load, it cannot be ruled out that the permissible thresholds could be exceeded, especially in very exposed locations. This could in turn lead to critical situations underneath the line, for example ice being dropped onto nearby streets, and could cause restrictions to operations.

Ice monitoring sensors on overhead lines, Koralm location

In the future, a network of weather information and sensors directly at the overhead lines should ensure that the risks of this ice load is identified early, so that countermeasures can be taken. In addition to this direct benefit, a more in-depth understanding of the icing behaviour of APG overhead lines can also be obtained. To this end, sensor and cloud solutions for data analysis are being developed and tested within the framework of the "Eismonitoring+" (Ice monitoring+) project. Knowledge gained about the weight of the ice, measured with sensors directly at the conductor cables, is combined with weather data and evaluated in the cloud.

Achieved goals and results

Based on many years of empirical data, the first sensors are used specifically where icy weather frequently occurs, at locations where there is danger for nearby objects if ice drops and additionally at locations that are very exposed and the day-to-day conditions are not fully known.

After a successful pilot project in 2017, the ice monitoring system is now being rolled out at selected locations across Austria. Prior to the 2021/22 winter season, three of these locations were equipped with sensors. Following this test run, the sensor system is to be expanded to all planned line sections and put into operation. Additionally, a review is to be conducted to determine whether it is possible to give a forecast regarding ice formation, in order to take proactive measures for such situations.

Monitoring of icing on wind turbines

- Project type: Research
- Contact persons: Christoph Karner
- Project period: 03.2020 – ongoing
- Project partners: ZAMG, Eologix, Windpark Simonsfeld

R&I direction of focus 8

Development and implementation of support systems in grid operation

Project description

Currently approx. 1,300 wind turbines are in use all across Austria. As a result of the decarbonisation of the electricity system, the number of wind turbines and thus the amount of wind energy in the energy mix will continue to increase. Already today, forecasts about the generated energy play an important role in securing the balance between power used and power generated, and thus in ensuring grid stability and security of supply.

The predicted amounts of wind energy obviously depend on the wind forecast. However, under specific wintry conditions, the existing wind potential can sometimes unexpectedly not be utilised, because iced wind turbines cannot be operated. Widespread ice formation that affects entire regions and thus many wind turbines at the same time can therefore cause unexpected power deficits if they are not anticipated and taken into account in time.

For this reason, APG and the Austrian Central Institute for Meteorology and Geodynamics (ZZAMG) joined forces to tackle this problem and conducted a pilot study on the prediction of icing events on wind turbines. The aim was to develop a data assessment model that can warn against icing well in time – in other words preferably the day before – based on weather and sensor data. In the winter of 2020/21, ten wind parks in the Weinviertel and Nordburgenland regions of Austria were monitored to this end.

Achieved goals and results

At the plants monitored within the scope of the research project, each had two to eight icing events with a duration longer than four hours during the winter of 2020/21. The tested, automated system warned against icing a total of 16 times. In the semi-automatic mode applied, the ZAMG meteorologist on duty assessed the icing situation daily, based on model calculations. In the end, warnings about ten icing events were issued. During the pilot run, only a single icing event occurred that was not predicted. In a further step, operational implementation took place at ZAMG for the winter period 2021/22.

The promising results of the pilot study show that such an approach has the potential for making a significant contribution to domestic security of supply.

Life Eurokite – red kite protection

> Project type: Research
> Contact persons: Sven Aberle
> Project period: 01.2021 – ongoing
> Project partners: Mitteleuropäische Gesellschaft zur Erhaltung der Greifvögel (a Central European organisation dedicated to bird of prey protection), and another 20 partners in 12 states (among them five power line operators in 4 states)

R&I direction of focus 6

Increased greening through sustainable innovation

Project description

APG's construction projects undergo strict environmental impact assessments (EIA). One of the areas of conflict in this context lies between nature protection and energy supply. Unfortunately, ensuring a secure electricity supply for Austria means that certain interventions in the environment cannot be avoided. APG has been investing great effort for many years to minimise the impact on the natural habitats, vastly exceeding the requirements stipulated in the legislation. To better understand the ecological effects, an objective database has to be created in this area.

In this specific case, the aim is to examine the effects of the transmission grid infrastructure on bird populations. In general, birds have difficulty recognising horizontal obstructions such as power lines. For this reason, vertical visual aids have long been applied at neuralgic points to prevent collisions. Large bird species in particular are in danger of colliding with power lines, as they cannot dodge the lines in time, due to their speed and size.

With its participation in the international research project "Life Eurokite", APG is making a proactive contribution to improving the research on the effects of the transmission grid infrastructure on bird of prey populations. The red kite found in Central Europe has been chosen as a representative bird. During the period from 2019 to 2023, approx. 500 red kites and 100 other birds of prey are being fitted with transmitters, to study human-caused

mortality. This makes it possible to record their spread and mortality for further investigation.

APG has undertaken to participate in measures that reduce the human-caused mortality of birds of prey. In addition to deriving measures against accidents involving power lines, this includes adopting a clear stance against poisoning and supporting the resolution and prosecution of poisoning incidents, adaptation of legal frameworks and subsidies, as well as raising public awareness.

3 New flexibility

In the future, keeping the electricity system in balance, i.e. ensuring that production and consumption remain in equilibrium at any given moment, will be an even greater challenge, due to the increased integration of volatile, renewable energy sources.

Pan-European transmission capacities and effective market mechanisms (i.e. horizontal market integration) are essential to be able to make use of regional overproduction elsewhere. For example, because wind lulls are regional and do not occur across the entire continent at the same time, the resulting fluctuations in power generation can be balanced by the integrated European energy system.

