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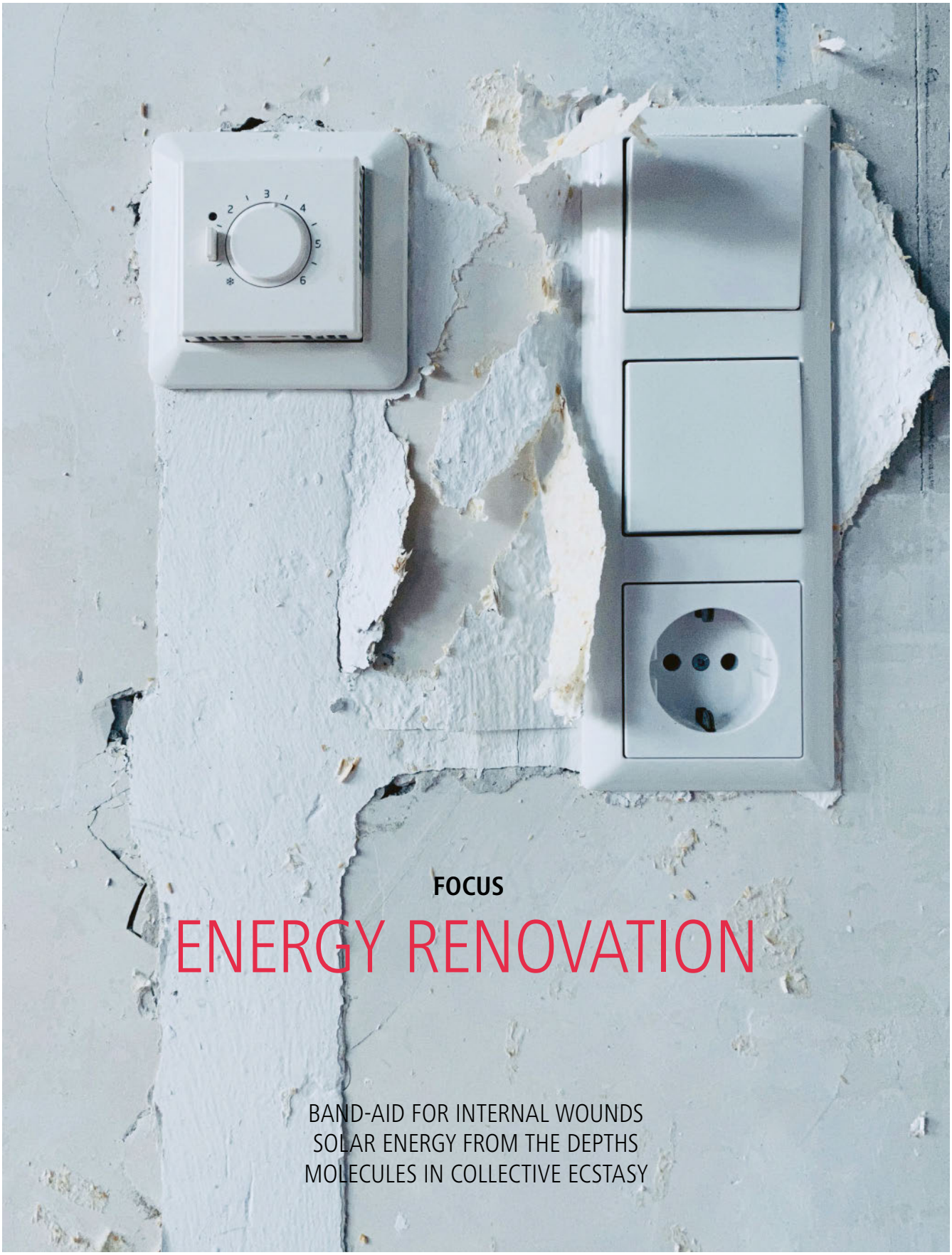

FOCUS

ENERGY RENOVATION

BAND-AID FOR INTERNAL WOUNDS
SOLAR ENERGY FROM THE DEPTHS
MOLECULES IN COLLECTIVE ECSTASY

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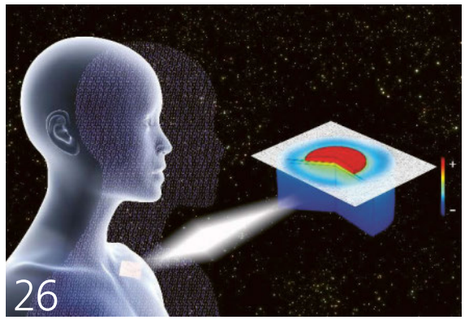
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Photos: iStockphoto, Daniel Kellenberger, Empa

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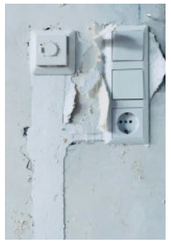

Heating and cooling of buildings is one of the largest sources of CO_2 in Switzerland with its 1.8 million residential buildings. If the energy turnaround is to succeed, most of them will have to be renovated. The current issue of Empa Quarterly illustrates what can be done and how to set priorities.
Image: iStockphoto

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THINK IN CYCLES

Dear Reader

Almost everything has a beginning and an end: life, the Corona crisis (hopefully), Donald Trump's presidency – and our approach to consumer products. Produce, use, discard, dispose of. It is obvious that this generates an enormous amount of waste, and many valuable materials are lost. It is also obvious that our natural resources are finite.

The logical consequence is that we must finally switch from throwaway to recycling mode. In other words: (almost) nothing is waste, (almost) everything is a resource. This won't work in every situation, but we should at least try.

For instance, by converting the greenhouse gas CO_2 from the atmosphere into climate-neutral methane. This closed carbon cycle, which we are exploring in our mobility demonstrator move, is also the subject of a new exhibition at the Swiss Museum of Transport (see p. 34). The same chemistry is also mastered by microbes deep down in the earth's crust. A European research project wants to take advantage of this to produce CO_2-neutral methane in the deep (see p. 24).

Even old car tires should not simply end up in waste incineration plants or landfills; Empa researchers are using them to produce a new type of asphalt and test its suitability for real-world applications (see p. 8). The discovery of various strains of bacteria from chemical waste landfills shows that, sometimes, something useful can come out of a landfill. These hardy microbes decompose even the most stable of environmental toxins – completely biologically (see p. 32).

Enjoy reading!
Your MICHAEL HAGMANN

Photo: Empa

COUGH, PLEASE!
What happens when someone coughs? How do droplets containing pathogens such as SARS-CoV-2 spread in the surrounding air? Although models describing such processes do exist, Empa researchers want to improve them – with the help of their specially developed coughing machine. As if from lung wings, two tubes expel compressed air out of the machine's "mouth" (see center of image, below the white bottle). With a precise control system, the machine simulates different coughing events along with the emitted droplets. The air is heated to body temperature and has a relative humidity of 98 percent to come close to the natural model – with or without a mask.

Further information on the topic is available at:
https://www.empa.ch/web/s604/corona-risiko-in-der-seilbahn

THE INVISIBLE KEYHOLE

HIDDEN SECURITY
Invisible sensors printed with conductive ink are concealed in this seemingly simple transparent film.

At first glance, Empa researcher Evgeniia Gilshtein's idea seems inconspicuous – or more precisely, invisible. What initially looks like a simple transparent film conceals a whole new level of security. Invisible buttons are printed with conductive ink on the transparent carrier material, the position of which is known only to insiders. Such circuits can be connected to a door lock as an access code, for instance. If the buttons on the polymer film are pressed in the correct order, the door opens.

https://www.empa.ch/web/s604/transparent-security

THE STORE OF THE FUTURE

Lidl Switzerland aims to operate its stores even more sustainably and efficiently in the future. Together with Empa, the company now puts this plan into practice. First, the energy consumption and the interaction of various operational systems in existing stores will be analyzed. Then, the Empa researchers will develop an optimized concept for the stores of the future based on the findings of their analysis.

https://www.empa.ch/web/s604/partnerschaft-lidl

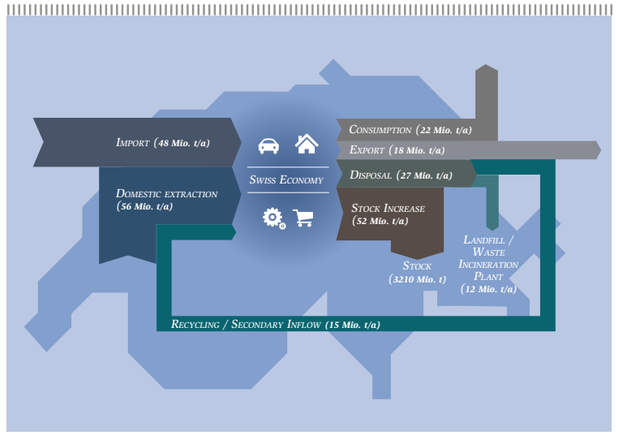
Photos: Empa, Lidl Schweiz AG

SWITZERLAND GETS HEAVIER

Empa researchers have analyzed the entire material and energy flows of the Swiss economy. Their synthesis report called MatCH ("Material flows Switzerland") now provides important data and comparisons. It is interesting to note that every year Switzerland becomes "heavier" by 52 million tons due to imports that remain in the country. 12 million tons of material are disposed of, and 18 million tons are exported.

