EmpaQuarterly

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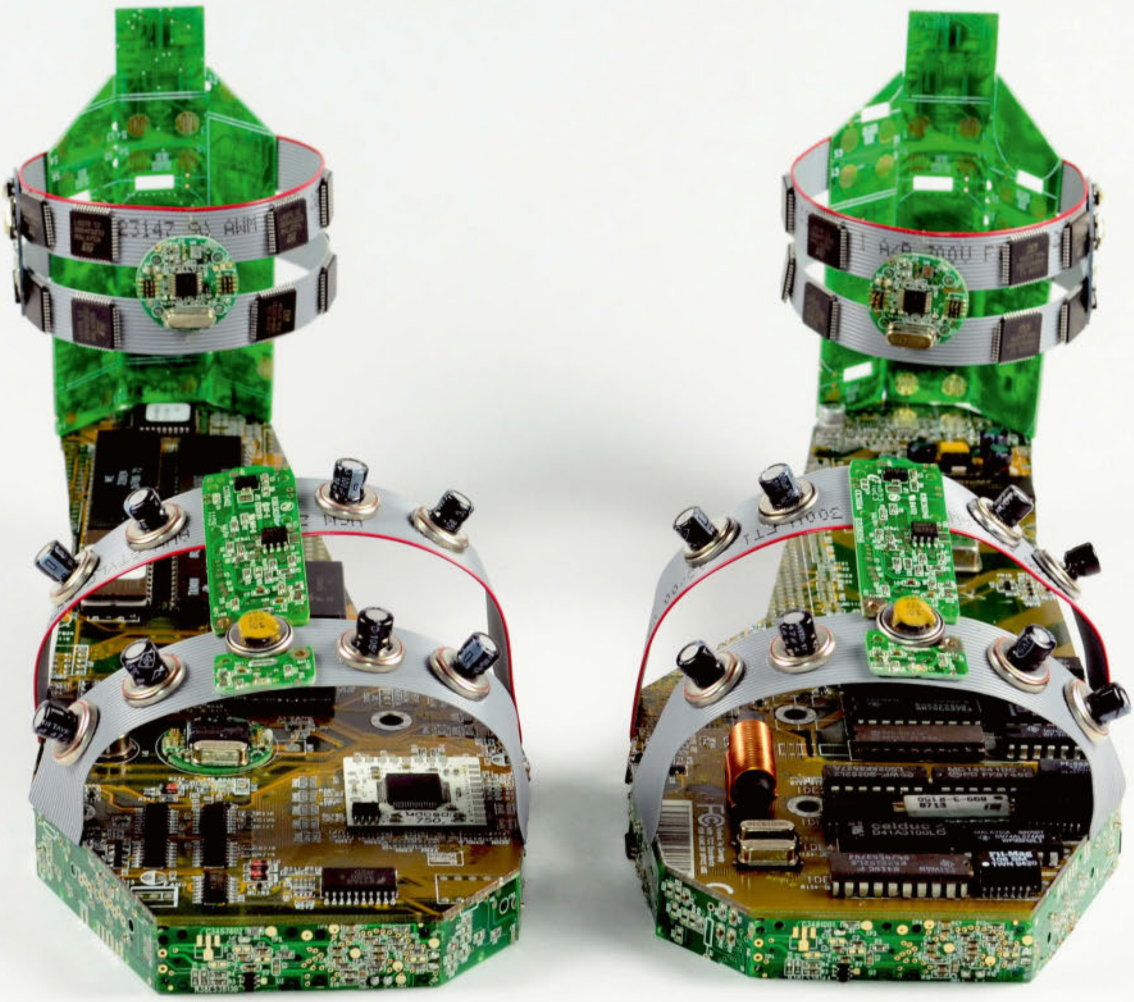


Materials reincarnated

Urban Mining & Recycling

Empa spin-off traces pollutants

Hydrogen technology at the Geneva Motor Show

Empa
Materials Science and Technology

MICHAEL HAGMANN Head of Communications

One man’s waste is another man’s fortune

Dear Readers

Buy, use, bin. Sometimes with another stage in-between: years gathering dust in a drawer all because you can’t bring yourself to “get rid of” that discarded cellphone, your dinosaur of a PC or your beloved iPod. Product cycles are getting ever shorter, and our consumer behavior, which has become a slave to these cycles, is becoming increasingly questionable. For instance, mountains of waste are towering skywards all over the place, and yet, at the same time, certain raw materials are gradually becoming scarce – including the very ones we need so desperately for our coveted high-tech gadgets: cobalt, indium or neodymium, to name just a few.

The – or at least one – solution to the problem lies in closed material cycles: everything keeps getting recycled, is broken up into individual parts, given a new form, revalued and re-used. This is the focus of the current issue of EmpaQuarterly. Whether in the construction sector or as electrical waste, the materials lying dormant in the “urban mine” are simply too precious to be thrown away.