To compensate for daily (short-term) fluctuations, e.g. day vs. night differences in PV production, it is necessary to have local storage facilities and enable flexible adjustment of electricity consumption. In the course of such vertical market integration, this flexibility can be harnessed.

To compensate for medium- and long-term production fluctuation, an increase in both horizontal and vertical electricity market integration is essential.

In addition to these requirements for how the electricity market should be structured as a result of the energy transition, the legal basis at EU level is frequently adapted, and these changes have to be taken into account and implemented accordingly. They mainly relate to ensuring a strong European single market, further liberalisation of the electricity markets and stronger benefits for end users. In many cases, implementing these changes also requires stronger horizontal and vertical market integration, which results in significant overlap with the strategic R&I dimension “New flexibility”.

APG's Power Grid Control, south-east Vienna

Future Flow

- Project type: Research
- Contact persons: Milan Vukasovic
- Project period: 01.2016 – 01.2020
- Project partners: European partners of the energy sector, including three transmission system operators (ELES, MAVIR, Transelectrica)

R&I direction of focus 1

Development and utilisation of decentralised flexibility potential

Project description

Across Europe, the energy transition is presenting transmission system operators and control area managers with major challenges. Thermal, flexibly controllable power stations close to consumer centres are largely being forced out of the market by weather-dependent, renewable energy sources whose locations are dependent on natural potential. The volatility and spatial distribution of these energy sources demand new approaches for safeguarding electricity balancing and for congestion management.

When a transmission grid that can only be expanded slowly due to dragged-out permit procedures is confronted with these realities, the costs for congestion management increase as a result of the need for increasingly frequent interventions in power station planning – so-called redispatch. This causes high costs, which each and every Austrian grid user ends up paying towards – more than 100 million euros annually. In addition to grid expansion, other innovative solution approaches are being pursued to reduce these costs.

Through the cross-border exchange of different energy products, optimised by means of IT systems, this cost optimisation has been developed and implemented for secondary balancing energy and redispatch. This was done within the framework of the EU-funded project "Future Flows". Additionally, existing flexibility has been made accessible in a decentralised manner, for example in industrial companies, and harnessed across country borders. Under the leadership of the Slovenian transmission system operator ELES, the prototype of the IT-supported trade platform has been put into operation for the control areas Austria, Slovenia, Hungary and Romania.

APG made significant contributions in the concept development phase, in particular regarding the design of the optimisation and call-off processes, and laid the foundation for usage-based distribution of the redispatch costs, based on power flow colouring.

Achieved goals and results

In this pilot project, 50 MW of flexibility provided by 96 prosumers ("progressive consumers") had to be made accessible across borders. The analyses performed concluded that full rollout of the cross-country coordination between the four countries would enable secondary balancing energy savings of 23 percent (in MWh).

The lower energy volumes for the actual required call-offs and the increased availability of flexibility, with increased competition, could ultimately lead to significant cost reductions. Calculations and analyses for the time frames considered in the project and pilot trials showed that the total costs for secondary balancing energy (aFRR) could be reduced by 60 percent for all four countries together, while the redispatch costs could be reduced by 57 percent.

Core

Flow-based market coupling as a target model in Central Europe

- Project type: Innovation
- Contact persons: Reinhard Kaisinger
- Project period: 04.2020 – ongoing
- Project partners: 16 European transmission system operators