The study was mandated by the Swiss Federal Office for the Environment (FOEN).

www.empa.ch/web/s604/MatCH



PRECISION
Sensors at CERN are often positioned using threads or wires.

EXCITING SUPERFIBER FOR CERN

When stretched to align accelerator components at CERN to the micrometer wires can fray over time. This can lead to inaccuracies in measurements. Empa researchers are now developing a metallized yarn coated with a special polymer that can align components over time without losing tension.

www.empa.ch/web/s402

Photo: Cern; Grafic: Empa

LOAD TEST
Since October 2020, rubber asphalt has been laid at a busy intersection in Zurich for test purposes.

WITH A PINCH OF RUBBER

Swiss drivers wear out countless tires. Instead of incinerating them, they could be reused locally: the asphalt of various countries has long contained rubber from used tires. Empa and its partners from industry are adopting this idea for potential applications in Switzerland.

Text: Norbert Raabe

Photos: Gian Vaitl, Empa

Commuters who nag about traffic stress should look at the ground every now and then. And take comfort in realizing it might be worse, much worse: Asphalt endures blistering heat, cold stress and plenty of pressure from above. It should also be as quiet as possible – and in the future, of course, more environmentally friendly.

Composed from a hot rock mixture and the binder bitumen at around 160 degrees, asphalt causes substantial CO_2 emissions – through production, long transport routes and paving. To improve its environmental footprint, old asphalt, which can already be recycled, will be used on a large scale in new pavements in the future. Moreover, recycled concrete or other residual materials – such as used car tires, of which there are plenty in Switzerland – can be "disposed of" in it.

An Innosuisse project led by Empa's Concrete and Asphalt lab has explored what benefits this idea could have in Switzerland. Specifically, can rubber particles replace the polymers in polymer-modified bitumen for heavy-duty asphalt? After all, compounds such as the widely used styrene-butadiene-styrene give pavement more plasticity, better recovery and longer life.

The focus of the project was on the practical implementation of the technology: After some preliminary tests, the asphalt mixtures for the experiments were produced by the manufacturers FBB and Weibel AG. The mix design was based on the standard semi sense asphalt SDA 4–12, a low noise sur-face course due to its high air void content. The AC B 22 H is a so called binder course that is placed under the surface course – in this case currently with 30 percent recycled asphalt. The selected rubber granules also came from Switzerland, from the manufacturer Tyre Recycling Solutions (TRS) in Pré-verenges in the canton of Vaud.

WET OR DRY?

Rubber asphalt can be produced using two different methods. In the "wet" method, the rubber granules are added to the hot bitumen; then the mixture is mixed with the defined aggregate – sand and gravel of different sizes, depending on the pavement. The catch is that the bitumen-rubber mixture becomes less viscous over time and the rubber begins to decompose; it can only be processed for about 48 hours. In the "dry" process, on the other hand, the rubber particles first trickle into the heated aggregate mixture. The bitumen is added later. Because the Swiss asphalt manufacturers are prepared for this, this path was chosen.

The experience at building materials manufacturer FBB in Bauma has thus far been positive. "No problem," says Christian Gubler, chairman of the management board, "it was easy." The particles were thrown through a flap into the aggregate mix – in bags that dissolve at high temperatures. "Just like we do when we add colorants, for example, for red asphalt," Gubler explains. There were no difficulties at Bern-based Weibel AG either. "The handling was trouble-free," says Samuel Probst, head of bituminous construction materials and pavement plants.

WATER, COLD AND PRESSURE

An Empa team led by asphalt specialist Lily Poulikakos examined the final products from micro to large scale. In addition to standard tests for bitumen content and air voids, electron microscope images showed whether and how the rubber particles dissolve and distribute within the asphalt matrix.

In the splitting tensile test, test specimens were burst under pressure from above – one wet and one dry – to determine how sensitive they are to water. Tear tests at minus 12 degrees showed how the material behaves in cold winter conditions. Finally, the traffic factor: In the "Hamburg Wheel Tracking" test, samples in 50-degree hot water endured 10,000 passes of a steel wheel weighing a good 70 kilograms – a tough test for rutting. Empa's own simulator was aimed in the same direction: It subjected 1.20-meter-long linings to 60,000 slow tire runs with high loads over the course of eight hours.

The analyses showed that it's details that matter. For instance, the optimum time between mixing and installation on the road depends heavily on the type and quantity of rubber granulate. In comparison with the well-known polymer bitumen asphalt, the surface course asphalts with 0.7 or 1 percent rubber fulfilled the requirements in the majority of cases. Resistance to cracking due to cold was significantly greater with one percent rubber than with the polymer bitumen asphalt. In terms of water sensitivity, the construction materials met the Swiss requirements, with one exception. And in Empa's own tire load simulator, small but deeper ruts appeared in the rubber asphalts than in the polymer bitumen pavement.

The conclusion: Despite some drawbacks, the rubber asphalt ultimately met the requirements. "It is definitely suitable for further investigations for use in road construction," sums up Empa researcher Poulikakos. Manufacturer TRS is also pleased with the results: "We now have a professional confirmation," says Sonia Megert, Chief Operating Officer. "It was a very good collaboration. Empa quickly found a solution whenever problems arose." ▶

Of course, all partners are aware that this is only the first step. Despite all the efforts, the laboratory does not correspond to real-world conditions, explains Poulikakos. The experiments do give a detailed impression, but how years of exposure will play out in reality "is another matter," says the specialist. "The truth lies ultimately on the road."

THREE TEST ROUTES

Further steps have already taken place. In the cantons of Jura and Vaud, Weibel AG built two test sections on cantonal roads using rubber granulate asphalt. "A rough asphalt on a road with a medium load," explains Samuel Probst, "and a surface asphalt on a road with a relatively high load. After all, they were supposed to be real endurance tests."

Unlike previous experiences with the "wet" production process, the paving went "absolutely smoothly," according to the manager in charge. On site, the workers did not have to endure any odors from heated rubber, and the consistency and workability of the asphalt was comparable to a polymer-modified asphalt. Admittedly, it will only show its true character after years. Paving took place last summer; the pavement is thus still in its infancy. Just like another test asphalt, which was laid as top layer at a heavily used intersection in Zurich. Its laboratory values were not beyond doubt: When the bitumen was hardness tested with a penetrating needle, the results fluctuated wildly and were sometimes well above the target values. "That suggests it might be too soft," says pavement specialist Martin Horat of the civil engineering office of the city of Zurich. "Let's see if there are deformations when it gets hot in summer."

Hans-Peter Beyeler, director at the "Eurobitume" association in Switzerland, is not particularly worried, though. "I already heard about that. I wouldn't worry about it for the time being," says the expert, who previously worked for almost 13 years as a pavement specialist at the Federal Roads Office (Astra). When rubber and bitumen are mixed, a new material is created; its behavior no longer corresponds to the original ingredients. His assessment: "The needle test may simply not provide useful information."

From his own experience, Beyeler understands that there is also resistance in the industry to asphalt as a "garbage chute" for recycled materials and skepticism about rubber in the road. Some 15 years ago, he witnessed how a test on the A1 in the canton of Aargau with rubber-modified bitumen, added as granules, went thoroughly wrong: The material was insufficiently dissolved in the mix; lumps formed in the asphalt. In the pavement, they spread on the surface; they had to be drilled out and filled with mastic asphalt.

FOCUS ON POLLUTANTS

To assess health risks from rubber additives in road asphalt, chemists from Empa's Advanced Analytical Technologies lab took a close look at components with risk potential. The results of leaching tests simulating the effects of a rainstorm showed that the levels of polycyclic aromatic hydrocarbons (PAHs), which can cause cancer, are lower in rubber than in asphalt. For heavy metals, zinc served as the lead element; very little of it was washed out. Lead and other harmful heavy metals were present only in harmless traces.

The Empa team also found that harmful benzothiazoles, which accelerate vulcanization in tire production, were released into the environment quickly and in relatively high doses. The experts' advice: remove these compounds before installing the rubber particles, for example by washing them out with water, which can then be disposed of properly.

THE TRUTH IS ON THE STREET

A lot has happened since then, however, so why not try again, Beyeler thinks. After all, there is good experience – not only in the US, where the technology has been in practice for a long time, but also in Bavaria. There, rubber-modified asphalts are already part of the building regulations – in other words, state of the art. The advantages, especially for porous surface courses: higher abrasion resistance, slower oxidation of the bitumen in the many air voids and thus delayed embrittlement. In short: a longer service life.

