Energetic

The new Research Center ENERGETIC unites research expertise at TU Graz in the field of energy

The European synchronous electricty grid stretches from the North Sea to the tip of Italy's boot and from the far west to the far east of Europe. Wolfgang Richter, a researcher at TU Graz, calls it "the most complex and largest machine humans have ever built" and for Sonja Wogrin, also a researcher at TU Graz, her research work in the field of electricity management is "the coolest job in the world". Climate change, the challenge of high energy prices and the difficulties of importing fossil fuels are presenting the energy industry and energy systems in Austria and Europe with ever greater challenges.They are met with investments in scientific research into the renewable energy sources of water, wind, sun and fusion energy. TU Graz is active in all of these areas. These research efforts were recently brought together in the Research Center ENERGETIC (Research Center for Energy Economics and EnergyAnalytics), which deals with sustainable energy supply at various levels. The spokesperson of the Research Center is Sonja Wogrin, professor and also head of the Institute of Electricity Economics and Energy Innovation at TU Graz. >

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Talk Science To Me
TU Graz-Podcast

How she organises her climate-friendly everyday life and why she loves her scientific work, Sonja Wogrin explains in the Talk Science to Me podcast.

DECARBONISE THE ENERGY SECTOR

There are two main reasons for Sonja Wogrin to love her scientific work: electricity economics is not only scientifically demanding, but also represents one of the central topics of the future. At the Institute of Electricity Economics and Energy Innovation, researchers simulate different energy systems, investigate possible scenarios, and test optimisation options and potential system expansions. "For example, we are investigating how more and more volatile power sources such as wind and solar energy, which are being fed into the system, affect the power grid, and above all, how economical these changes are." After all, investments in renewable energy sources are in part enormous and must be counter-financed. "It's very simple: if an investment is not worthwhile, it won't happen," says a convinced Wogrin. "Capital-intensive technologies, such as hydropower plants, have a longer payback period than a wind farm. Energy infrastructure is particularly long-lived, which means that the investments we make today will be with us for decades to come. Therefore, it has to be well thought out. But it is definitely necessary. We have to commit to that as a society."

In Austria electricity only accounts for about 20 per cent of the total energy required. The remaining 80 per cent is used for heating, cooling, transport and industry. According to Wogrin, decarbonising the electricity sector is the easiest exercise despite all challenges, because most of the important technology options – wind, water and solar power – are already naturally available.

For this reason, the researcher also sees the electrification of the other sectors as the most promising path. Especially since electricity, unlike other energy sources, is very easy to transport: "The electricity that is produced off-shore in wind farms in northern Germany, for example, is available here in Austria almost immediately. It's a miracle of engineering." However, this free movement of electricity across Europe and across national borders also brings challenges. And there are both winners and losers. If cheap electricity is sold by German suppliers to Austria, for example, the German suppliers and the Austrian consumers are happy about a larger sales market and cheap electricity. German consumers, whose electricity prices could potentially rise, and Austrian suppliers, whose sales market will be joined by further competitors, could be less pleased.

Lunghammer – TU Graz

Wolfgang Richter in the hydraulic engineering laboratory at TU Graz.

HYDROPOWER AS ENERGY BALANCE

To store energy effectively is a topic of Wolfgang Richter's. At the Institute of Hydraulic Engineering and Water Resources Management, he is working on pumped-storage hydropower plants – i.e. large-scale storage options for volatile renewable energy that have already been in operation in Austria for a century. "If the trading of electricity increases even more, for example the import of volatile renewable energy from off-shore wind parks, pumped-storage hydropower is a beneficial trading option that strengthens Austria's position as a landlocked country," Richter says.

"They are forever assets because they were hewn out of rock 100 years ago and since then have been producing exactly the same electricity that we use all over europe." In a pumped-storage power plant, water is pumped from a lower reservoir to a higher one at times of low prices on the energy market (which means a surplus in production), and when prices are higher at times of higher consumption in the morning or evening, the high pressurised water powers electricity-generating turbines. There are currently pumped-storage power plants in Austria with a capacity of three terawatt hours and over 5,000 megawatts of installed turbine and pump capacity. Power plants of over 800 megawatts are currently being built, which makes pump storage hydropower plants the most important electricity storage systems.