R&I direction of focus **1**

Development and utilisation of decentralised flexibility potential

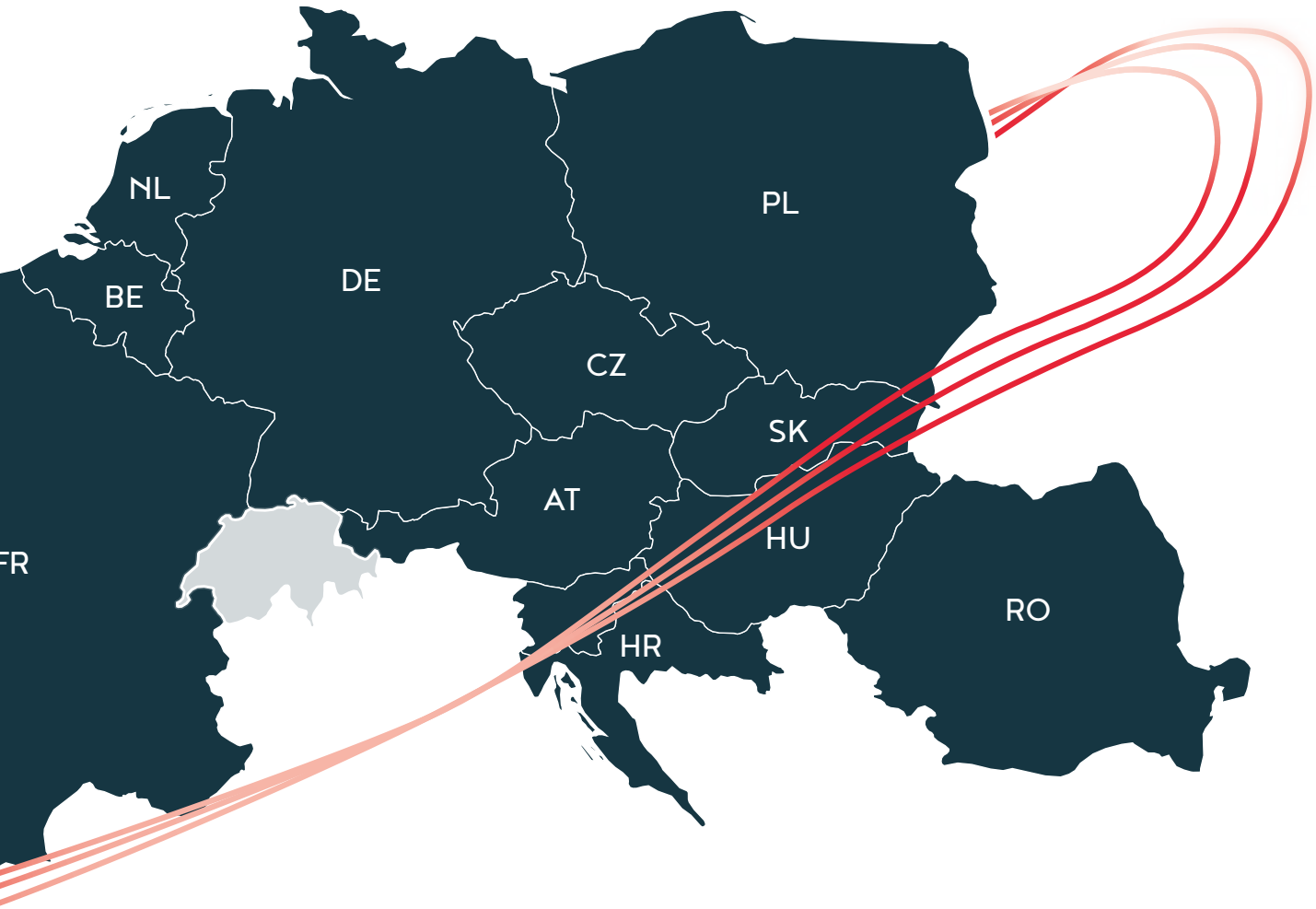
Project description

The energy transition can only succeed if the European electricity market converges – national electricity markets have to be increasingly horizontally integrated. This, for example, ensures that wind energy from the North Sea can be saved in pumped storage in the Alpine region. Additionally, it thus is possible to compensate for regional lulls in renewable energy production.

To enable this, optimal use of cross-border transmission capacities is required. Currently, these are calculated on the previous day (Day Ahead) by neighbouring transmission system operators and sent to the electricity exchange. There, they join the buy and sell offers of the electricity market participants. At present, the calculation of the available interconnection capacities involves certain simplifications, which do not adequately reflect the physical properties of the transmission grid. These simplifications lead to situations in which the transmission capacity that can be used is less than what is physically available. This reduces the common good and makes it more difficult to reach the EU target, which specifies that 70 percent of the cross-border coupling capacity is to be used for short-term electricity trading.

Achieved goals and results

In the course of this project, the calculation and offer methods applied are to be optimised so that the offered transmission capacities better match the physical reality. The resulting more efficient utilisation of existing infrastructure leads to an increase in the common good, because high price differences between countries can be avoided. Thus the grid users profit from the cost reduction, and overall Austria's standing as an industrial location is strengthened.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XBID

New procedures in cross-border intraday electricity trading

- Project type: Innovation
- Contact persons: Anita Gansterer-Weber, Christoph Jachmann
- Project period: 01.2020 – ongoing
- Project partners: Seven electricity exchanges and European transmission system operators from 12 countries

R&I direction of focus 1

Development and utilisation of decentralised flexibility potential

Project description

On the intraday electricity market, where electricity is constantly sold and bought for same-day delivery, it is currently not possible to generate revenue from auctioning off cross-border capacities. Contrary to the other segments of the electricity market, the cross-border line capacities are thus not assigned any value. The result is insufficient investment incentives for expanding the transmission grid infrastructure and the various segments of the electricity market are not consistently structured in relation to each other.

With the integration of three additional auctions per delivery day, pricing is to be implemented for cross-border capacities on the intraday electricity market. To this end, the current procedures on the intraday market have to be adapted and joint usage of infrastructure together with the day-ahead market has to be established, whilst ensuring that trade can continue in real time.

Furthermore, in the XBID research project, conditions are to be created at EU level to allow the combination of different offers in a retradeable order on the continuous intraday electricity market: "cross-product matching". This makes it possible – for the first time – to combine offers of different products that were previously divided into separate order books. This should increase the liquidity of the intraday market.

Achieved goals and results

For the implementation of the intraday auctions, a systematic analysis of all implementation variants was conducted over several iterations for the first time, then compared and evaluated based on previously defined parameters. For this purpose, exact time-based flow charts were created for the markets involved, as well as a matrix in which all combination variants were compared and evaluated, using criteria such as effort, complexity and costs.

For cross-product matching, the focus was on producing the first comprehensive technical analyses, in order to develop a procedure that will make it possible for the first time to combine offers of different products and also make the resulting combinations tradeable. In the first analytic tests, it became apparent that maintaining the processing speed of offers is a key challenge, because cross-product matching yields many different combinations that the system has to calculate in real time. An additional challenge was developing a price determination mechanism with which all market participants can achieve a price that is acceptable to them, independent of whether the system combined orders.

PICASSO and MARI

- Project type: Innovation
- Contact persons: Christian Spindler, Christina Wirrer, Matthias Eder
- Project period: 01.2020 – ongoing
- Project partners: European transmission system operators

R&I direction of focus 1

Development and utilisation of decentralised flexibility potential

Project description

As control area manager, APG is responsible for keeping the grid frequency stable at 50 Hz. For this to succeed, electricity production and consumption have to be balanced at any given moment in time. Fluctuations in production or consumption have to be equalised quickly. To this end, APG has to procure control reserves on the market, by means of tenders. The resulting costs have to be passed on to the grid user at the end of the day. Together with its European partners, APG has strived for years to minimise these costs, and has had significant successes. Thanks to the existing cooperation agreements, the annual costs between 2014 and 2020 were reduced by around 80 percent, to 40 million euros. Other market innovations in the context of the control reserve market are aimed at reducing the costs even further or stabilising them at this relatively low level, while creating more flexible options for participating in the control reserve market.