In any case, there would be enough raw material. Around 70,000 tons of scrap tires are produced in Switzerland every year. A small proportion of this is recycled, but the majority is thermally utilized – in waste incineration plants and, in large part, in cement plants, where the tires replace coal as fuel and thus improve the CO_2 balance

A BENEFIT FOR THE CLIMATE?

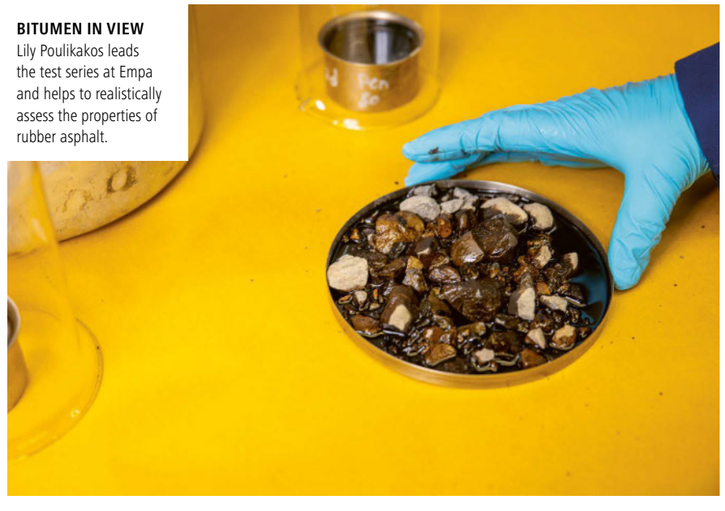
Empa researcher Zhengyin Piao is investigating the environmental impact of using old tires in road pavements as part of his PhD thesis in cooperation with the Institute of Environmental Engineering at ETH Zurich. Piao analyzed the entire life cycle of two whispering pavements with rubber asphalt. His calculations based on a model of a one-kilometer stretch of road show that these pavements perform similarly to polymer bitumen asphalt in terms of energy consumption. But they produce significantly lower CO_2 emissions – mainly because of the polymers in the conventional product.

So would rubber granules in roads contribute to climate protection? Piao's answer: It depends. In Switzerland, cement plants save so much CO_2 emissions by burning old tires that, overall, asphalt with rubber performs a little weaker than with polymers. But if cement plants succeed, as planned, in reducing their CO_2 emissions even further in the coming years or even partially neutralizing them with carbon capture technologies, including underground storage, the cards would be reshuffled – possibly in favor of rubber asphalt ...

Whether the idea will catch on in Switzerland depends, of course, on the market. They do have one advantage, says expert Samuel Probst from manufacturer Weibel AG: At least for the moment, they are cheaper than polymer bitumen asphalts. Nevertheless, he remains cautious: "If the test sections develop positively in the long term," he says, "I could imagine that a market will develop for it one day." ■

Further information on the topic is available at:
www.empa.ch/web/s308

Photos: Gian Vaitl, Empa



BITUMEN IN VIEW
Lily Poulikakos leads the test series at Empa and helps to realistically assess the properties of rubber asphalt.

BAND-AID FOR INTERNAL WOUNDS

Closing wounds in the digestive tract is a challenge. Empa researchers have now developed a polymer patch for the intestine that can be used to stably bond and seal internal injuries.

Text: Andrea Six

PATENTED
The team led by Inge Herrmann and Alexandre Anthis have developed a hydrogel patch that stably seals surgical wounds.

Photos: Empa

A burst appendix or a life-threatening intestinal volvulus are emergencies that need to be treated by surgeons immediately. However, a life-saving operation, in which tissue from the digestive tract has to be reattached, bears some risks. After all, everything that is transported through the gastrointestinal tract to the outside world in fact belongs there – and should under no circumstances end up inside the abdominal cavity. Highly acidic digestive juices and germ-laden food residues could trigger peritonitis or even a fatal sepsis.

STABLE
The composite material holds even under maximum load.

Needle and thread by themselves are not necessarily the perfect surgical tools for joining two pieces of intestine together, though – after all, you wouldn't think of sewing up a leaky food pouch either, would you?. Empa researchers have thus developed a patch that stably seals two sutured pieces of intestine and thus prevents dangerous leaks.

DREADED COMPLICATIONS

The idea of sealing sutured tissue with a plaster has already made its way to the operating rooms. But after the first of these products turned out to be poorly tolerated or even toxic, these plasters are currently made of biodegradable proteins. The problem is that clinical success is not always optimal and varies depending on the tissue, on which they are used. That's because the protein patches are primarily intended to support the healing process. They dissolve too fast when in contact with digestive juices and don't always hold tight. "Leaks after abdominal surgery are still one of the most feared complications today," explains Empa researcher Inge Herrmann, who is also professor for nanoparticulate systems at ETH Zurich.

The team led by Herrmann and Alexandre Anthis from Empa's Particles-Biology Interactions lab in St. Gallen therefore joined forces with Andrea Schlegel, a surgeon at Queen Elizabeth University Hospital in Birmingham, to search for a material that could reliably seal intestinal injuries and surgical wounds. They found a synthetic composite material consisting of four acrylic substances that, together, form a chemically stable ydrogel. What's more, the patch actively cross-links with the intestinal tissue until no more fluid can pass through. The researchers have already successfully patented this novel technology. The quadriga of acrylic acid, methyl acylate, acrylamide and bis-acrylamide works in perfect synergy, as each component conveys a specific feature to the final product: a stable bond to the mucosa, the formation of networks, resistance to digestive juices and hydrophobicity.

> "After all, you wouldn't want to sew up a leaky milk carton with a needle."

TAILOR-MADE PATCHES

In lab experiments, the researchers showed that the polymer system met their expectations. "Adhesion is up to ten times higher than with conventional adhesive materials," says Empa researcher Anthis. "Further analysis also showed that our hydrogel can withstand five times the maximum pressure load in the intestine." And in the material's design lies its tailored effect: The rubbery composite selectively reacts with digestive juices that might leak through intestinal wounds, expands and closes all the more tightly. The inexpensive, biocompatible super glue, which consists largely of water, could thus shorten hospital stays and save healthcare costs. Alexandre Anthis is thus already planning the next steps towards clinical application of the new wound plaster: "We are in the process of founding a start-up company to bring this innovative material to the market." ■

Further information on the topic is available at:
www.empa.ch/web/s403/particles-4d

FIRST SORT, THEN REFURBISH

Switzerland's building stock is quite impressive. There are around 1.8 million buildings in the country, but only one percent of this building stock is renovated each year. In other words, it will take 100 years for the entire building stock in the country to be renovated – which would be too slow to achieve the energy transition. But before politicians decide on stimulating subsidies, this daunting task must first be structured: which measures make sense for which buildings? And where to start?

Text: Rainer Klose

Heating and cooling of buildings is a major contributor to CO_2 emissions in all industrialized countries. To achieve the Swiss government's climate targets – net zero by 2050 – Switzerland's building stock must thus also make a significant contribution. But planners and decision-makers need a handout to introduce the appropriate measures in the most meaningful order. In 2019, Kristina Orehounig and her team undertook such a sorting.

ARCHETYPES OF ALL HOUSES

There are around 1.8 million residential buildings in Switzerland. Modeling the renovation needs for each house individually would require a huge amount of computation. So Orehounig and her team resorted to data mining. They searched national databases and sorted the buildings into 50 different archetypes, sorted by year of construction, heating type and number of occupants. The result: The majority of the Swiss buildings were built between 1949 and 1994, and 77 percent of these buildings are heated electrically, with oil or gas. This shows that there is considerable potential for renovation.

The researchers performed the same allocation for commercial buildings, sorting them into 45 different archetypes based on databases – restaurants, schools, hospitals, offices and stores, each subdivided by size and year of construction.

Since solar energy represents an essential basis for the energy supply of the future, all archetypes were assessed for their suitability for photovoltaics. This was done using climate data for the region, in which the building is located, as well as roof geometry data from the Federal Office of Topography (Swisstopo), which provided information about the size and slope of the roof surface.

Photo: Daniel Kellenberger

OVERVIEW
Kristina Orehounig is head of Empa's Urban Energy Systems laboratory since 2018. Her team conducts research on networked energy systems with the aim of massively reducing the energy demand and CO_2 emissions of buildings and neighborhoods. To this end, around 30 researchers from various disciplines are working together: civil engineering, mechanical engineering, electrical engineering, architecture and environmental technology are represented in her team.

TOWN AND COUNTRY

The selection of the appropriate energy retrofit method also depends on the building density: Houses in the city can be efficiently connected to a heating network – in contrast, for widely spaced buildings in the countryside, a heating network often does not make sense. Hence, the Swiss building stock must also be sorted by urban and rural areas.

"Greenhouse gas emissions could be reduced by 60 to 80 percent."