Especially in the Alpine region, these storage power plants are very popular because of the naturally existing gradients and are constantly being expanded. One option at present to expand existing power plants with regards to limiting curcumstances or new power plants in the vicinity of urban settlements, is in particular underground pumped-storage hydropower plants with new caverns. You don't necessarily need a mountainous topography, explains Wolfgang Richter: "It is perfectly possible to build a pumped storage facility in shallow areas with the right geology by excavating deep. An additional advantage is that this could also store heat and cold in the water in closed-loop pump storage hydropower plants in order to compensate seasonally for cooling in summer by storing the heat, and heating in winter by storing the heat via heat grids."

In his research, he is mainly concerned with transient flow processes and model tests of surge tanks, which are large underground structures consisting of tunnels and shafts that make it possible to control the large quantities of water of several hundred thousand tonnes in the long pressure tunnel systems. "These applications are safety-critical and very individual to each plant. No water is allowed to spill or leak, it also minimises the pressure surges when the machines have to switch over quickly or be shut down fast, which guarantees the longevity of the plants."

COMPENSATION FOR GAS-FIRED POWER PLANTS

An important advantage of storage power plants is above all their ability to react quickly. This makes it not only the backbone of the Austrian electricity system, but of the European one as well. In the event of a blackout – i.e. a widespread power failure – they are the first to react and produce electricity. Restoring a power grid after a power failure is, among other things, the field of research of Herwig Renner at the Institute of Electrical Power Systems >

What happens during a blackout?

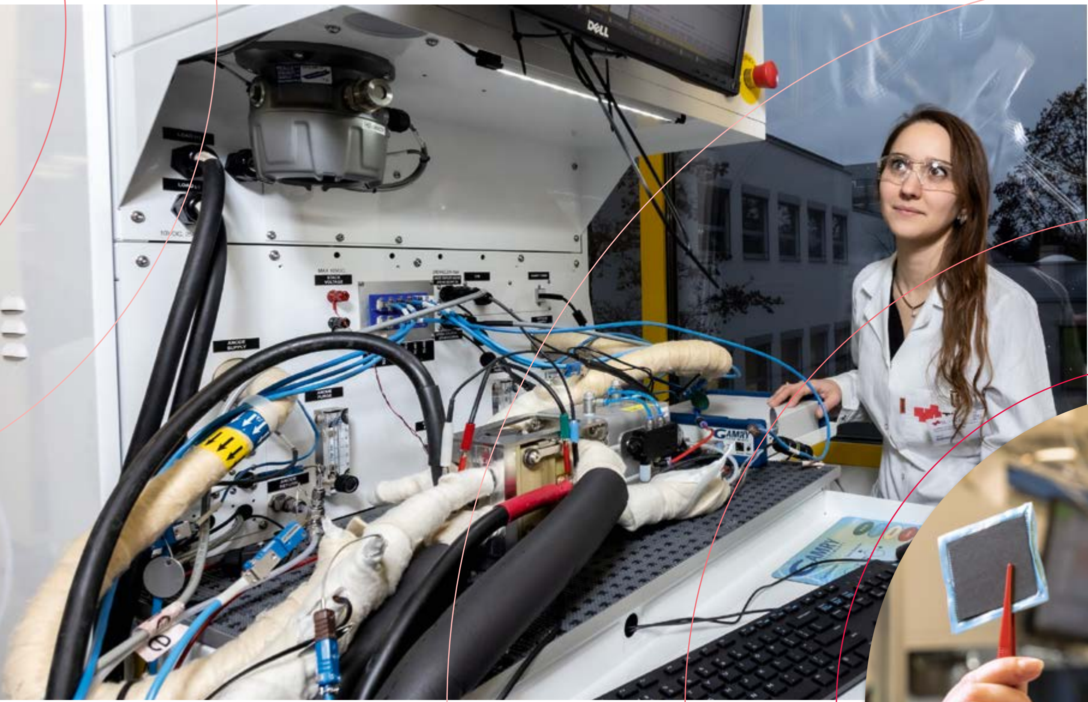
at TU Graz. For example, the institute team advises electricity producers on safety exercises and blackout scenarios. But here, too, the provision of renewable energy and, above all, its integration into the existing power grid is a key issue. For Herwig Renner, however, the primary issue is not fluctuating electricity sources and their integration, but the challenges posed by the planned phase-out of gas-fired power plants: "These plants can be used for balancing and peak energy in our energy grid due to their good control characteristics," he explains. This guarantees the stable operation of our electricity grid, which is based on a fragile balance between production and off-take.