Fundamentally, there are three control reserve types: Within a few seconds, frequency deviations can be automatically stabilised with the primary control reserve, called the frequency containment reserve (FCR). This balancing is conducted by networking the frequency containment reserves of the entire continental European grid. The secondary control reserve – the automatic frequency restoration reserve (aFRR) – differs from this. It comes into play when deviations continue for longer periods and has to be kept in the respective control areas. To prevent longer-lasting activation of the automatic frequency restoration reserves, the tertiary control reserve, called the manual frequency restoration reserve (mFRR), is utilised within a quarter of an hour. This too has to be kept in the respective control areas.

The changes to the market design that have resulted in significant cost reductions in recent years were, in particular, the simplification of access to the market for providers of control reserves, for example by combining smaller players into virtual power stations, as well as the reduction of the intervals of the daily auctions and product time slices. This increases the competition between control reserve provides and causes prices to fall.

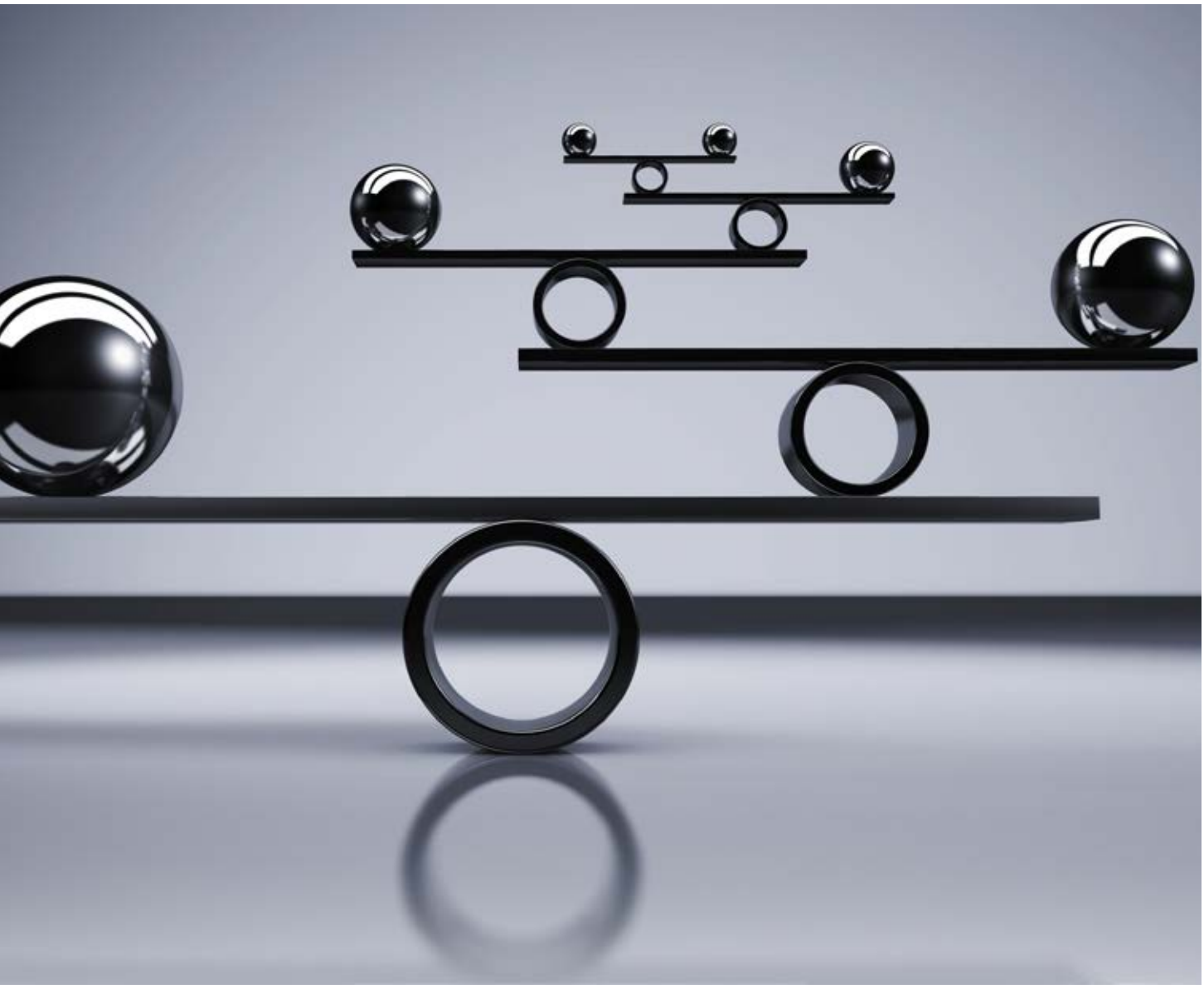
These approaches are to be continued at international level, in cooperation with European transmission system operators. Key activities converge in two initiatives: PICASSO (Platform for the International Coordination of Automated frequency restoration and Stable System Operation) and MARI (Manually Activated Reserves Initiative). Currently the markets for secondary and tertiary balancing energy are restricted to control areas. The goal is to raise them to European level and to reduce the auction intervals to 15 minutes.

APG and the four German transmission system operators have a pioneering role in this endeavour. For both the automatic frequency restoration reserve and manual frequency restoration reserve, APG and the four German transmission system operators are successfully cooperating to jointly optimise the call-offs for the secondary balancing energy and tertiary balancing energy, and to exchange the secondary balancing power provision. Design components of these existing models were used for the development of the European control energy platforms and can serve as successful examples for any future collaborations on exchanging the balancing power provision.