The researchers divided the entire Swiss land area into tiles of one square kilometer in size; tiles without houses were ignored. The rest was sorted again using public databases – depending on the amount of living space located on each tile, as well as other characteristics. The result is twelve Swiss neighborhood archetypes: four urban, four suburban, and four rural archetypes that describe the distribution of buildings in Switzerland.

HOW TO RENOVATE EFFECTIVELY

After all the sorting, renovation measures could be calculated for the individual archetypes. The researcher's conclusion: It is worthwhile to tackle the renovation of roofs and the replacement of windows in older houses with the highest priority. This alone can reduce the demand for heating and cooling energy by 20 to 30 percent.

The next step should be to renovate the heating systems in almost all types of houses – apartment buildings, schools and office buildings can often be renovated more cost-effectively than detached single-family houses. Why? In larger buildings, renovation of the heating system affects many square meters of occupied space at the same time. Any technical intervention is therefore more (cost-)effective.

SAVING GREENHOUSE GASES

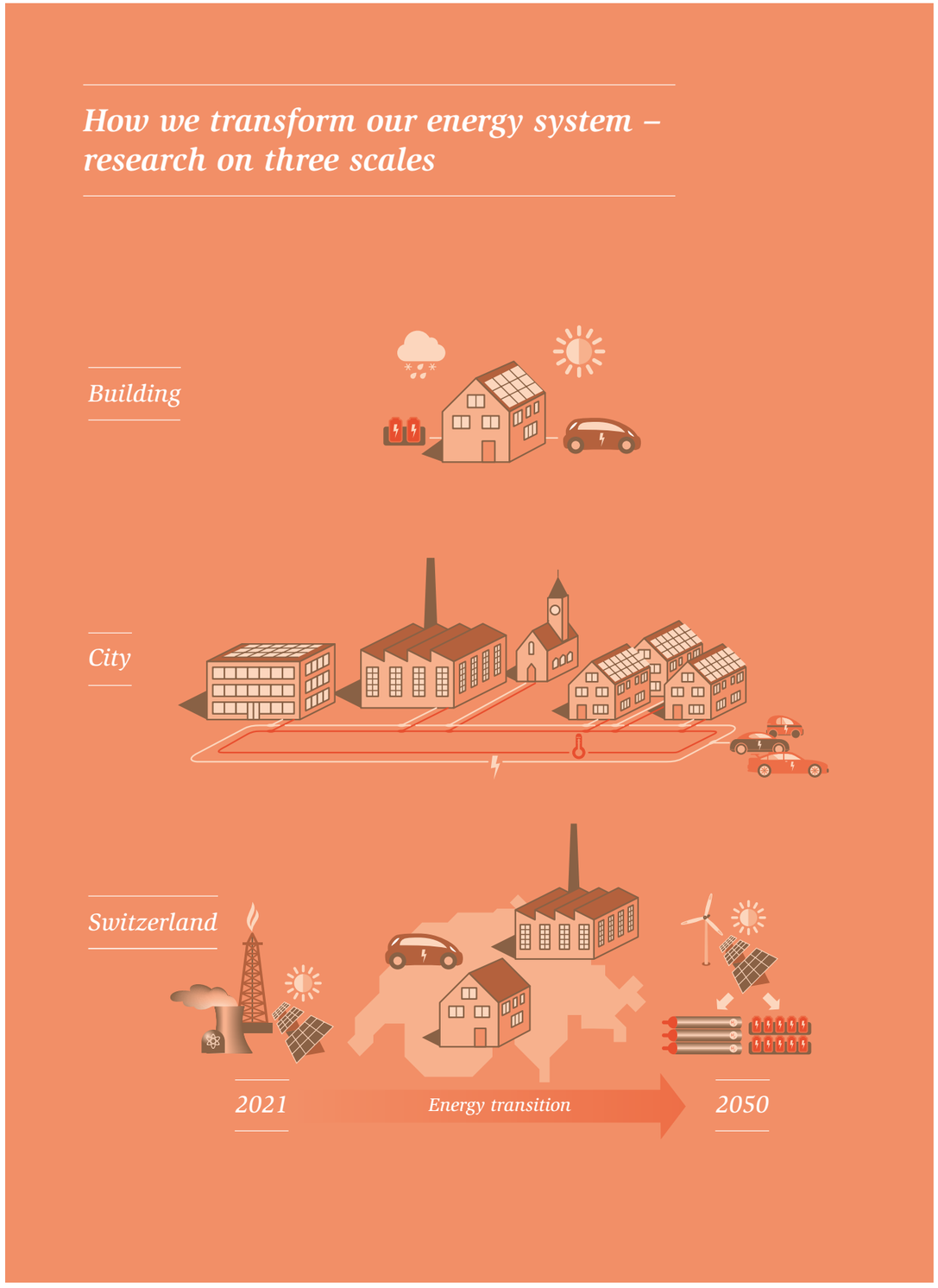
It is important to replace fossil fuels as fast as possible – with photovoltaics on the roof and on facades. Heat can then be generated, for example, by air-source heat pumps powered by the building's own solar electricity or other renewable energy sources. Biomass heating systems – biogas or wood pellets – also effectively reduce CO_2 emissions.

At the end of the analysis, Kristina Orehounig is hopeful: "If the proposed measures are taken, greenhouse gas emissions caused by Switzerland's building stock can be reduced by 60 to 80 percent." ■

Further information on the topic is available at:
www.empa.ch/web/empa/urban-energy-systems

TOWARDS ENERGY NETWORKS AND STORAGE

As the energy system is transformed, the planning and operation of buildings and neighborhoods is becoming increasingly complex. Solar energy is generated primarily in the summer at midday, but is expected to be consumed throughout the day, perhaps even in the fall and winter. So new energy storage systems for hours or days, as well as long-term storage for months, is needed to meet energy demand at all times. Empa is investigating battery storage for electricity and various heat storage technologies as well as the conversion of solar power into fuels to meet this challenge. The storage of sustainably generated energy should not only happen on a national level, but also on a building or neighborhood level. At the same time, fossil heating systems, such as gas boilers, must be replaced as fast as possible with new and sustainable systems – such as hydrogen fuel cells, a district heating connection, or heat pumps fed by renewable electricity. The whole transformation should also be balanced according to social and economic criteria. All these decisions need a scientifically sound basis. The researchers who calculate energy models will not run out of work any time soon.



Grafic: Empa

LIVING IN A CRYSTALBALL

Alain Aerni is trying to look into the future: his "Crystalball" energy control system combines photovoltaics, heat pumps and charging stations and uses weather reports to predict energy requirements. In late 2020 he presented his system at an event at the Empa Academy.

Interview: Rainer Klose

Mr. Aerni, you are an engineer and have optimized the energy efficiency of your own residential building, which is 20 years old. Your company Soleco now offers this service to other homeowners. What idea should one start with if one wanted to start a project like this?

It always starts with the costumer's needs. The first step is to determine the heating requirements of the house. What do I need to achieve a room temperature of 22 degrees Celsius throughout the year? What is my hot water consumption? Do I want to charge one or two electric cars in the garage, and how many kilometers do I want to drive each day?

Do I need a storage battery if I want to charge an electric car?

If you want to use solar energy in your home particularly economically, you should currently still do without a storage battery. So if you have days with home office, you can charge the electric car on these days and drive with it the next day. Only those who are always on the road during the day and at the same time want to charge their cars with their own solar power will not be able to do without a storage battery.

What else does the customer need to consider?

The important question is how long you intend to stay in your home. The time horizon influences the choice of components. There are long-lasting components, such as a geothermal probe – a very efficient system for heating a house. Those are designed for 50 years of use, but it also takes decades to pay for itself. For customers who only want to plan ahead ten to 15 years, I'd rather recommend an air-source heat pump.

And if I know my heating requirements and my time horizon, then I'm ready to go?

(smiles) Not quite yet. Now the noise factor comes into play. If you use an air-source heat pump and run it on solar power from your rooftop, that's very efficient. But such a system makes noise and can disturb the neighbors. If you have a single-family house with a lot of surrounding area, this is not a problem. For a large apartment building, you need bigger machines: bigger fans, bigger compressors. In a tightly built neighborhood, that becomes difficult.

The building authorities might not approve it?

That's right. You have to comply with the official threshold values. Fortunately, there are also so-called split units: Here, only the evaporator and the fan are mounted outside, the compressor is installed in the house. These units are quieter.

ALAIN AERNI

BORN: 3 Mai 1960 in Moudon / VD.
EDUCATION: Dipl. Ing. EPFL and Master in Science of Management MIT.
PROFESSION: Founder and CEO of Soleco AG, Maur / ZH
AWARD: Digital Journey Award 2018 of the Centre d'Electronique et de Microtechnique (CSEM) for the development of a platform for the management of renewable energies in buildings.

So you have to have an advisor to guide you through the offers that are on the market.

