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SMART SOLUTION FOR OPTIMISATION ISSUES IN THE POWER GRID

ENERGY TECHNOLOGIES CATEGORY. The power grid is an energy infrastructure that is currently benefiting greatly from the excellent research being conducted at Swiss universities. Using mathematical methods and digitalisation, researchers are working on the power grid of the future – a grid that is coming under increasing pressure as electricity production becomes more decentralised, e.g. on the roofs and facades of buildings. This is a problem for the distribution network operators, who have to transmit this electricity; the existing grids have finite physical capacity, and to expand them is costly and time-consuming. Our universities are coming up with solutions to this problem. For example, ETH Zurich is working on a pilot project at AEW Energie AG, a distribution network operator in Aargau. Thanks to an optimisation algorithm developed on the basis of basic mathematical research conducted at ETH Zurich, the AEW network can be boosted by 10% – virtually, i.e. without the need for physical expansion. This is achieved by means of permanent real-time measurements and control commands that optimise reactive power and voltage in the grid.

Specifically, the network operators' dilemma is an optimisation problem: the more electronic components or decentralised systems with irregular grid feed-in are connected to a

Alessandro Scozzafava, team leader in Grid Development and Maintenance at AEW Energie AG, and Lukas Ortmann, professor for Control Systems at OST Rapperswil (from left to right)

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section of the grid, the more reactive power flows occur. This reactive power is caused by phase shifts in current and voltage in the AC grid and, in contrast to active power, it cannot be utilised. It does, however, cause load on the power line. The ETH Zurich algorithm, which is based on a mathematical method developed at the Institute of Automation at ETH Zurich and the NCCR Automation with the support of the Swiss Federal Office of Energy, continuously evaluates the voltage and reactive power in the grid using real-time measurements (online feedback optimisation), with the aim of optimising reactive power flows. "The project regulates the reactive power at an installation, which also has a positive local effect on the voltage. This results in a higher active power flow, even though the cross-section of the line remains the same," explains Alessandro Scozzafava, team leader in Grid Development and Maintenance at AEW Energie AG. If there is too much capacitive reactive power in the network, the voltage can rise so much that it exceeds the limit values. Axpo, which operates the upstream grid, remunerates compliant (inductive) reactive energy and charges for non-compliant (capacitive) reactive energy. If less non-compliant reactive energy is exchanged at the grid supply point to Axpo, this reduces the costs for AEW's network usage tariff for reactive energy, which in turn results in more favourable network usage tariffs for AEW customers.

The ETH Zurich algorithm ensures that AEW can itself optimise the reactive power problem in its medium-voltage network. If the real-time measurements indicate a problem, control commands are sent to the inverters of a large 865kWp photovoltaic system operated by AEW in Tägerig, Aargau. The inverters then produce inductive (voltage-reducing) or capacitive (voltage-increasing) reactive power, which is used to optimise the reactive power available in the grid.

The pilot project has now been successfully completed. "Without really trying it out, you can't say whether it will fail because of some minor detail. And here we were able to show that it really works in practice in the grid," says Lukas Ortmann, looking back. He was in charge of the project at ETH Zurich and is now professor of Control Engineering at OST Rapperswil. The pilot project involved only one PV system controlled for reactive power production in the medium-voltage grid. However, the ETH software solution could open up much greater potential if it were also to be used decentrally in systems with inverters (PV systems, charging stations, heat pumps) in the distribution grids downstream of AEW, Ortmann explains. This way, solar energy could be made more grid-friendly and grids could be operated more efficiently, securely and cost-effectively thanks to the continuous feedback data.

"Power grids are critical infrastructures, and so it is no surprise that network operators are cautious about implementing new solutions. At first we were afraid that we wouldn't find a partner for the pilot project," says Ortmann. But AEW Energie AG was very keen to work with ETH. "As the person responsible for network development, one of my tasks is to look to the future. That's why we immediately agreed to work with ETH," says Alessandro Scozzafava. And AEW seems to have no regrets: the ETH software is still operative in its network.