Achieved goals and results

PICASSO is an acronym and stands for: "Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation". The name describes the implementation project that makes Europe-wide exchange of the automatic frequency restoration reserve possible. For the manual frequency restoration reserve, a similar goal is being pursued by MARI (Manually Activated Reserves Initiative). Both initiatives operate within the framework of the European Association for the Cooperation of Transmission System Operators (ENTSO-E) and form the core of the implementation of the EU regulation on electricity balancing (2017/2195).

The grid user profits from the cost reductions achieved. Other players on the Austrian electricity market get the chance to offer their grid services across Europe.



ABS4TSO

- Project type: Research
- Contact persons: Viktor Zeh
- Project period: 05.2018 – 12.2021
- Project partners: AIT (Austrian Institute of Technology), TU Vienna and VERBUND

R&I direction of focus 1

Development and utilisation of decentralised flexibility potential

Project description

One of the main tasks of APG is to keep the electricity system balanced. For a stable grid frequency of 50 Hz, production and consumption have to be balanced at any given moment. A sudden change in production or consumption causes a corresponding imbalance and the grid frequency changes. The speed of this change depends on the so-called system inertia. The system inertia is determined by the rotating masses in the turbines and generators of the power stations in operation. High system inertia benefits the stability of the grid because it provides time to restore the balance with control reserves.

The large rotating masses are mainly found in hydroelectric power stations and thermal systems. However, in the course of the energy transition, the latter are increasingly being replaced by wind turbines and photovoltaic systems. These forms of energy production generate direct current. Before it can be fed into the grid, it has to be converted into three-phase current by means of inverters. This means that the rotating masses get disconnected from the grid, so its overall inertia changes. This makes the grid frequency a lot more vulnerable. Some frequency fluctuations cannot be balanced with the existing control reserves fast enough. Therefore new approaches are needed to identify these within milliseconds and stabilise the network. Various different mechanisms are feasible – e.g. extremely fast control reserves or an "artificial inertia".

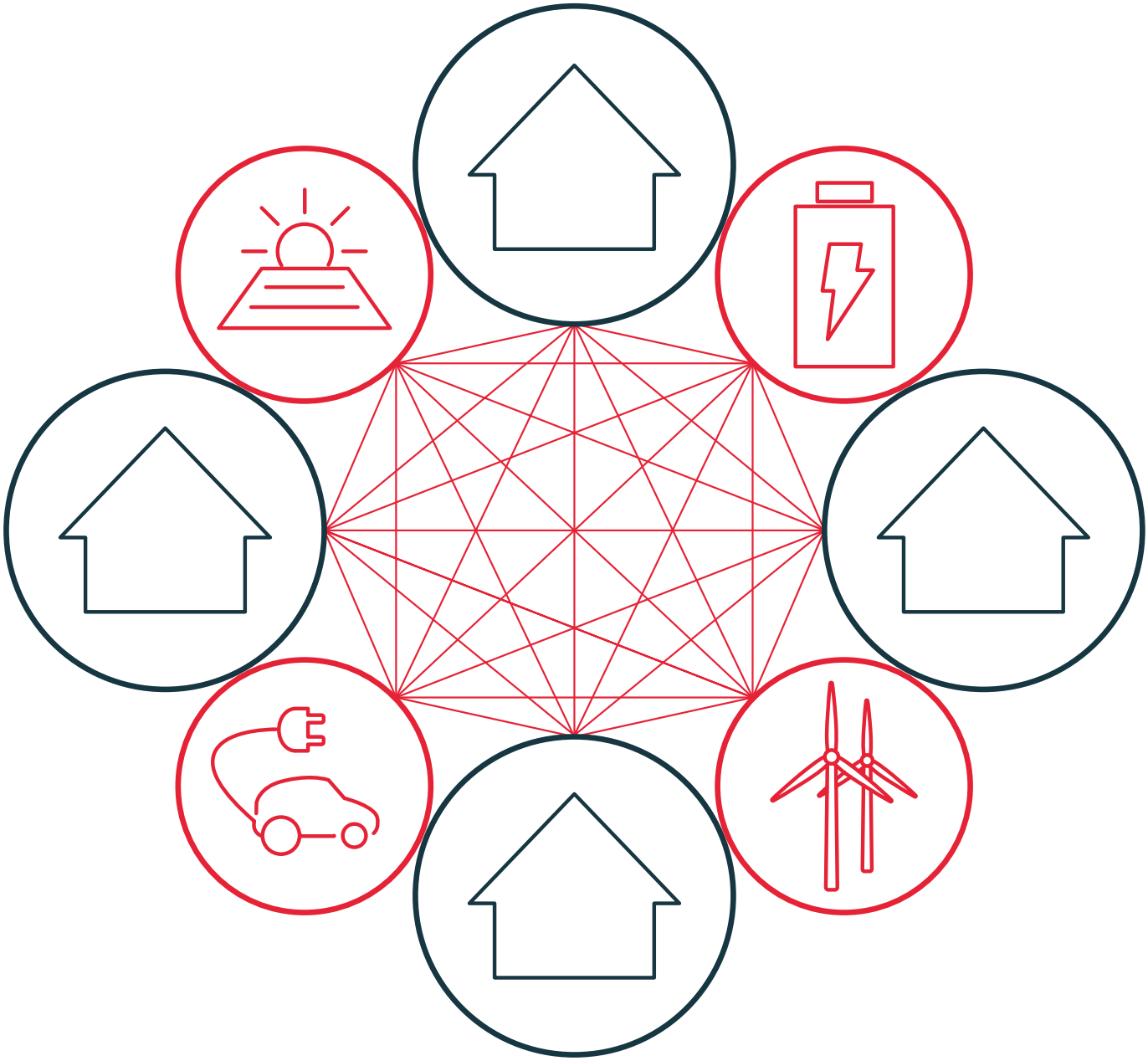
With this motivation, the flagship project ABS4TSO has been initiated together with AIT (Austrian Institute of Technology), TU Vienna and VERBUND.