Today, gas-fired power plants help to balance the loads in times of high energy demand as well as low energy yield from renewable energy sources – for example in winter or at night. However, this fact makes our energy systems dependent on the import of fossil fuels and gas suppliers. For Renner, a Europe-wide view of this issue is a key point: "The statistics tell us that the off-shore wind farms in northern Germany produce power inversely to photovoltaics and could thus help bridge the winter months. For this to happen, however, the energy must be able to be transported from northern Germany to the rest of Europe, which in turn requires our energy networks to be designed for this purpose." Renner sees great potential here, especially in the expansion of the already partly existing direct current lines: "They are very stable and, above all, can transport electricity over very long distances, even underground."

HYDROGEN SYSTEMS

In addition to the expansion of grid capacities for Europe-wide transport, storage options offer great potential – such as battery storage on a small scale, the large-scale pumped-storage power plants, but also hydrogen, among other things. Merit Bodner is involved in this field at TU Graz. At the Institute of Chemical Engineering and Environmental Technology, she is primarily concerned with the ageing of fuel cells and electrolysers and, above all, how this can be detected and stopped. "A big issue today is still that the lifetime of a fuel cell or an electrolyser cannot be fully predicted," explains the researcher.

In addition, the "all-round green" hydrogen system is also an issue. "Substances of concern are still processed in fuel cells – something which is now regulated by the new PFAS regulation," she explains. "There is still the exception that substances that cannot yet be replaced by sustainable alternatives today may continue to be used – but of course it is an important research concern to make hydrogen systems sustainable and fit for the future." Teflon, for example, is one of these questionable materials, as is platinum. Platinum is mined a huge container under socially precarious conditions and requires massive earthmoving. One tonne of raw ore contains only about 10 grammes of platinum. But finding alternative materials is not easy at all, explains Merit Bodner: "Many substances that we could use simply do not have the necessary characteristics to be considered for hydrogen systems." As a solution, researchers are working on specifically designed new materials that have the same or in some cases even significantly better properties than conventional materials. And recycling is becoming increasingly important. For example, 100 to 2,000 grams of platinum group metals can be extracted from one tonne of electrical waste. An important step towards lower resource consumption.



Lunghammer – TU Graz

Merit Bodner will give one of two keynote lectures at the TU Graz Science for Future Science Day, which this year is dedicated to the topic of New Worlds in Production.

Talk Science To Me
TU Graz-Podcast

Christopher Albert on fusion energy.

FUSION ENERGY

Today, most of the renewable energy that needs to be stored comes from sources such as wind, water and sun. In addition to these natural sources, fusion energy can help. Classically, electricity is generated in nuclear power plants by means of nuclear fission. More and more countries now want to get out of this form of energy production – because of the high risk potential in the event of accidents and, above all, the need to store the residual materials for decades under the highest safety conditions. But instead of splitting nuclei of heavy molecules such as uranium, nuclei of lighter molecules such as hydrogen can also be fused to produce energy. The prototype is the sun. "The processes in a fusion reactor are similar to those in our sun, except that we don't use pure hydrogen, but the hydrogen derivatives tritium and deuterium," explains Christopher Albert, a theoretical physicist at TU Graz. His research focuses on energy from nuclear fusion, and in particular on particle motion and the rotation of the plasma that is created in the reactor. The stability of the reaction and the currently high energy input to get a reaction going and keep it active are particularly important research topics. There is still a long way to go before actual fusion power plants can be built – intensive work is currently underway to set up an experimental power plant in Germany. Christopher Albert also wants to set up an experiment in Graz as an extension of his theoretical work. "We want to check our calculations and simulations there. There will be no radioactivity or nuclear fusion, but it would allow us to study plasma much more extensively." A corresponding funding application is currently being prepared.

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Although it is still a very long way to practical power plants, Albert sees great potential in fusion energy: "A big advantage is safety. If there is an incident, the reaction just stops – we tend to have the opposite problem and find it very difficult to sustain the reaction. In the worst case, there is damage to the plant – like when a huge container falls over in a steel power plant." And the problem of nuclear waste is a much smaller one due to the much shorter half-lives and lower radioactivity of the material.

BUREAUCRATIC HURDLES

Regardless of where the energy ultimately comes from and how it is stored, an important factor for decarbonisation, according to Sonja Wogrin, is to reduce bureaucratic hurdles: "If I plan a new power line today, it can take a good ten years before it is actually built. Of course, strict environmental protection is necessary, but we must commit ourselves to climate neutrality." Herwig Renner on the network planning side has a similar view: "Our power grid planning is currently very conservatively oriented towards rarely reached peak loads. This very often prevents new plants from being allowed to feed into the grid." ■