Yes, but you shouldn't just think about the heat pump, you should think about the whole system from the start: the heat pump, the size of the photovoltaic system, the hot water storage tank, the electric car charging station, the blinds for the shading and, if necessary, the storage battery. After all, you want to control everything together so that everything works together smoothly. The components you buy must therefore be able to communicate with the central control system.

Is there no "plug-and-play", no common standard?

We are not far enough yet. There is, for example, a common standard for the control of heat pumps, the "SG Ready Label". But this does not cover all the functionalities that are necessary for a good system. The SG Ready Label needs to be developed further. We are working with partners to propose a common standard. But at the same time, there are more and more manufacturers who are sealing off their systems from the outside in order to expand their market share.

How much networking makes sense? Is it possible to overdo it?

If you want to be efficient, you have to keep an eye on the major consumers: Heating, hot water demand, electromobility and storage battery. It's not important when the washing machine or the tumble dryer are running. They can be switched on manually. What is important, however, is taking solar radiation into account. Our control system "Crystalball" (see box) can predict the heating on sunny days and the heat loss on cold days with ▶

ALAIN AERNI
The engineer retrofitted his 20-year-old house for energy efficiency and connected it to the grid.

Photos: private

WELL DISTRIBUTED
Aerni's home makes the most of solar energy.

the help of the weather report, and thus use the heat pump more economically and in a more targeted way.

You also have been cooling your home with your own solar power since the refurbishment. You converted your 20-year-old radiant floor heating system to radiant floor cooling. Is it that simple?

You don't even have to convert anything. It's just important that the water running through the floor isn't too cool. So you need an adjustable heat pump, the output of which matches the area you want to cool.

How big should the photovoltaic system on the roof be? Is it possible to exaggerate?

There is certainly an optimum that fits the energy system of the house. If you cover your entire roof with photovoltaics, you are certainly above that. But there is nothing wrong with that.

Why?

Think about the neighbors. You could supply electricity within your neighborhood to others who don't yet have photovoltaics. And think about the national energy supply. In winter, when the sun is flat, we're glad for every bit of solar power we can feed into the grid. In future, we can also produce hydrogen from surplus electricity. Of course, that's not worthwhile in a single family home. But at some point, there will be suppliers who will buy the electricity from homeowners in the summer and convert it into hydrogen.

Well, then we're perfectly prepared for the energy transistion!

Well, there is still a conflict: Some electricity suppliers would like to use blocking periods to control devices with rather large energy requirements – for example heat pumps and charging stations – in such a way that the load on the grid is reduced. This means that you may not be able to start up your heat pump just when you are producing the most electricity with your photovoltaics. You would then have to sell the electricity to the electricity supplier at a very low rate. In this case, electricity suppliers optimize their profits at the expense of homeowners.

But central control is necessary to ensure grid stability, isn't it?

As a homeowner, I clearly don't want that. And it's not necessary either.

How would you solve the problem?

With my control system, I can contribute to a stable power grid without anyone having access from the outside. My system is set to optimize costs. The electricity supplier only has to tell me the variable tariffs – preferably eight or even 24 hours in advance, then "Crystalball" will automatically use the heat pump and other electricity consumers in the right way.

This building we're sitting in is a considerable energy store: Each degree of temperature in the walls means 74 kilowatt hours of energy. If the electricity tariff is high tonight, and it's low right now, I'll heat a few hours ahead and not again tonight – and have effectively relieved the load on the power grid. Still, it's nice and warm in the house. So all we have to do is communicate tariffs and let the market play its part, and then each homeowner can retain sovereignty over his or her domestic installations. And the energy transition will still succeed. ■

"CRYSTALBALL" PLANS AHEAD

Alain Aerni, together with two partner companies and the Centre d'Electronique et de Microtechnique (CSEM) has developed the intelligent building control system "Crystalball". The software regulates the interaction between the photovoltaic system, heat pump, storage battery and electric car charging station. With the help of the weather report, it plans the energy flows three days in advance, loads the required range into the electric car, cools or heats the house, and picks the cheapest electricity rates to charge or draw electricity from the public grid. By planning ahead, the home's massive ceilings and walls can be used as free heat storage. https://crystalball.solar/

Photos:: Empa

COMPOSING NEW ENERGY SYSTEMS

Modern, decentralized energy systems are a highly complex matter. Planning them in an optimal and cost-efficient way is a major challenge for energy planners. Sympheny, an Empa spin-off, offers a software that helps planners to find the most suitable energy concept for a building, neighborhood or even an entire city, and thus to meet their sustainability and energy efficiency goals.

Text: Loris Pandiani

PROJECT CHUR
Sympheny is looking for new energy solutions for urban quarters together with the Chur-based utility company IBC.

Photo: iStockphoto

A renewable energy system is pretty much like a symphony. To achieve harmony, it takes more than just scribbling a few notes on a piece of paper. Rather, it requires an experienced composer who finds the ideal composition and determines the appropriate instruments for the piece, as well as a conductor who ensures that the individual musicians are in perfect harmony with each other. Only when everything plays together a melodious symphony takes shape. In the energy system, the role of the composer is played by energy planners. Their task is becoming increasingly complex, however, as new technologies are constantly entering the market and new requirements – for instance, with regard to sustainability and reliability – are constantly emerging.

RETHINKING ENERGY SYSTEMS

This increasing complexity is mainly due to the shift from centralized to decentralized energy systems. It is driven by the transition towards a climate-friendly society. In decentralized energy systems, several buildings in a neighborhood or area are connected, sharing renewable energy and various conversion and storage technologies. The buildings, as energy prosumers, simultaneously use, store and feed-in surplus energy into the grid, for example from their photovoltaic system. They become an important instrument in the system themselves. A key advantage of decentralized energy systems over traditional, centrally organized ones is that energy can be provided closer to where it is being consumed. Transport routes are thus minimized, which in turn enables more efficient interaction between the individual energy and storage technologies.

For planners, this means that it is essential to consider energy systems as a whole, and to select the optimum solutions considering a large number of technologies and combinations thereof. Through innovation, the spectrum of available solutions expands even further. At the same time, energy planners must ensure grid stability and always keep an eye on economic efficiency. As a result, creating a melodious symphony becomes a highly complex task. One can no longer rely on the standard, well-worn pieces that dozens of orchestras have played before. A company that has recognized this problem and is providing a remedy is the Empa spin-off Sympheny. The name is no coincidence. Sympheny's aim is to ensure that the manifold energy flows on site are integrated into a harmonious whole – maximizing energy efficiency and sustainability.

A WEB TOOL SIMPLIFIES ENERGY PLANNING

Sympheny offers planners a cloud-based tool that helps them to plan easily and cost-effectively the optimal energy system for a building, neighborhood or even a city. "Our platform takes into account a variety of factors, such as available renewable energies and suppliers on a given site, different energy demands, relevant technologies, and others. At the same time, it also considers the various goals of the planners, such as reducing CO_2 emissions, increasing renewable energy use and minimizing costs," explains Andrew Bollinger, CEO of Sympheny.

Based on this multitude of information, the online tool helps energy planners to quickly and effectively find the optimal energy system for the site. In doing so, it helps to answer crucial questions, such as whether photovoltaic systems should be installed on the roof or on the façade, whether and which seasonal storage units should be implemented, or how the thermal networks should be structured. Most importantly, it can help energy planners to answer these questions in combination – considering the numerous dependencies and interactions between technologies and energy flows on a given site.

KNOWHOW FROM THE LAB,

The software is based on many years of research. Empa's Urban Energy Systems lab has been investigating new methods for optimizing decentralized energy systems for a number of years. The research eventually resulted in the tool, which has been steadily developed in collaboration with Empa's industry partners. Last year, the team finally decided to enter the market. Thus, the spin-off Urban Sympheny AG was founded in April 2020.

"We see great market potential for our solution, as energy planning is becoming increasingly complex. For energy planners, time is valuable, so it important to help them find the best solution as quickly as possible. Through its powerful algorithms and cloud-based workflows, Sympheny empowers planners to navigate this complexity with maximal efficiency, enabling them to make better planning decisions, more quickly than before," says Bollinger. At the same time, the software promotes the integration of sustainable and renewable energy sources. In this way, Sympheny's team wants to make a contribution to the energy transition.

A SCORE FROM THE REAL WORLD

Joint projects with partners from industry show the great potential of Sympheny's solution. One example: Together with Empa, Sympheny helped the utility company IBC Energie Wasser Chur to find new energy concepts for neighborhoods that would enable them to reduce CO_2 emissions to net zero by 2040. For this purpose, a digital model was created for the city of Chur in Sympheny's software. Sympheny's algorithms were then deployed to evaluate many possible energy concepts, calculate the cost and CO_2 performance of each, and find the optimal solutions for the city. With this selection of solutions, the company can now easily find the one that enables it to achieve its net zero goal at minimum cost.