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CHAM'S CLIMATE-NEUTRAL NEIGHBOUR-HOOD POWERED BY 100% RENEWABLE ENERGY

Roland Regli, Head of Execution at Cham Group, and Thomas Wickart, Managing Director of AWIAG Andy Wickart Haustechnik AG (from left)

RENEWABLE ENERGY CATEGORY. Over 360 years ago, a paper mill in Cham was granted the right to generate hydropower from the River Lorze. This not only opened a new chapter in the history of Swiss industry, it also laid the foundations for Papieri Cham, an unprecedented contemporary residential and business district with around 1000 flats and 1000 jobs. The new neighbourhood's largely self-sufficient energy system uses 100% renewable, fossil-free energy and its electricity is produced by a hydroelectric power plant and photovoltaic installations. The local electricity grid enables a connection for self-consumption at medium-voltage level. The district is heated and cooled using geothermal energy and the thermal energy of the River Lorze. A highly digitalised energy management system ensures optimal use and efficient consumption of Papieri's energy. Everything has been carefully planned out, from smart technologies for residents and businesses to an electromobility concept and biodiversity measures. Cham Group AG is creating Papieri Cham with its energy-concept planning partners Andy Wickart Haustechnik AG, Alfacel AG and pom+Consulting AG.

Paper was still produced at the Papieri site until just a few years ago, and this unique industrial flair can still be felt today – around a quarter of the old factory buildings are preserved and carefully restored, thus safeguarding this history. The River Lorze meanders through the neighbourhood, where the third phase of construction work is still underway in many places. Completion is planned for the end of 2026. But you can already see generous green spaces, renaturalisation efforts, beaver and fish steps, a footbridge over the River Lorze and inviting public areas. The site, which covers approximately 11 hectares, is intended to provide a welcoming environment for both people and nature. It has received certification as a 2000 Watt Site in recognition of its exemplary energy efficiency and use of renewable energy.

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One of the project's most impressive elements is its unique energy concept: "The technological sophistication of our system landscape allows us to increase energy efficiency and achieve a high level of self-sufficiency," explains Roland Regli, Head of Execution at Cham Group. "Fossil-free was our goal from the outset, and we'll get there using state-of-the-art technologies and a high degree of digitalisation." The energy supply comes 100% from renewable sources and is 100% climate-neutral.

The immediate environment provides the perfect setting for the project: there is already a run-of-river power plant on the River Lorze that supplies 1250 MWh of base-load electricity per year, and photovoltaic systems will contribute a further 1110 MWh once complete. Around 40% of the Papieri's total electricity requirements will be covered by local production and distributed to consumers via its own medium-voltage self-consumption network with three transformer stations. This electricity will then go towards use in buildings, for outdoor site lighting or for electric vehicle charging stations. Infrastructure is being designed with storage batteries for bidirectional charging and will be expanded in stages. The heart of this residential and business district will offer up to 400 parking spaces with charging facilities and the first fast-charging park in Switzerland, with at least 10 DC fast-charging stations. Intelligent load management controls heat pumps, charging stations and ventilation systems, which can be restricted or switched off completely during peak loads.

Around 190 geothermal probes, distributed across eight geothermal probe fields, utilise the earth as an energy source and storage facility. The river water is also used as an energy source and for regenerating the geothermal probe fields. Heat pumps supply the neighbourhood's own heating and cooling network. The energy management system automatically selects which energy sources to tap depending on the temperature.

The energy flows on the site are measured continuously, which allows load management to optimise energy production and consumption whenever necessary. The wealth of measurement data also provides an ideal research platform capable of delivering some of the first long-term data on a system that generates energy using a combination of river water and geothermal probes. The Papieri site is participating in a research project organised by the International Energy Agency (IEA) in cooperation with the Institute of Energy Technology at the Eastern Switzerland University of Applied Sciences in Rapperswil and supported by the Swiss Federal Office of Energy. Neighbourhood residents also benefit from digitalisation: they can control their flat's basic functions using an interactive touchscreen and an app, and their energy bills are also automated and updated quarterly based on their measured consumption.