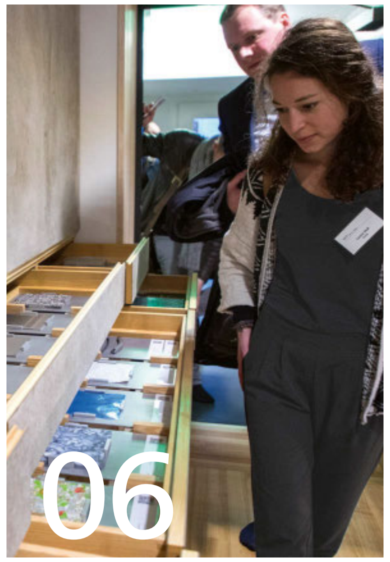
American artist Steven Rodrig has found an ethically pleasing approach to this problem: taken by the beauty of discarded computer circuit boards, the eco-conscious “computer geek” uses them to create impressive – and thought-provoking – sculptures. “It seemed a waste to me to have these individually perfect pieces discarded,” says Rodrig, explaining the motivation behind his art, which can be viewed at pcbcreations.com.

On that note an (unsolicited) piece of advice: every now and then try to not immediately replace everything that is no longer all the rage and still works perfectly fine. And when it does eventually need to go – go to a recycling point, don’t just put it in the trash.

Oh yes: happy reading and until the next issue!

Focus

Circular flow of things



Cover
The sculpture, entitled Data Sandal, by New York artist Steven Rodrig, consists of used computer circuit boards. Recycling materials has never been so beautiful and inspiring. Photo: courtesy of Steven Rodrig, www.pcbcreations.com

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Empa Social Media

A systematic approach to recycling

Today's industrial societies offer their citizens comfort and ease, jobs and leisure, as well as an appropriate infrastructure. At the same time, the modern living environment is transforming into a warehouse brimming with precious raw materials that are coveted by industry. But just how big is the resource depot we live in? Which material flows feed it? Where can precious materials be extracted and re-used? In this issue, we present research projects devoted to questions like these.

TEXT: Rainer Klose / PICTURE: Empa

In the recently concluded ProSUM-Project, which was funded by the EU's Horizon 2020 research program over three years, researchers from 30 countries set up a public database that provides information on the flows and stocks of critical raw materials in the European "urban mine". This means that, for the first time ever, a comprehensive and easily accessible database is available for an entire region of the world. Empa played a key role here.

The other project – a unit in the research building NEST – is an attempt to design a fully recyclable housing unit that is already composed of recycled materials. Lodging in the materials store for the coming generations – well conceived of and implemented. The result is an extremely stylish apartment for two people that has amazed NEST visitors since the beginning of the year.

Living in a materials depot

A residential module fully constructed from reusable, recyclable, and compostable materials: This is the premise for the newest unit in NEST, the modular research and innovation building run by Empa and Eawag in Dübendorf. On 8 February 2018, the NEST Urban Mining & Recycling unit will open its doors and henceforth house two students. At the same time, as an active lab it will also help to advance the construction industry´s transition to a recycling economy.

TEXT: Stephan Kälin / PICTURES: Wojciech Zawarski, Gian Vaitl, Zooey Braun, Rene Müller, Felix Heisel

A growing scarcity of resources, along with the resulting desire to move away from today's throwaway mentality, means that the building sector must give more thought to the multiple use and recyclability of materials, as well as to alternative methods of construction. The newest NEST unit called “Urban Mining & Recycling” implements these ideas; the result is a residential module featuring structures and materials that can be fully reused, repurposed, recycled, or composted, following deconstruction of the module. The concept was devised by Werner Sobek with Dirk E. Hebel and Felix Heisel. Werner Sobek is Director of the Institute for Lightweight Structures and Conceptual Design at the University of Stuttgart and founder of the Werner Sobek Group. Dirk E. Hebel is the Director and Felix Heisel is the Head of Research at the Chair of Sustainable Construction at KIT Karlsruhe and the Future Cities Laboratory at the Singapore-ETH Center. “The ongoing, sustained growth of the global population as well as dwindling resources urgently require us to do some rethinking in the construction industry”, says Werner Sobek. «In future, we must reduce our consumption of construction materials and build for many more people.”

The concept of cycles must, therefore, play a central role on the path to more sustainable construction: “The materials that we utilize will not just be used and then disposed of; instead they will be extracted from their cycle and later returned to it”, says Dirk E. Hebel in explaining the concept. Thus, a wide variety of serially processed components are used in the Urban Mining & Recycling unit; the various materials can be separated, sorted and, without any residues, returned to their respective material cycles. Among other things, the unit uses new insulation boards made from mushroom mycelium, innovative recycling stones, recycled insulation materials, and leased carpeting.

All joinings can be easily reversed

The structure and large parts of the facade are made of untreated wood. “The innovation here lies in the joinings”, explains Felix Heisel from KIT. “All joinings can be easily reversed because, for instance, the materials are not glued together but rather tucked, folded, or screwed.” The used wood is also applied in such a way that an otherwise standard chemical coating is not necessary anymore, thus making purely type-sorted recycling or purely biological composting feasible. In addition to the wood, the edging of the facade is made of repurposed copper sheets that previously covered the roof of a hotel in Austria and sheets that have been manufactured from melted down, recycled copper.

The entire unit was prefabricated and installed in the research building on the Empa campus in Dübendorf in just one day. Soon, two students will move into the three-room apartment and regularly discuss their everyday experiences with the researchers involved. “By implementing and demonstrating the systematic cycle concept in a real-world building project, we of course hope that we can trigger a change in thinking in the construction world”, says Enrico Marchesi, Innovation Manager at NEST. “In future, buildings should not only offer residential and work spaces, but also simultaneously serve as material repositories for the next generation.” //

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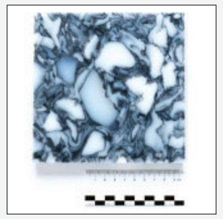
TTouch and feel at the Urban Mining & Recycling unit's opening day on 8 February.