What's more, in an in-depth analysis, the project team also defined the necessary measures for each solution in order to transform the existing energy system. For IBC Energie Wasser Chur, the most interesting aspect might be that it is now possible to convert its current energy system into a CO_2-free system without increasing the life cycle costs – despite the fact that high investments are required for the conversion. In the transformation process, the company also has the opportunity to recalculate each upcoming conversion step based on the latest data, for example new technologies, and to make any necessary adjustments. This further minimizes the risk for the transformation of the energy system. ■

ON THE SCREEN
Sympheny helps planners to compose sustainable energy concepts by optimally orchestrating the energy flows of a given site.

Graphic: Sympheny AG

URBAN SYMPHENY AG

Sympheny offers a software (web tool) to support local energy planners in identifying optimal energy supply solutions for sites, neighborhoods, districts and communities. Sympheny's service is based on novel calculation methods and algorithms developed at Empa and ETH Zurich. The tool enables the fast evaluation of a variety of conventional and novel energy supply solutions – taking into account the interplay between different resources, energy flows and technologies – and finding optimal, site-specific solutions. www.sympheny.com

Further information on the topic is available at:
https://www.sympheny.com/

PILOT PLANT
The RAG Austria plant pumps hydrogen into the ground.

Photo: RAG Archiv

SOLAR ENERGY FROM THE DEPTHS

During the winter months, renewable energy is in short supply throughout Europe. An international project is now considering an unconventional solution: renewable hydrogen and carbon dioxide are pumped into the ground together, where naturally occurring microorganisms convert the two substances into methane, the main component of natural gas.

Text: Stephan Kälin

Underground Sun Conversion: The technology with this rather exciting name, patented by the Austrian energy company RAG Austria AG, offers a way to seasonally store renewable energy on a large scale and make it available all year round. In summer, this involves converting surplus renewable energy – solar power, for instance – into hydrogen (H_2). This is then stored together with carbon dioxide (CO_2) in natural underground storage facilities – for example former natural gas deposits – at a depth of over 1000 meters.

This is where little helpers come into play: Microorganisms from prehistoric times, so-called archaea, convert hydrogen and CO_2 into renewable methane (CO_4) via their metabolism. Archaea are found all over the world, mainly in anaerobic, i.e. low-oxygen environments; they were responsible for converting biomass into natural gas millions of years ago. By feeding hydrogen and CO_2 into suitable porous sandstone deposits, this process can be started all over again. The methane "produced" in the depth can then be withdrawn from the reservoirs during winter and used in a variety of ways as CO_2-neutral natural gas.

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IN SEARCH FOR SUITABLE LOCATIONS

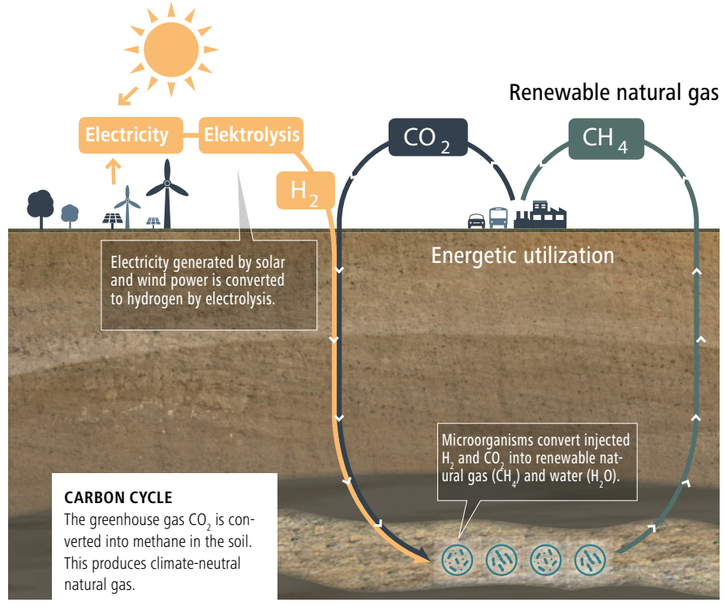
Austrian and Swiss energy companies and research institutions have now joined forces to further develop the technology. In a project funded by the EU's research framework program ERA-Net and the Swiss Federal Office of Energy (SFOE), the technical and economic potential will be explored over the next two years. In Switzerland, the energy company Energie 360°, Empa, the University of Bern and the Eastern Switzerland University of Applied Sciences (OST) are involved. Empa is developing a perspective on the energy system as a whole: «We are looking at when and where surplus electricity occurs, where suitable CO_2 sources would be and ultimately where there is demand for renewable natural gas," explains Martin Rüdisüli from Empa's Urban Energy Systems lab. Together with the geological conditions, which are being investigated by researchers at the University of Bern, and the economic boundary conditions, which are being worked out by OST scientists, a map of possible locations for the application of the Underground Sun Conversion technology is to be created.

Empa's Rüdisüli considers the technology to be promising. Particularly because, in addition to biological methanation, it also provides an answer to the seasonal storage problem: "Even with a large increase in methane gas production, there would be no need to expand the aboveground storage infrastructure thanks to the natural storage facilities in the Earth's interior," he says.

DECARBONIZING OUR ENERGY SYSTEM

The volatility of renewable energy sources is one of the great challenges of the energy transition. In winter, we basically have too little renewable electricity; in summer, there is too much. In an analysis of the potential of the power-to-gas technology in Switzerland – i.e. the conversion of renewable electricity into chemical energy carriers such as hydrogen or methane –, Rüdisüli predicted a surplus of a good 10 TWh of solar electricity in Switzerland over the next few decades - assuming that around half of the suitable roof surfaces were equipped with photovoltaics, which in turn is necessary if it is to replace the nuclear electricity that is being phased out. If the excess electricity is converted into methane in the summer, it could be used to power around one million gas-powered vehicles on a renewable basis all year round. "Converting renewable electricity into seasonally storable energy carriers is an important pillar of a decarbonized future energy system," says Rüdisüli. ■

Further information on the topic is available at:
https://www.underground-sun-conversion.at/

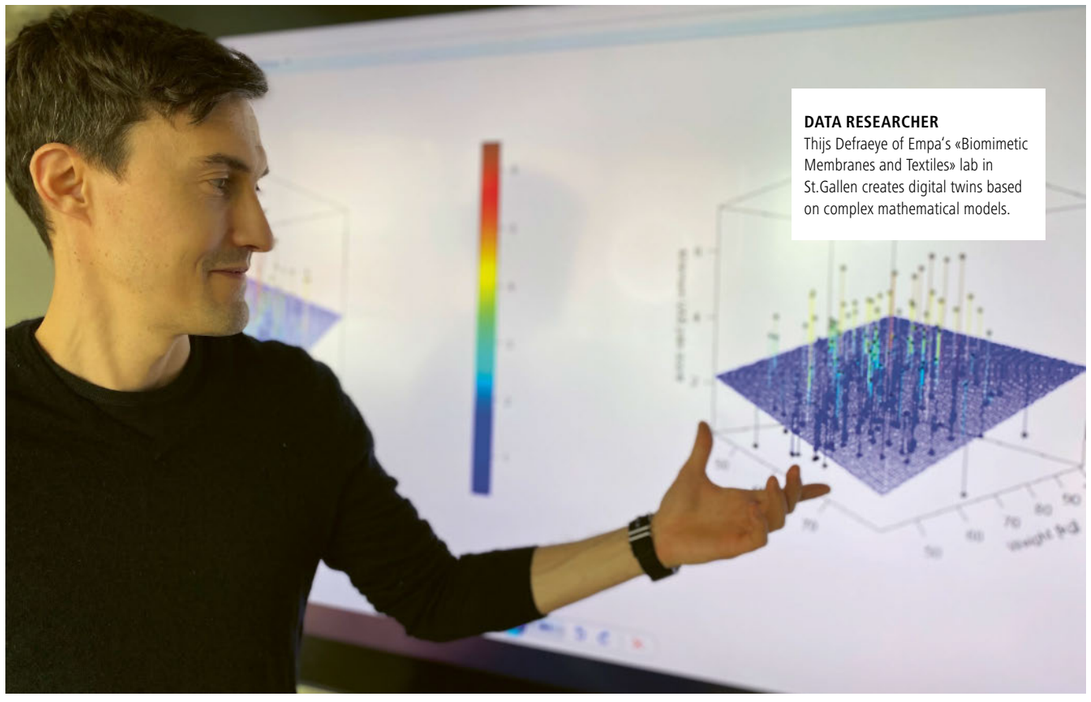


Grafic: RAG

THE SIMULATED PATIENT

Digital twins enable customized medical therapies. Empa researchers have now modeled several hundred such avatars based on real people and treated them experimentally. For the first time, the digital twins received feedback from real patients.

Text: Andrea Six



DATA RESEARCHER
Thijs Defraeye of Empa's «Biomimetic Membranes and Textiles» lab in St.Gallen creates digital twins based on complex mathematical models.