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CLEMAP – SWISS INTELLIGENCE FOR CHARGING WITH SOLAR POWER WITHOUT UNNECESSARY GRID EXPANSION

Pascal Kienast, co-founder, COO and head of Business Development at CLEMAP AG, Alessandro Buriola, head of Product Range Development at Otto Fischer AG, Gino Agbomemewa, co-founder, CEO and product developer at CLEMAP AG (from left to right)

ENERGY-EFFICIENT MOBILITY CATEGORY. To reach the net-zero climate target by 2050 we need a lot more electricity, for example for charging electric vehicles. This electricity can be produced using photovoltaic systems on buildings. However, these systems rapidly increase the power feed-in and feed-out of the property, and as a result, the connection to the power grid has to be extended at great expense. To get around this, we need to make buildings smarter. The innovative load management system developed by CLEMAP AG in close co-operation with Otto Fischer AG does exactly that. The CLEMAP technology algorithms coordinate the charging stations of different manufacturers throughout a building, dynamically prioritising or limiting the charging power depending on how much electricity the photovoltaic system on the roof is producing. The load management system can even set the charging current so that vehicles are charged solely with solar power. The solution is 100% Swiss Made, developed in Zurich and produced in Ticino.

The CLEMAP solution consists of a compact measuring device and a local control function installed in the building's distribution board or fuse box. The inconspicuous device con-

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OTTO FISCHER AG, 8010 Zurich
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tains a concentration of intelligent algorithms and interfaces for monitoring power; these analyse the building's energy flows and optimise power loads accordingly. No additional measurements are required. A software programme allows remote control of the charging stations, monitoring via a dashboard and billing (if required).

CLEMAP AG was founded six years ago by five engineers from ETH Zurich and SUPSI, among them the current CEO Gino Agbomemewa and COO Pascal Kienast, who have known each other since their childhood days in Ticino. "The demand for energy monitoring systems for buildings increased rapidly at that time. So we set out with the aim of developing networked modular energy platforms for monitoring and optimising energy flows," Gino Agbomemewa explains. The founders quickly realised the challenge they were facing: the lack of available practical, manufacturer-independent load management solutions, especially for electromobility. The manufacturers of loading stations and PV systems tend to have their own, non-standardised interfaces. Otto Fischer AG was one of CLEMAP AG's first customers and sales partners. The company was looking for load management solutions for its customers. The load-management device was connected was connectted to the 257 kWp photovoltaic installation on the roof of the Otto Fischer AG premises. "Our powerful device controls over 30 AC and DC charging stations from different manufacturers," explains Pascal Kienast. "It can be easily activated by electricians; no pre-configuration is required, the investment costs are low and the device is scalable from two to fifty charging stations." Otto Fischer AG is very happy with the result. "Thanks to the CLEMAP solution, we can meet the needs of all the user groups at Otto Fischer AG: the delivery section's electric van, and the employees' and visitors' private vehicles. And we have been able to significantly increase our own use of the photovoltaic system," says a delighted Alessandro Buriola, head of Product Range Development at Otto Fischer AG.

CLEMAP AG in Zurich currently has ten employees. It is well established on the market and is already active abroad. It is constantly developing its solutions and expertise in various customer and research projects. CLEMAP energy management solutions help to contain the costs of grid expansion. For example, the CLEMAP device can already be employed in measures that help balance demand on the grid, such as flexible tariffs and vehicle-to-grid. "Charging stations always want to charge as quickly as possible and are essentially unintelligent. Thanks to CLEMAP, they become a key element in cost-efficient energy transition," explains Gino Agbomemewa.