The unit Urban Mining & Recycling is on the second floor at NEST.

Materials in Urban Mining & Recycling

Kitchen worktops made of scrap glass: The kitchen worktop looks a bit like ice on a lake that has cracked and refrozen. It is made of old glass bottles that were sintered at relatively low temperatures. The semi-melted, softened shards join up without any added binding agent to form a single slab, in which the shapes of the individual shards are still visible.

Marble look thanks to old chopping boards: What looks like marble is actually different-colored, single-variety, high-density polyethylene from a wide variety of sources. PET bottle caps, used chopping boards and entire kitchen tops are melted together and processed into slabs, which are used as wall cladding for the bathroom in the unit.



Wall panels made of drink cartons: Shredded and pressed, old drink cartons make a durable, damp-proof paneling material. In the unit, the colorful elements are used as wall panels and tabletops.

Door handles from a Belgian bank: remove from one place and install in another. Direct reuse is the simplest way to live up to the life-cycle mindset. And the Urban Mining & Recycling unit is no exception: The door handles in the unit are designer pieces from the 1970s and come from Générale de Banque's Brussels headquarters.

"Salami" and "nougat" bricks made of rubble: These days, when an existing building is demolished the majority of the rubble is mineral. This can be used to "bake" bricks that have their own, unique look depending on the base material. The marketing highlight is the names that the manufacturers have given the bricks: "Salami" is a reddish stone with white flecks that stem from old ceramic sinks. And the NEST unit has a wall of light "nougat" bricks with dark-brown flecks, which in this case come from what used to be bricks.

Insulation boards made of fungi: One of the unit's most novel building innovations is surely the fungus structures. The root system of fungi (mycelium) is mixed with a nutrient source (in this instance, waste wood chippings) and grows into a predefined shape. After a few days, the mesh is heated to between 60 and 70 degrees Celsius, killing the organism. The resulting material is just the ticket as insulation panels in walls.

The complete Material Library and information on the manufacturers are available on: **www.nest-umar.net**

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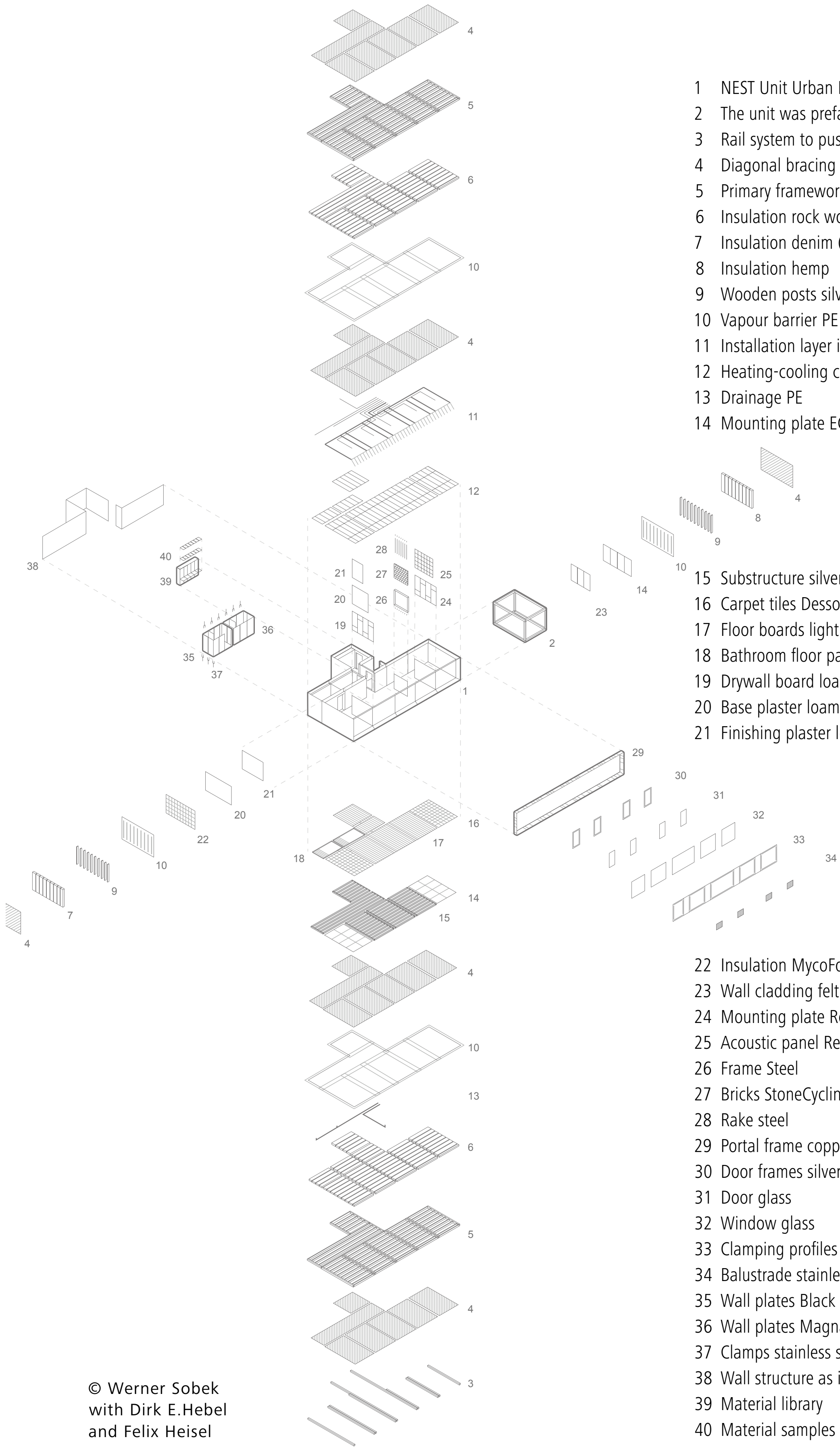
Urban Mining and Recycling Unit
The set-up in detail:

The unit consists of materials that are slotted, interlocked or screwed into each other. At the end of their service life, the components can easily be removed mechanically and recycled separately. No glues, foams or sprayed sealing materials whatsoever were used anywhere in the structure.



1 NEST Unit Urban Mining and Recycling
2 The unit was prefabricated in 7 modules and connected on site.
3 Rail system to push modules in and out of NEST
4 Diagonal bracing silver fir
5 Primary framework silver fir
6 Insulation rock wool
7 Insulation denim (jeans)
8 Insulation hemp
9 Wooden posts silver fir
10 Vapour barrier PE clammed overlapping
11 Installation layer in pure metals und solar thermal energy
12 Heating-cooling ceiling Aluminium
13 Drainage PE
14 Mounting plate ECOR
15 Substructure silver fir
16 Carpet tiles Desso
17 Floor boards light brown ash
18 Bathroom floor pan stainless steel
19 Drywall board loam
20 Base plaster loam
21 Finishing plaster loam
22 Insulation MycoFoam
23 Wall cladding felt
24 Mounting plate ReWall
25 Acoustic panel Reapor
26 Frame Steel
27 Bricks StoneCycling
28 Rake steel
29 Portal frame copper
30 Door frames silver fir
31 Door glass
32 Window glass
33 Clamping profiles Aluminium
34 Balustrade stainless steel
35 Wall plates Black Dapple
36 Wall plates Magna Glaskeramik
37 Clamps stainless steel
38 Wall structure as in 4,7,9,10
39 Material library
40 Material samples und data sheets

A city's mineral resources

Just how environmentally friendly, energy-saving and sustainable is "urban mining"? Efstathios Kakkos from Empa's Technology and Society lab in St. Gallen supported the new NEST unit Urban Mining & Recycling scientifically.

TEXT: Andrea Six / PICTURES: Empa

Just how environmentally friendly, energy-saving and sustainable is "urban mining"? Efstathios Kakkos from Empa's Technology and Society lab in St. Gallen supported the new NEST unit Urban Mining & Recycling scientifically.

Just because it says "bio" on the label doesn't necessarily mean it contains "bio". This is certainly the case if environmental analyses conducted on foods are anything to go by. How sustainable and environmentally friendly a product is can only be determined using precise, comprehensive analyses. This goes for food, but also another essential part of life: housing. The newly established Urban Mining and Recycling unit, or UMAR for short, in the research and innovation building NEST on the Empa campus in Dübendorf is supposed to be more environmentally friendly, energy-saving and sustainable than a similar traditional housing unit. Efstathios Kakkos from Empa's Technology and Society lLab investigated how well these assumptions tally with the reality in his Master's thesis.

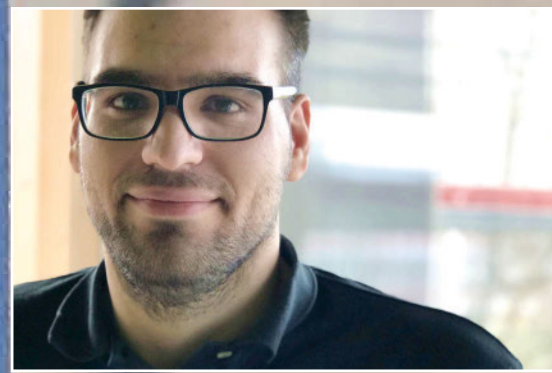
Within ETH Zurich's Integrated Building Systems project, Kakkos analyzed the resource-saving UMAR housing module and the materials, construction elements and building processes used in it in terms of energy consumption, emissions and environmental impact – throughout their entire life cycle. He thus assessed a building from a holistic perspective. Such comprehensive analyses yield three lean values: the cumulative energy demand (CED), environmental pressure points (EPP) and the global warming potential.