Photo: Empa

The enormous advances in modern medicine allow us to provide patients with an improved quality of life even during severe illnesses. Synthetic opiates, for example, can be used to control severe pain caused by cancer. However, the exact dosage is still a challenge. Painkillers, such as fentanyl, must be administered precisely to be effective without harming patients with sometimes life-threatening side effects. Currently, such painkillers are administered through the skin by means of a drug patch, among other methods – a gentle method that helps enable patients to return to their daily lives. However, the appropriate dosage can only be determined by trial-and-error. Reactions to an under- or overdose are only seen in retrospect, when the medication has long since left the drug patch.

This is now set to change: To ensure that the correct drug dosage can be determined and kept constant for each individual patient in the sense of personalized medicine, Empa researchers, together with a team from the University of Bern, are using computer and data sciences. The team led by Thijs Defraeye from Empa's "Biomimetic Membranes and Textiles" lab in St. Gallen is using multiphysics modeling to develop a digital twin of the human body that allows to control and predict the course of therapy.

ALREADY 100 AVATARS TREATED

In the mathematical models, on which the complex digital twin is based, the researchers have taken into account a variety of variables from real people, such as age and lifestyle. This is because the effect of a drug is influenced by a plethora of physical parameters that can vary greatly from person to person. "When creating an avatar, we take into account, for example, how the drug is metabolized in the body during treatment and how much ultimately gets to the pain center in the person's brain," explains Empa researcher Defraeye.

To ensure that the dosage is not only safe but also effective, the in silico twin can also receive physiological and psychological feedback from real patients. For example, humans provide information on whether and to what extent they continue to perceive pain. Of particular interest here is the length of pain-free periods. And since not every day is a good day, and life is full of unpredictable events, the effective pain perception of those affected also varies much more than a doctor's visit every other week could address. "With this feedback from humans, the avatar can dynamically adjust the therapy and even predict the course," explains Empa researcher Flora Bahrami.

In future, sensors will also measure other physiological parameters such as heartbeat or respiration rate in real time and report back to the avatar.

DIGITALIZATION AGAINST FOOD WASTE

Digitization can enable major advances not only in medicine, but also in other areas – such as food technology. Just recently, the Empa team led by Thijs Defraeye was awarded a prize in data.org's Inclusive Growth and Recovery Challenge. The highly endowed award is sponsored by the Rockefeller Foundation and the Mastercard Center for Inclusive Growth. The goal of the joint project with the BASE Foundation (Basel Agency for Sustainable Energy) is to use computer models and mobile apps to promote sustainable agriculture and improve the ecological and economic situation for small farms in developing countries.

Data processing and the modeling of parameters from agriculture, technology and current economic conditions are key to enable small farms to manage their products with foresight in real time. This is because currently, up to 60% of such farms' harvests have to be disposed of in developing countries, as fruits and vegetables spoil before they reach the market due to lack of access to cold chains. The researchers want to counter this immense food waste.

"At the end of this technology development, there should be an app for cell phones that supports the sustainable use of resources during storage, refrigeration and sale of the goods," says Empa researcher Seraina Schudel. The large-scale project also provides Empa researchers with an excellent basis for further developing the field of computer and data sciences, and digital twins in particular, for numerous applications.

Thus far, several hundred personalized avatars have been created and individual therapies been tested virtually in cooperation with the Cantonal Hospital of St. Gallen. "We have already been able to show that the optimal treatment regime for women and men, as well as for younger and older people, differ significantly," Bahrami says.

Pain therapy using transdermal patches is just the beginning of avatar-assisted treatment, though. In collaboration with clinics and hospitals, Empa researchers have already turned their attention to other therapies such as insulin administration for diabetes using digital twins. ■

Further information on the topic is available at:
https://www.empa.ch/web/multiphysics

MOLECULES IN COLLECTIVE ECSTASY

When fluorescent dye molecules nestle perfectly together, something completely new is created: an excited state distributed over many molecules. Such collective excitations can be used in a variety of ways – for organic solar panels, in sensors, for ultrafast data transmission or in microscopy, for example. Empa researchers, together with colleagues from ETH Zurich, EPFL, the Paul Scherrer Institute (PSI) and IBM Research Zurich, have succeeded in making such chemical light amplifiers ten times more efficient than before.

Text: Rainer Klose

REVOLUTION THROUGH DYES
What artist Katharina Grosse showed at the Hamburger Bahnhof in Berlin sometimes succeeds in chemistry, too.

Photo: Jens Ziehe

What we see here is energy transfer that is much faster than in any semiconductor, enthuses Jakob Heier. The physicist works in Empa's Functional Polymers lab, and the discovery he has made with his team could cause a stir in many areas – such as sensor technology, optical data transmission or the fabrication of organic solar cells. We are talking about islands of dye molecules with a perfect, internal structure. Among experts, such structures are called J-aggregates. Although they have been known for more than 80 years, they recently attracted renewed attention in research. This is due to the special electronic inner life of these dye islands. To understand what Heier and his colleagues have found, a short excursion into the world of dyes is helpful: If a dye is to glow, the molecule must first be activated – also with light. Optical brighteners in detergents, for example, absorb UV light and emit bluish (visible) light – which is why white garments shine so brightly in the UV light of a club. The emitted light is lower in energy than the light used to activate the dye, because part of the energy is converted into vibrations, i.e. heat, in the dye molecule.

MOLECULES AS ENERGY ANTENNAS

The J-aggregates studied by Heier and Empa PhD student Surendra Anantharaman behave differently from individual dye molecules. In these molecular islands, the dye molecules are well ordered and very close together, much like matches in a box. In this constellation, the dye molecule does not "have" to glow, but "can" pass on its energy to a neighboring molecule.

Compared to classic semiconductors made of silicon, there is a crucial difference, though: In a silicon semiconductor, such as a solar cell, the excitation energy is transported via charge carriers, for example electrons, which "hop" through the material, so to speak. In J-aggregates, on the other hand, the electrons only oscillate back and forth in the dye molecule and never leave it. Instead of electrons, only oscillations are transmitted – similar to transmitting and receiving antennas in the macroscopic world. In fact, J-aggregates can "transmit" energy on the smallest scale – extremely fast and across hundreds of molecules.

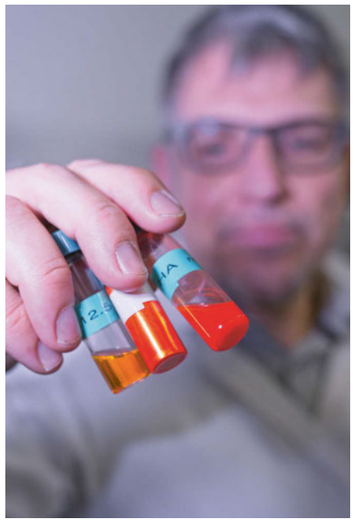
HIGH LOSSES FOR 80 YEARS

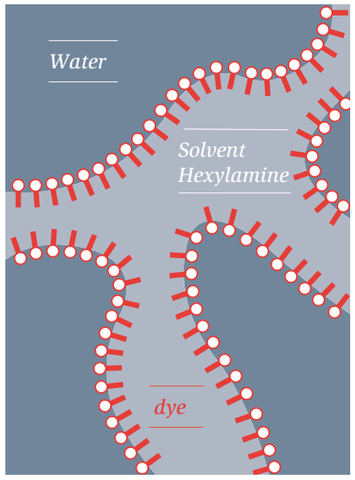
The phenomenon of J-aggregates and their special energy transmission was first discovered as early as 1936 by Edwin E. Jelley in the US and Günter Scheibe in Germany. But up to now, about 95 percent of the radiated energy was lost and could not be transmitted. "Construction errors" in the system were to blame. In reality, the molecules were not so perfectly aligned. And whenever the energy pulse encountered one of these defects during its journey through the J-aggregate, the energy transport was interrupted. An ordinary molecular vibration terminated the transfer, a bit of heat was generated, and the game was over.

THE PERFECT ANTENNA FOREST

The Empa team, supported by researchers from ETH Zurich, EPF Lausanne, PSI and IBM Research Zurich, has now succeeded in developing a dye system, in which up to 60 percent of the incoming light is re-emitted. This also means that up to 60 percent of the energy can be transmitted without loss – compared to the previous five percent, this is a sensation.

The key to success was perfectly constructed dye islands that had been created in a fine emulsion of water and hexylamine. An emulsion is a ▶





ENERGY VIBRATION
Top: Jakob Heier with samples of his "antenna dye."
Below: Like matches in a box, dye molecules line up at the phase boundaries of a bicontinuous emulsion. This is the only way for signal transmission to succeed.

mixture of liquid droplets in another liquid – milk or mayonnaise are emulsions that everyone is familiar with.