The acronym ABS4TSO stands for Advanced Balancing Services for Transmission System Operators and concerns the development of newer and faster control reserve options. The heart of the project is a 1 MW/500 kWh battery storage system located at the substation in south-east Vienna. It is intended for the future provision of ancillary services related to synthetic inertia, fast frequency response and dampening of low-frequency system oscillations. The focus of the research is on the required inverter configuration and control.

Achieved goals and results

Concept development started in 2018. Initial system testing was then carried out in the AIT laboratories. In 2021, pilot operation of the innovative battery storage system started in APG's substation in south-east Vienna. Parallel to the technical development, the framework conditions that will be required in the future for possible market products and connection rules are being established.

This project makes a significant contribution to the development of new technical solutions for safeguarding the system stability during the increasing integration of renewable energy sources. Additionally, new system service products are being developed based on the respective technical requirements. These could be innovative business cases for providers.



"Stromausgleich Österreich"

Innovative electricity balancing for Austria

- Project type: Research
- Contact persons: Markus Riegler
- Project period: 06.2020 – ongoing
- Project partners: Equigy, A1 (World Direct), Fronius, EVN

Project description

Deviations from the balance point, where generation and consumption are equally high, become apparent as fluctuations in the grid frequency, which is normally 50 Hz. If more power is generated than consumed, the grid frequency increases – if more is consumed than generated, if falls. If these fluctuations are not stopped by means of immediately effective measures, there is a risk of the grid collapsing.

To prevent this, APG procures balancing energy and balancing power on the control reserve markets. Currently, it is mainly large, flexible power plants that offer short-notice adaptation of their generating capacity. Due to the changing producer mix, the significance of thermal power stations for these purposes is decreasing, while demand for flexible control reserves is increasing. It is therefore crucial to make full use of both existing and new flexibility.

On the control reserve market, certain pre-qualification criteria have to be met. This currently creates major barriers to market entry for individual small plants. In a few cases, these can be integrated in the form of virtual power stations, using aggregators, but this procedure involves a lot of organisational work and a high number of manual process steps. Most flexibility potential in the industrial and private sector, for example heat pumps with heat accumulators, electric vehicles or home batteries, therefore remains untapped.

The goal of the "Stromausgleich Österreich" (Electricity balancing for Austria) project is therefore to create a centralised, internet-based platform where decentralised electricity generation and consumption systems (flexibility resources) can be integrated into the relevant energy markets in a way that offers easy access, is standardised, transparent and non-discriminatory.

Achieved goals and results

After the successful concept development and the theoretical proof of value (PoV), the purpose of the proof of concept (PoC) was to address technical challenges and demonstrate that the concept can be implemented. The first operationally usable version, the minimum viable product (MVP), is now being tested further to identify challenges and requirements.

A European platform is being created in cooperation with other European transmission system operators and the implementation partner EQUIGY. Its purpose is the innovative connection of automatic frequency restoration reserves and it will serve as the foundation for further applications in the future. A concept for such a comprehensive utilisation of flexibility, for example also for congestion management, is being developed in parallel in cooperation with the electricity industry. The first draft of this joint concept will be coordinated with the regulatory authority in 2021. Commissioning of the MVP is planned for the first half of 2022.

VAMOS

APG market model

- Project type: Innovation
- Contact persons: Valentin Wiedner
- Project period: 06.2019 – ongoing
- Project partners: LearnConsult

R&I direction of focus 2

Intensification of cross-sectoral activities

Project description

The European electricity market is so complex that no simple if-then statements are sufficient. To handle this complexity, electricity market models are needed that are easy to control, so that the effects of various input parameters, like changed demand patterns or new power station technologies, can be examined.

As early as 2013, APG acted on this necessity and started to create prototypes of processing chains for electricity market and grid calculations. Two years later, it was possible to use these to examine the effects of the bidding zone change. To make this tool available to a wider expert base, the MATLAB-based prototype has been further developed into a user-friendly software product called: VAMOS – Varied Model Operating System.

A unique selling point of VAMOS is the processing chains that can be compiled from a wide variety of analysis tools and run in coordinated parallel processes. Various user-friendly tools can be used to efficiently collect input data for complex processing chains and to consistently compile it. During all steps, plausibility checks are performed automatically.
To enable many experts from different areas to collaborate, VAMOS is set up on a common platform via a web interface. This also ensures that large volumes of data can be processed efficiently both during data collection and simulation.

Achieved goals and results

With the help of VAMOS, APG can determine the most effective measures for grid development planning or examine the effects of new market designs and market rules. In addition, VAMOS is also available to other transmission system operators. During the European bidding zone review, all Central European TSOs are using it as a simulation platform.

Thanks to the experience gained with VAMOS at European level, the platform is continuously being developed further. In the future, elements of the larger energy system, e.g. natural gas and H2 infrastructure, are to be mapped in the software, for the purpose of sector integration.