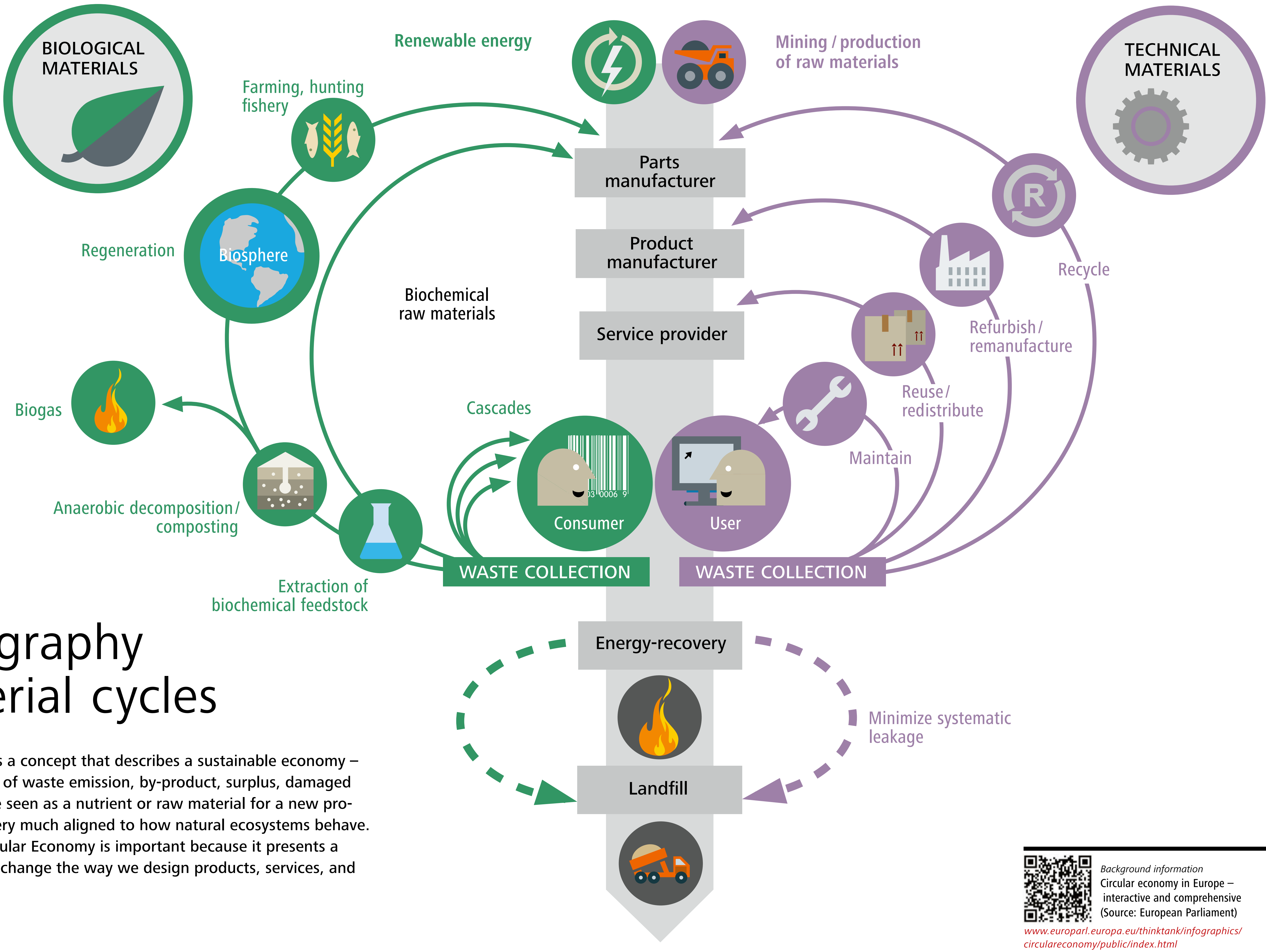
"All in all, the life cycle assessment reveals that the UMAR building elements that are reused, recycled or recyclable fare much better than those from conventional concrete construction," says Kakkos. According to the Empa researcher, ceiling and floor constructions have the greatest influence on this positive effect. According to his analysis, the UMAR unit's CED, EPP and GWP are 20 to 70% lower than the values for conventional construction. On the one hand, the better performance can be attributed to the use of wood as a renewable raw material. On the other hand, the values are more favorable because production costs can be minimized if parts such as door handles can be reused.

UMAR especially seems environmentally friendly when it comes to disposal. For instance, no wrecking balls or heavy machinery are required for the demolition; simple tools such as drills and screwdriver are sufficient to dismantle the unit. The deconstruction requires merely 3% of the energy that would be necessary to tear down a similar concrete unit.

"We have clear evidence that large quantities of energy could be saved and environmental damage avoided if the UMAR construction method were to be used extensively in future," says Roland Hischier, Technology and Society Lab. //

Efstathios Kakkos from Empa's Technology and Society lab is analyzing the UMAR unit's eco-potential in his Master's thesis.





Choreography of material cycles

The Circular Economy is a concept that describes a sustainable economy – one in which any types of waste emission, by-product, surplus, damaged or unwanted goods are seen as a nutrient or raw material for a new production cycle. This is very much aligned to how natural ecosystems behave. The concept of the Circular Economy is important because it presents a framework to radically change the way we design products, services, and systems.

Source: www.ellenmacarthurfoundation.org/circular-economy/overview/concept

Background information
Circular economy in Europe – interactive and comprehensive
(Source: European Parliament)
www.europarl.europa.eu/thinktank/infographics/circulareconomy/public/index.html

Europe’s urban mine

TEXT: Empa-Redaktion / PICTURE: Empa

In January 2018 the first pan-European database for secondary raw materials, including many “critical” ones, went online. Ever since, we have known more about which raw material depots reside in cars, batteries and electronic devices sold, used and stored in the 28 EU countries – and ultimately recycled or disposed of. Empa played a key role in the ProSUM project.