The Empa researchers observed that not just any emulsion would do the job: It had to be a so-called bicontinuous emulsion, which means the droplets suspended in the outer liquid must not be distant from each other, but must have combined to form streak-like structures. Only in this geometry the dye molecules will combine to the desired defect-free J-aggregates and can "send" the absorbed energy over long distances without loss.

FAILURES ARE PART OF THE GAME

The study that has now been published also mentions – in good scientific tradition – the failed attempts and the history of the successful experiment. After all, chemists and physicists all over the world should be able to build on the experience of the Empa team. For example, it was not possible to crystallize the dye in the form of thin films on a solid surface. Too many defects in the crystals ruined the transfer. Aqueous solutions, in which the dye aggregates into tiny droplets, likewise do not work. Only bicontinuous emulsions lead to signal transmission – and only if there are individual dye molecules left in a liquid phase that can fill holes and close gaps in the J-aggregates – in other words, "repair" defects.

WHAT APPLICATIONS ARE CONCEIVABLE?

The researchers certainly still have a long way to go before what they have now achieved in an emulsion can be made technically useful. But signal transmission through dyes could penetrate many areas of everyday life. For example, it is possible to capture weak infrared light with the help of these dyes and convert it into digital signals with the help of quantum dots – an advantage for sensor technology and solar cells, which are supposed to provide electricity even in very weak light. Because of their unique properties, J-aggregates also lend themselves to applications in quantum computers and optical data transmission.

Finally, the signal-conducting dye aggregates could become useful in diagnostics in living tissue: Infrared light, or thermal radiation, penetrates deep into human tissue without damaging cells. J-aggregates could make this radiation visible and digitize it. This could greatly facilitate and improve high-resolution microscope imaging of living tissue. ■

Further information on the topic is available at:
https://www.empa.ch/web/s209

Photo & Grafic: Empa

DETOXIFIERS FROM THE LANDFILL

Bacteria from an Indian landfill could help eliminate contaminated chemicals. The focus is on pesticides such as lindane or brominated flame retardants, which accumulate in nature and in food chains. Researchers at Empa and Eawag used these bacteria to generate enzymes that can break down these dangerous chemicals.

Text: Rainer Klose

LANDFILL IN INDIA
An extremely useful bacterium was discovered here.

Photo: Empa

The production of chemicals is a cumbersome business. Often, only a small part of what is actually wanted is produced in the factory. The large remainder is unusable – or even worse. Examples? The defoliant "Agent Orange" used by the US army in the Vietnam War was produced in great hurry. It contained dioxin as an impurity. As a result, not only did trees in the combat zone lose their foliage, but US soldiers and Vietnamese civilians also fell ill with cancer years later.

There are also examples from agriculture: In the production of the insecticide lindane, a hexachlorocyclohexane (HCH), only less than 15 percent of the desired substance is produced; 85 percent of the reaction broth is hazardous waste. In the 1950s, this toxic mixture was still sprayed in its entirety on fields and orchards. Later on the effective lindane was separated and sold pure, the rest being dumped in landfills. There the chemicals often still lie today. Lindane has been banned in the EU since 2007, and it has not been used in Switzerland for some time.

The flame retardant hexabromocyclodecane (HBCD) is also a mixture of several substances. It was invented in the 1970s, produced on a scale of several 10,000 tons per year and used in polystyrene insulation boards for house facades, in textiles and in plastics for electrical appliances. It has been banned worldwide since 2014. In Switzerland, plastic containing HBCD is not recycled, but must be destroyed in waste incineration

INTERNATIONALLY OUTLAWED

Since 2004, the Stockholm Convention on Persistent Organic Pollutants has regulated the handling of such long-lived environmental toxins (https://www.fedlex.admin.ch/eli/cc/2004/347/de). Switzerland ratified the agreement in 2003, but all these substances are already in the environment – and finely distributed. HBCD is found in sewage sludge, in fish, in air, water and soil. In 2004, the World Wildlife Fund (WWF) took blood samples from eleven European environment ministers and three health ministers and detected HBCD and lindane in the blood of every single one of them.

BACTERIA, THE RESCUERS FROM THE SOIL

It begs the question: Can we recapture or detoxify the chemical waste of past generations? Fortunately, scientists aren't shying away from icky places in their search for solutions. In 1991, they discovered three strains of bacteria that could consume lindane and its useless chemical siblings in chemical waste sites in France, Japan and India almost simultaneously: *Sphingobium francense, Sphingobium japonicum and Sphingobium indicum*. Could these bio-cleaners perhaps also digest the flame retardant HBCD and other toxins?

A BIO-CATALYST

Empa chemist Norbert Heeb and Eawag microbiologist Hans-Peter Kohler, together with researchers from the Zurich University of Applied Sciences (ZHAW) and two Indian institutes, put them to the test. They modified the genes of the Indian bacteria and produced HCH-degrading enzymes in pure form. An enzyme is a protein molecule, a bio-catalyst so to speak, with which bacteria, but also other living cells, can build up or break down chemical substances. The pollutant molecule HCH inserts itself into the enzyme like a key into a lock. Then part of the molecule is split off. The now harmless fragments are released again, and the enzyme is ready to take up the next pollutant molecule.

MUTATIONS OPEN UP OPPORTUNITIES

Together with undergraduate student Jasmin Hubeli, Heeb investigated not only the enzyme variants found in landfills, but also an enzyme obtained from a genetically modified bacterial strain. Here, the researchers had deliberately enlarged the "keyhole" so that the larger HBCD molecules could be broken down more easily. The result: The genetic modification influenced the rate, at which the pollutant was broken down.

Empa researcher Heeb is hopeful about their results: "This means that we now actually have a chance to use biological methods to render harmless these long-lived toxins produced by mankind and distributed over large areas." There is still a long way to go, however. The lock-and-key principle of helpful enzymes still needs to be figured out in more detail before tailor-made enzymes for chemical toxins are available in the future. ■

Further information on the topic is available at:
https://www.empa.ch/web/s502

THE MOUSE IN THE NEST

On Sunday, 7 March 2021, the "Sendung mit der Maus" celebrated its 50th birthday. For the anniversary edition of the most successful children's program on German television, Armin Maiwald, presenter from the very beginning, visited NEST at Empa in Dübendorf. The topic: How will we build in a circular way in the future?

https://www.wdrmaus.de/

WITHIN
Armin Maiwald at the heat-storing room divider in NEST's "Urban Mining and Recycling" unit.

DISCOVERING THE FUELS OF THE FUTURE

INTERACTIVE
The new permanent exhibition by Empa and Avenergy Suisse provides information about climate-neutral fuels.

Together with partners Avenergy Suisse and Hyundai, Empa is presenting a new permanent exhibition on sustainable fuels of the future at the Swiss Museum of Transport as of March 2021. Among other things, the focus is on questions like: How does green electricity find its way into the tank? And: Which fuel makes sense for which purpose? In an interactive game, visitors can even virtually produce hydrogen themselves.

www.empa.ch/web/s604/powerfuel

Photos: Empa, Verkehrshaues der Schweiz

SWISS IDEAS FOR THE GREEN DEAL

TURNED ON
A virtual Peter Richner joined the roundtable discussion in Austria.

Sustainable construction requires radical innovations – such as those being investigated and implemented in NEST at Empa. Inspired by the Swiss example, the international research platform ReConstruct organized an online discussion on solutions for climate-neutral building on 22 March. Peter Richner, deputy CEO of Empa, joined Austrian Climate Minister Leonore Gewessler at the virtual roundtable.

https://www.rethinkconstruction.net/

Photo: Empa

EVENTS

(IN GERMAN AND ENGLISH)

28. MAI 2021
Kurs: Elektrochemische Charakterisierung und Korrosion
Zielpublikum: Industrie und Wirtschaft
http://www.empa-akademie.ch/korrosion
Empa, Dübendorf

13. – 15. JULI 2021
Kurs: Aerogel Industry – Academia Forum
Zielpublikum: Industrie und Wirtschaft
http://www.empa-akademie.ch/aerogel
Empa, Dübendorf und online

09. – 10. SEPTEMBER 2021
Kurs: 3D Drucken in der Medizintechnik
Zielpublikum: Industrie und Wirtschaft
http://www.empa-akademie.ch/medizintech
Swiss m4m Center, Bettlach

09. SEPTEMBER 2021
Kurs: Alkali-Silica Reaction – a Multidisciplinary Approach / Webinar via Zoom
Zielpublikum: Forschung und Industrie
https://www.ch/asr

15. SEPTEMBER 2021
Kurs: Additive Fertigung von Metallen
Zielpublikum: Industrie und Wirtschaft
www.empa-akademie.ch/addfert
Empa, Dübendorf

08. OKTOBER 2021
Kurs: Energy Harvesting (in Englisch)
Zielpublikum: Industrie und Wirtschaft
www.empa-akademie.ch/harvesting
Empa, Dübendorf

Die komplette Liste der Veranstaltungen finden Sie unter: www.empa-akademie.ch.

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