4 Network Development

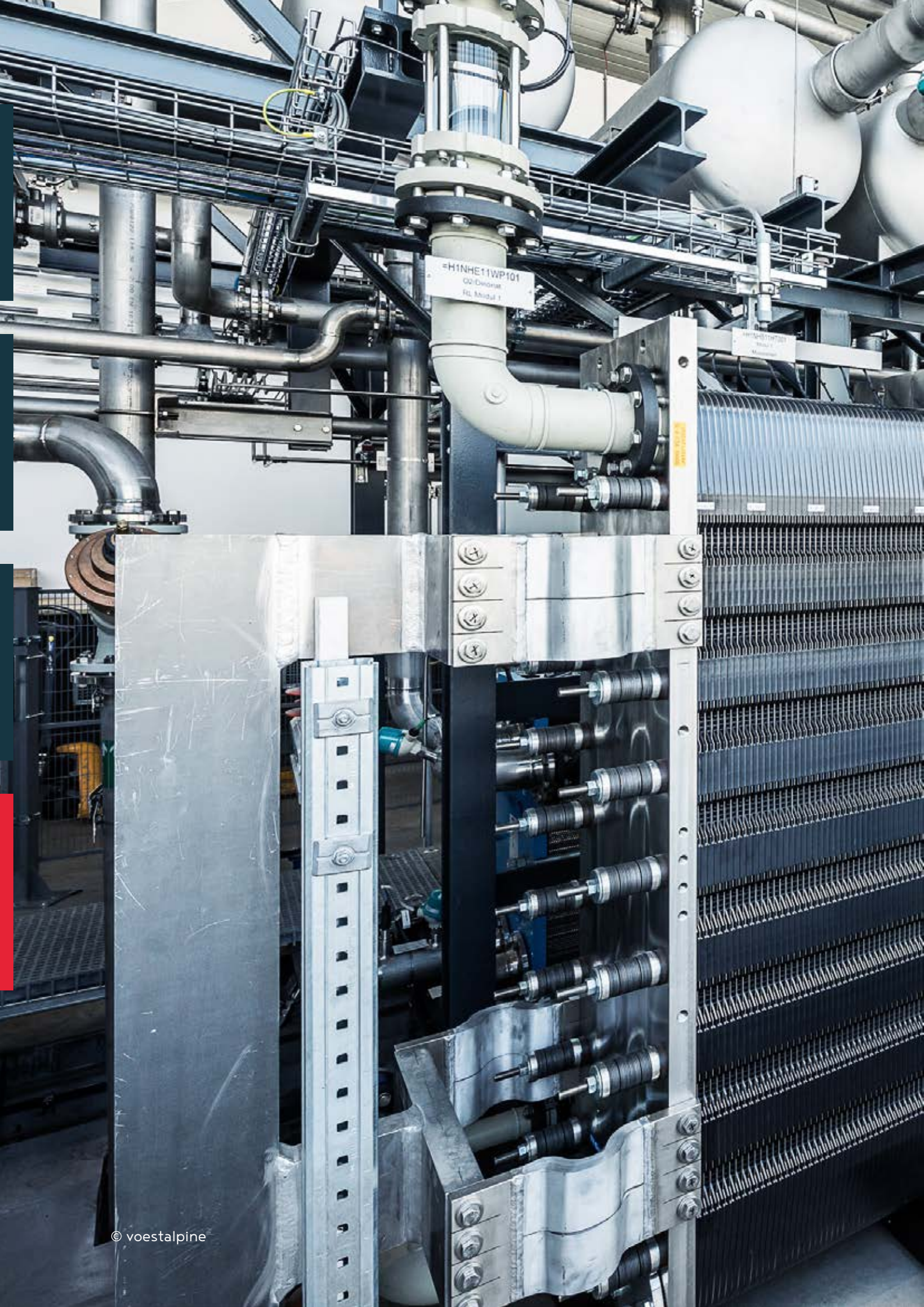
The Austrian Renewable Energies Expansion Act (Erneuerbaren-Ausbau-Gesetzes - EAG) has set the goal of increasing the electricity generated from renewable sources by 50 percent by 2030: +27 TWh. Based on the annual full load hours that can be assumed for wind and photovoltaic energy, this means doubling the installed capacity for renewable energy: approx. +19.5 GW.

For network sizing, the power to be transmitted is the decisive factor, in particular the power peaks. Network development thus significantly contributes to the success of the energy transition. The network development plan lists projects for the next ten years.

To master new challenges in the converging energy system of the future, network development is also one of the three R&I dimensions.

The important questions contained therein, which the subsequently introduced initiatives also strive to answer, are:

- Which plants, for example at the interface between the sectors, are to be integrated into the energy system of the future and how can they be operated in the spirit of the economic optimum?
- Which new technologies for transmission technology and operational management can be integrated into the existing grid to reduce or postpone the conventional costs of grid expansion?



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H2Future

> Project type: Research
> Contact persons: Ronald Engelmair
> Project period: 01.2017 - 12.2021
> Project partners: Verbund, Siemens Energy, voestalpine, K1-MET, TNO

R&I direction of focus 2

Intensification of cross-sectoral activities

Project description

Decarbonisation or electrification affect all industrial sectors and private life. Therefore it is not only of essential importance for the electricity sector to transition to renewable energy, but the energy-intensive industry also faces new challenges. Steel production is particularly energy-intensive, due to the high process temperatures needed. Replacing carbon with green hydrogen as a reducing agent plays a significant role in reducing the CO2 emissions in steel production.

The generation of hydrogen by means of electricity in electrolysis plants is a typical application of sector coupling, which usually causes an increased energy demand. The EU flagship project H2Future not only looks at the decarbonisation potential in steel production, but also tests the possibilities offered by such systems in the area of flexibility provision for the electricity system.

To get initial empirical values, the layout and operation of a 6 MW electrolysis plant was examined on the company premises of voestalpine AG in Linz, as part of the Horizon 2020 H2Future project.

APG designed the grid-friendly operation of the system and ensured effective integration of the system into the electricity market for control reserves.

Achieved goals and results

Since decentralised flexibility, for example in industrial companies, and sector coupling are becoming increasingly important, APG can generate significant insights in the course of this large-scale project.