Hundreds of tons of gold, platinum, indium and neodymium are contained in the electronic waste squirreled away in European households. In future it will be possible to oversee and use this enormous depot of precious raw materials more effectively.

Every European owns an average of 250 kilograms of electrical and electronic devices. These are joined by 15 kilograms of lead batteries and two kilograms of other kinds of batteries, including 500 grams of lithium ion batteries, and a 60-kilogram share of a car. All these goods eventually break down or become obsolete. Some of them are thrown away and recycled, others are resold on platforms like ebay and ricardo. However, considerable quantities end up in drawers, cupboards and garages, where they form “raw material depots”.

A pile of fragmented data

Data on the presence and distribution of critical raw materials in Data on the presence and distribution of critical raw materials in products, components and waste has been generated from various quarters in recent years, such as research institutions, industry, public authorities and non-government organizations, and stored in various databases, formats and reports. As yet, however, nobody has collated and processed this data so that the recycling industry, authorities and political decision-makers can factor all these raw materials into economically and ecologically sensible strategies. This is precisely the challenge that the project “Prospecting Secondary Raw Materials in the Urban Mine and Mining Waste” (ProSUM), funded by the EU research program Horizon 2020, set itself (www.prosumproject.eu). Besides 17 research facilities from 12 countries, the project also involved three Empa laboratories, especially the Technology and Society lab, which was in charge of the work package “Product Characterization”.

Headed by Patrick Wäger, the lab has been investigating recycling systems for many years. One of the research focuses is handling electrical and electronic waste (known as e-waste) in Switzerland as well as in developing and threshold countries. In recent years, the focus of the activities has widened to include critical raw materials such as indium, rare earth elements and platinum metals.

A young science

Empa researcher Heinz Böni and his team have been concentrating on the role of critical raw materials in the “social metabolism”. A play on the physical metabolism, this is what environmental scientists call the material and energy flows triggered by social activities. Research on social metabolism is a rather young science, with Peter Baccini and Paul Brunner paving the way in the late 1980s at Eawag, the ETH Domain’s aquatic research institute. Since 2007 a research group at Yale University has been focusing on assessing raw material supply risks; the Yale researchers developed a “criticality matrix”, based on which the EU published its first study on the criticality of raw materials in 2010.

Böni’s team especially focuses on closing material cycles for rare metals and critical raw materials. In a project funded by the Swiss Federal Office for the Environment, for instance, the researchers examined the recovery of neodymium, which is found in voice coil magnets in hard drives, for example, and recycling indium, which is found in flat screens. Currently, the Empa team is working on possibilities of recovering rare metals from electrical and electronic vehicle components and thus keeping them in the material cycle.

An invitation from the Netherlands

It was researchers from Delft University of Technology who eventually approached the Empa scientists and asked them to join the ProSUM consortium. “The Dutch colleagues knew us from collaborations on other projects,” says Patrick Wäger, who headed one of the five ProSUM work packages. The starting point was a database for mineral raw materials in the EU, which the French Office of Geological and Mining Resources (BRGM) had developed within the framework of an earlier EU project, “Minerals4EU”. Empa researcher Amund Loevik was tasked with collating the scattered data from different sources and putting it in a consistent form. The primary goal was to assess the quality of the data and weight it accordingly.

To accomplish this ambitious task, Wäger and Co called for backup from other Empa colleagues: Matthias Rösslein from the Particles-Biology Interactions lab helped Loevik with processing and evaluating the data using statistical methods. Analytics experts Renato Figi and his team from the Advanced Analytical Technologies lab developed and validated new methods to take and prepare samples and conduct chemical analyses (see page 16). The key objective here was to determine the level of critical raw materials contained in selected products and fractions from processing old batteries, electrical and electronic devices and in diverse shredder fractions from end-of-life vehicles.

In January 2018 the ProSUM database finally went live on www.urbanmineplatform.eu. The Urban Mine Platform contains datasets on flows, stocks, composition and waste flows from batteries, electrical and electronic devices and vehicles. This enables researchers, the recycling industry and political decision-makers to obtain specific information on past and future developments, such as with a view to estimating the raw material potential of particular stocks in the urban mine or developing innovative recycling strategies. //

Traces in scrap

Last year Empa's inorganic analytics lab was granted the status of "Reference Laboratory" within the scope of the ProSUM project, funded by the EU. Fine-grained samples of shredder waste from scrapped cars, e-waste or mine dumps from all over Europe end up here. Empa chemists find out what is in them, what is worth extracting and what could be dangerous for staff at recycling plants.

TEXT: Rainer Klose / PICTURE: Empa

EU Reference Laboratory

Renato Figi's inorganic analytics lab was declared a Reference Laboratory in 2017 within the scope of the ProSUM project and tasked with validating the analytic results of the other partner countries. Reference labs develop standard methods within the EU, which are supposed to be used uniformly by national laboratories in all 28 EU member states so that results are comparable.

Renato Figi and Claudia Schreiner find minute traces of precious raw materials in scrap.