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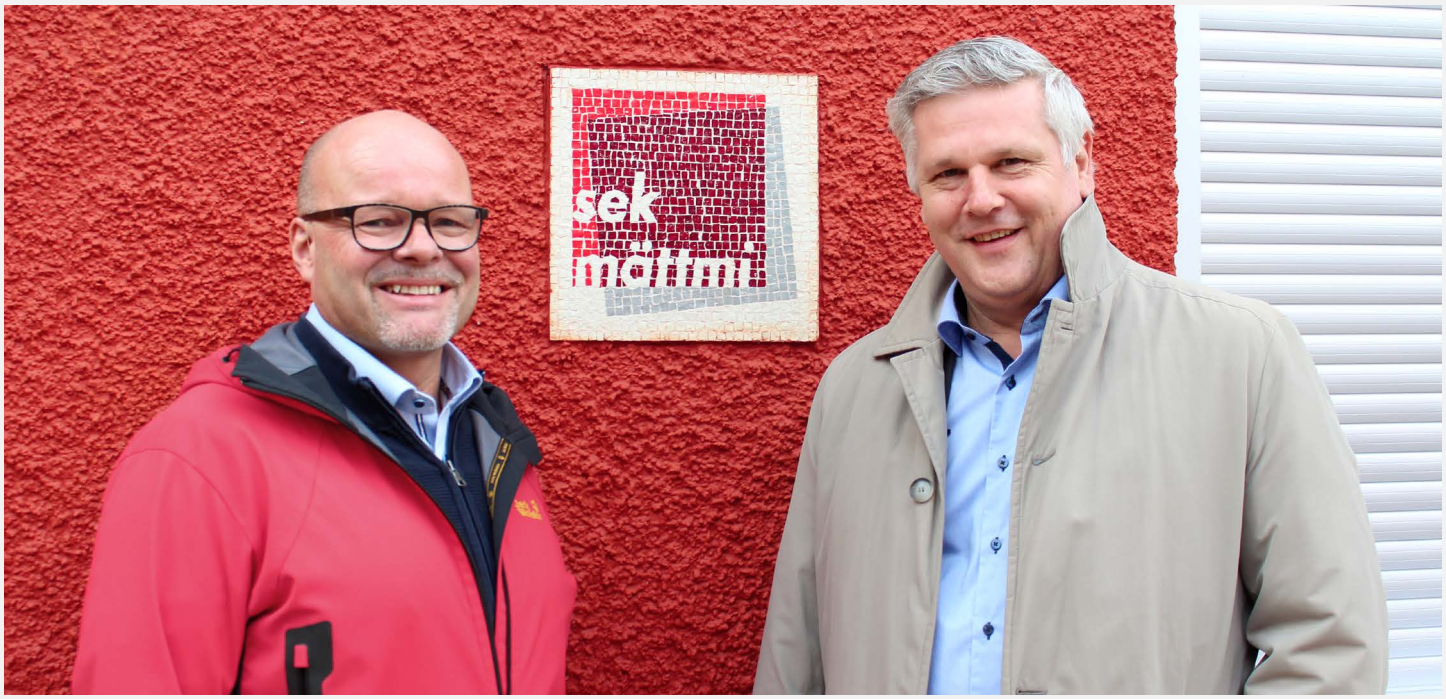
SEK MÄTTMI: A SECONDARY SCHOOL COMBINES CLIMATE NEUTRALITY, ENERGY SELF-SUFFICIENCY AND COST SAVINGS

BUILDINGS AND SPACE CATEGORY. The Knonau-Maschwanden-Mettmenstetten secondary school, affectionately known as sek mättmi, had been looking for an energy solution for quite some time. The aim was to minimise carbon emissions, produce as much of its own energy as possible and maximise energy self-sufficiency – all while keeping costs under control. Solutions based on individual technologies were generally unconvincing, too expensive or not interconnected enough. Finally they found their winner: an integrated energy system that utilises the Hybridbox intelligent energy hub for sector coupling. The Hybridbox was co-developed by Roger Balmer, owner of Pro-Energie GmbH in Eschlikon (TG). Today, the school's five buildings and indoor swimming pool in Mettmenstetten are completely climate-neutral. Thanks to its photovoltaic systems, heat pumps and a combined heat and power plant (CHP), the energy system operates at a self-sufficiency level of around 54% over the course of a year, rising to 70% when it comes to the school's electricity needs. For the pupils, a fully renewable and climate-friendly energy supply at school is now part of everyday life. And the taxpayers are happy too: energy costs have fallen so much that the local council's tax rate could theoretically be reduced by almost half a percentage point.