Even at the current stage of the project, it is already possible to draw conclusions for designing the economic operation of such a system on the balancing market. During ongoing pilot operation, which was also monitored and followed by APG, additional knowledge regarding optimal operation was gained. The lessons learned significantly influence the design of the future climate-neutral energy system.

Power-to-gas pilot plant

> Project type: Innovation
> Contact persons: Viktor Zeh
> Project period: 02.2021 - ongoing
> Project partners: Gas Connect Austria

R&I direction of focus 2

Intensification of cross-sectoral activities

Project description

In Austria, the goal is to have 100 percent of the domestic electricity system covered by renewable energy sources by 2030. The next goal, a decade later, is to be climate neutral across the entire Austrian energy system. Thanks to the high share of hydropower, renewable energies are already making a major contribution to electricity production. With 75.1 percent, calculated based on domestic gross electricity consumption, Austria ranked first EU-wide in 2019. If one considers the entire energy system, the percentage of renewable energy sources is significantly lower, at 34 percent. Almost two thirds of the total primary energy comes from imported fossil energy sources, i.e. oil and gas.

When it comes to the decarbonisation of the energy sector, the electricity sector is playing an increasingly important role, through both the direct electrification of applications (e.g. electric vehicles and heat pumps) and the production of green gases. This convergence of the electricity, heat and transportation sectors is in turn of essential importance for the electricity sector itself. High shares of renewable energy sources need to be integrated in a way that does not compromise security of supply.

Therefore, new solutions for long-term energy storage are required. One of the most important approaches for this is "power to gas", in other words the conversion of electricity into renewable hydrogen in electrolysis plants. The renewable gas can subsequently be stored or used in other applications, such as further conversion into green methane. To ensure that operation is optimal from a systemic and economic point of view, a holistic

Sample image

approach that takes into account the choice of location, dimensioning and operating times is needed.

Within the scope of the project "Power-to-Gas-Pilotanlage" (Power-to-gas pilot plant), conducted in cooperation with Gas Connect Austria (GCA), a cross-sectoral concept is developed. The idea behind it is that "sector transformers" will enable coupling of the electricity and gas networks in the future, similar to the transformers that couple different voltage levels within the electricity system. The generated hydrogen can then be fed into the gas network and existing storage facilities for natural gas. Should there be a lack of electricity, the hydrogen could be converted back to electricity again.

Neither APG nor GCA own the energy. Instead, the conversion capacities of the power-to-gas plant is provided to the market in a non-discriminatory way, similar to the principle of cross-border coupling lines that is already in use today.

Achieved goals and results

The insights gained thus far show that for the energy transition to succeed, such holistic approaches will have to be available on a large scale in the 2030s. To this end, research will have to be conducted to find answers to the open technical, regulatory and economic questions; practical experience is necessary. APG and GCA are therefore planning one of the first industrial power-to-gas plants with a conversion capacity of 50 MW.

After comparing the needs of both sectors, a location in eastern Austria was chosen. Here the conditions are optimal: The expansion of wind power will lead to large production peaks in the coming years, and at the same time the high-level electricity and gas networks are only a few kilometres apart.

Smart Wires

Innovative load flow management

- Project type: Innovation
- Contact persons: Jörg Leonhardt
- Project period: 08.2020 – 12.2021
- Project partners: Smart Wires

R&I direction of focus **4**

Continuous search for, evaluation and utilisation of new technologies

Project description

Large parts of the energy transition have to be mastered with the existing transmission infrastructure, since delayed approval procedures mean that the grid expansion cannot keep up with the growth in renewable energy sources. The effects of this discrepancy are felt already today, as the current transmission grids have to cope with volatile energy flows that they were not designed to handle. Electrical load flows always take the path of least resistance. If one simply let this run its course, some points in the grid might suffer from congestion, while other line sections still have capacity left.

Since 2006, the APG grid has been using phase-shifting transformers (PSTs) to control the load flows. The importance of elements for load flow management to optimally use existing grids will increase further. However, conventional PSTs are also characterised by high costs and space requirements and low flexibility.

A promising and flexible alternative to PSTs are mSSSCs (modular Static Synchronous Series Compensators) based on power electronics. By injecting a voltage that either lags behind or leads the current, the impedance of a line section can be influenced. Thus the active power in the grid can be optimised: The load on highly stressed lines is relieved and the load flow is better distributed to lines with less load. Compared to PSTs, mSSSCs not only offer cost and space advantages, but also faster controllability and better scalability.

Achieved goals and results

At the end of 2021, an mSSSC of Smart Wires Inc. was successfully tested; pilot operation took place in a 220 kV substation of APG.

The goal is to use mSSSCs in the APG grid to reduce expensive redispatch measures and costs for grid users. Additionally, this operation contributes to optimal utilisation of the existing systems. At the same time, the modularity of the applied system further increases the security of supply.

Backstory

Jörg Leonhardt, who is responsible for this project, has been examining various possibilities of load flow management for many years in his function as grid planner in asset management. In the course of this work, the first detailed exchange between APG and the US technology company Smart Wires, a provider of innovative load flow management based on power electronics, occurred in 2018. APG communicated specific requirements that have to be taken into account and applied, prior to implementation.

To get the ball rolling for testing the new load flow management solution, the project manager used the internal employee suggestion system in the summer of 2020. Within a short period of time, the idea became a successful interdepartmental cooperation.

From the beginning, maximum knowledge building with optimal use of resources has been the main focus. The quick implementation also reflects this, with only three months between signing the cooperation contract and setting up the pilot system in the autumn of 2021.

A 220 kV substation was selected and for four weeks, tests were performed with a modular system from Smart Wires. In the process, data and experience was gained that gives APG a knowledge advantage for the future use of such innovative tools.

LEGAL AND CONTACT INFORMATION

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