Goggles on – and don't touch anything," says Renato Figi, head of Empa's inorganic analytics lab. As soon as we step into his lab, we realize that this somewhat unusual greeting makes perfect sense: There are beakers of green, yellow and tangerine-colored solutions standing in the fume hood. The tangerine beaker is covered with a watch glass, which Figi, wearing protective gloves, removes and carefully rinses with distilled water. "The beaker contains aqua regia, a mixture of concentrated hydrochloric acid and nitric acid." One drop on your shirt and you can kiss it goodbye; if it splashes in your eye, it's an immediate trip to the hospital for you.

However, it is not just laboratory visitors who need protection from the caustic solutions; it goes both ways. After all, we are talking about quantities measured in "parts per billion" (ppb). Or to put it another way: a billionth of a gram of the substance under investigation in one gram of sample substance. One speck of street dust, one flake of dandruff – this would already be fatal for the level of accuracy the Empa chemists are striving for.

Grains from the shredder

For the ProSUM project (see page 14), Figi and his team analyzed granulated samples from different waste groups: ground-up electrical and electronic devices, vehicle scrap, all manner of chopped-up batteries and mining waste. Decoding a sample begins in the dry – with an X-ray fluorescence analysis (XRF). "Thanks to this device, we can find every element that is heavier than fluorine with the atomic weight 19 up to uranium with the atomic weight 238," explains Figi. Many analytics labs in industry content themselves with this kind of analysis; their accuracy, however, ends in the percentage range.

Sharp acids, hot plasma

In order to get down to the ppb level, you need good old wet chemistry: the samples are poured into a Teflon container along with concentrated nitric acid, hydrogen peroxide, aqua regia or even hydrofluoric acid and heated to temperatures of up to 280 degrees Celsius in a special microwave oven. Figi: "This dissolves most things, bar a couple of fluoride compounds with rare earths." The liquid samples are then atomized and analyzed in 18,000-degree plasma. This is provided by two special devices called ICP-OES (Inductive Coupled Plasma-Optical Emission Spectrometer) and QQQ-ICP-MS (Inductive Coupled Plasma Mass Spectrometer). The resulting spectra – series of figures in a computer table – are evaluated by both Figi and his colleague Claudia Schreiner to avoid missing something. But this is when the real detective work begins.

Leaving traces – reading traces

As Figi knows: many elements that are only present in tiny amounts in the sample might be hiding behind other more dominant components. Iron and nickel, for instance, are close in terms of atomic weight, i.e. they are not always easy to tell apart in the mass spectrometer. However, the chemistry detectives have a trick up their sleeves: "We can remove the unwanted elements from the solution using a chemical reaction," explains Figi. "I precipitate the iron out of the solution as iron oxide, leaving only nickel behind in the mass spectrum – and I can determine the exact amount in the sample." Sometimes the chemist even goes a step further and adds a small amount of an element, which he suspects is in the sample, analyzes it under the spectroscope again and compares the results. This is known as "spiking".

"You end up amazed by all the things you can find in a normal, run-of-the-mill hair-drier," says Figi. Not just neodymium from the magnets for the drier's electric motor – that is to be expected. The Empa team also found traces of praseodymium and samarium in the samples. "Looking for traces isn't just about recycling the waste in the most lucrative way possible," says Figi. "It's also a question of protecting the staff at recycling plants from being poisoned." For instance, if it comes into contact with acids, a high arsenic content in a sample can cause arsine to form – a notorious poison gas from World War I. "It strongly smells of garlic," says Figi. "One whiff and there's only one thing to do: get the hell out of here!"//

Matthias Koebel next to a sample of aerogel granules. It takes a lot of know-how to produce the ultra-light insulating material.

“Research should be fun”

Research should set things in motion. This is the motto of Matthias Koebel, Head of Empa’s Building Energy Materials and Components lab. The chemist has ambitious goals and successfully combines an inquisitive spirit with entrepreneurial flair.

TEXT: Cornelia Zogg / PICTURE: Empa

Matthias Koebel is a pragmatic. One who not only understands things but also wants to use them. You immediately sense this when he talks about the research projects conducted in his lab. Research is his passion, especially when the projects he tackles eventually find their way from the lab “to the street”. One of his core topics is aerogel, a class of material that, thanks to its unique properties, is regarded as a promising alternative to previous materials in a wide range of fields – from outer space to the construction industry. A classic representative, silicate aerogel, is heat-resistant up to 600 degrees, ultra-light, non-toxic, waterproof, a great insulator and can be produced as a powder or granules and used widely in various products.

Lucky coincidences

On the other side, aerogel is still expensive to produce, which makes it hard to compete with conventional materials. Nonetheless, Koebel and his team not only succeeded in producing aerogel more simply on a laboratory scale, but also in gathering vital experience in what is known as the scale-up. In the end, they managed to produce the material in large quantities using a simplified and even less expensive method.

But the path was anything but straight as the scientist from Aargau happened upon aerogel thanks to a series of lucky coincidences, of which – he concedes – he has had many in his life. It was a coincidence that he ended up at Empa as a chemist in what was then the Building Technologies lab – i.e., as a kind of exotic bird in a flock of architects, construction physicists and engineers. There, he came across aerogel insulating materials within the scope of a CTI project. And his scientific spirit also stood him in good stead here as Koebel was not willing to content himself solely with upscaling. “In order to take something from a lab scale to large-scale production, first of all you need to understand the process,” he says.