This successful energy solution has a long history. Back in 2011, the school still had oil heating – a system that burned around 75'000 litres of heating oil annually – and a boiler that needed replacing. This was the impetus for a search for



Roger Balmer (left), owner of Pro-Energie GmbH and Markus Ruggiero, head of infrastructure in the sek mättmi school administration

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alternative energy sources. The aim was to minimise carbon emissions and maximise energy self-sufficiency, all while keeping investment expenses under control. In addition to the high costs, a woodchip heating system did not fulfil the objectives; a pure heat pump solution on the other hand was out of the question because of the indoor pool's high energy consumption. High investment costs also led to the rejection of a geothermal probe system. According to Markus Ruggiero, head of infrastructure at sek mättmi, the search for a solution was long and complicated: "In our experience, energy consultants generally stick with their favoured solutions and aren't all that open-minded. They also tend to lose sight of cost concerns," he explains, "but it was important to us that we act responsibly – with respect to climate protection and the federal government's Energy Strategy 2050, but also towards taxpayers. At the end of the day, we have to meet all of our targets while inspiring confidence in the public that we are finding the right solutions."

The right solution finally came from Roger Balmer, owner of Pro-Energie GmbH, and Roland Zwingli, the team who had already worked on an Umwelt Arena Schweiz project to build an energy self-sufficient apartment block in Brütten (ZH). "Before we could develop our concept for sek mättmi, we first had to carry out measurements. At that point, nobody knew anything about the actual energy flows in the school complex, and you need that knowledge if you're going to do customised energy planning," Balmer says. Control points were installed and the first energy guzzlers were eliminated almost straight away by replacing things like old ventilation systems and boilers. "We then used the data measurements to decide how we could achieve the targets that had been set." Today, users can track all energy flows in real time. All energy flows into an intelligent energy hub, known as the Hybridbox, which is also used in the 2021 Watt d'Or-winning residential complex in Männedorf that Umwelt Arena and René Schmid Architekten AG built together. The Hybridbox is the system centrepiece that enables sector coupling: it regulates heating, cooling and heat recovery; electricity production for self-consumption or feeding into the grid; and the biogas-powered combined heat and power (CHP) plant, which produces heat and electricity (90kW) in winter. "People should always be our focus. The Hybridbox allows this complex energy system to be operated using relatively simple elements."

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PRO-ENERGIE, 8360 Eschlikon
↗ **WWW.PROJEKT-ENERGIEMANAGEMENT.COM**

HYBRIDBOX AG, 8360 Eschlikon
↗ **WWW.HYBRIDBOX.COM**

Thanks to the new energy system, sek mättmi can cover its own energy requirements in summer independently and with zero emissions. Previously, carbon emissions weighed in at around 245 tonnes. Photovoltaic systems (PV) with an output of 222 kWp, an air heat pump and heat recovery all contribute to the school's net-zero energy supply. The pupils helped to install the PV panels with support from Solafrica, one of the Watt d'Or winners in 2023. In the colder months of the year, the CHP plant runs on biogas produced from local sewage sludge that has been collected in the Schönau Cham wastewater treatment plant. "This energy system allows us to save around CHF 75'000 per year, which amounts to half of the site's previous energy costs." Before the new energy solution was installed, sek mättmi drew 250 MWh of electricity from the grid. It can now meet 70% of its own annual electricity needs. "We have to bear in mind that when the construction phase ends, the optimising process begins," Balmer says. In fact, new ideas are already in the discussion or planning phases, for example a fine-tuned storage battery, hydrogen or methanol, small wind turbines on the roof or an additional PV system to cover the bike park. "We'll be getting two francs back on every franc we invest, and the taxpayers see that. And ultimately they are the ones who decide whether to approve the budgets for climate- and energy-friendly solutions," Ruggiero says.

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