This prompted the team of “nobodies” to start synthesizing aerogel themselves and learn the ropes. Only a short while later, Koebel suddenly found himself at a congress in the US rubbing shoulders with all the top-shots in the field, which also resulted in him co-editing a reference work on the topic – and sticking with it over the years. And with a certain degree of success, too, as he says with a hint of pride: “Meanwhile, we’re extremely well-connected and have become top-shots in the field ourselves.”

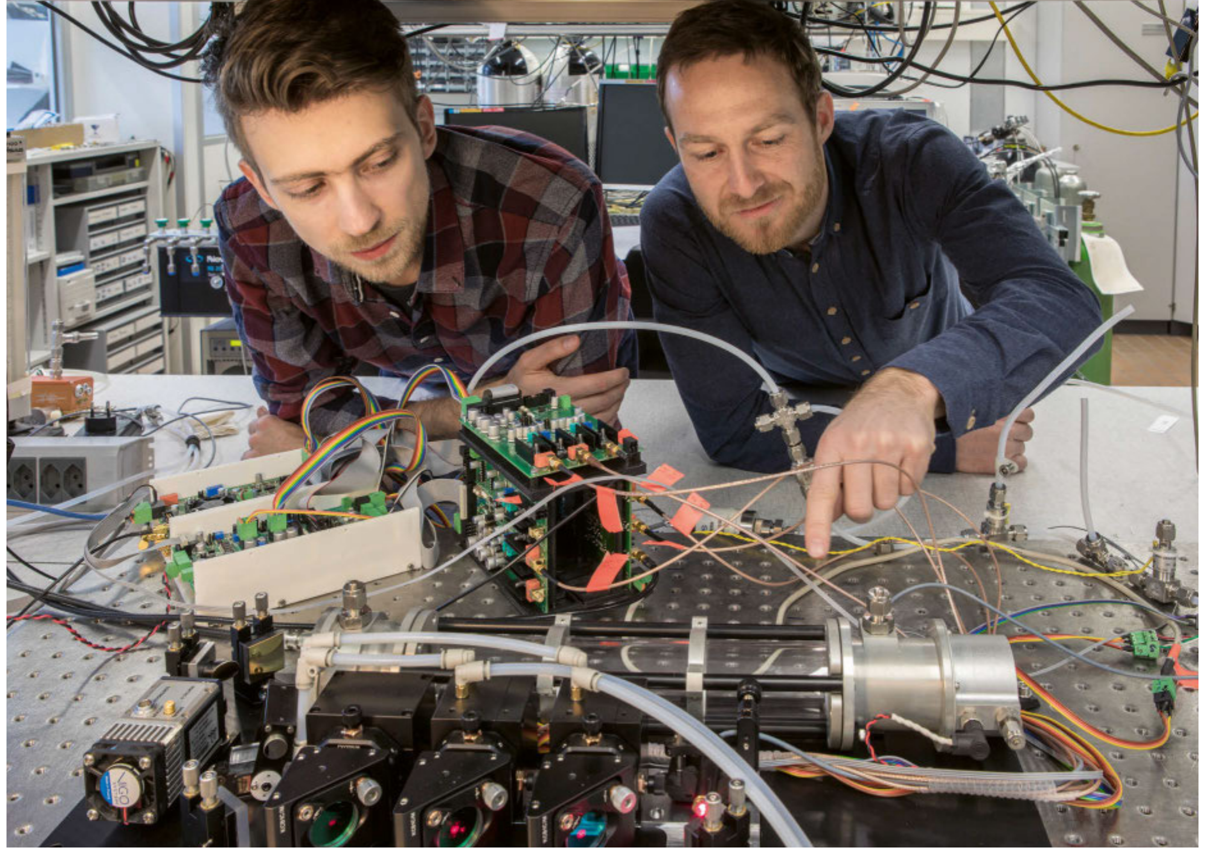
From the lab into society

His strong focus on practice is also reflected iHis strong focus on practical applications is also reflected in the structure of his lab. While two teams concentrate on basic research on aerogel and other colloidal materials, a third group is devoted to finding potential applications for the new materials. Koebel has plenty of ideas, but of these numerous brainwaves he only pursues the ones he deems promising – as Koebel is the kind of entrepreneur whose heart is not just in research, but also in society.

He sees himself more in the role of a «mad scientist” – but only to make sure his ideas don’t get stuck at the lab door. “I want to achieve something,” he stresses, and that is precisely why it is not just pivotal for him to advance research in the lab, but also to implement it on the market. The scientists in his team are, therefore, expected to adopt a two-pronged approach, i.e. not just think about the next scientific publication but also keep one eye on a possible industrial application. Thinking and experimenting takes time, Koebel notes, one aspect that is all too readily lost in our society, which is geared towards quantitative output. In Koebel’s lab, however, it may take a bit longer until the next publication, but then the quality needs to be right.

Chemist and amateur chef

Enjoyment is a principle that characterizes Koebel’s life in general. Taking time so that many ideas can be tested, so good research can take shape and so you end up where the true treasures lie buried; so you can really get to the bottom of things. “Chemistry is like cooking,” says Koebel. “Chefs need to know their ingredients, master the craft and be gourmets to produce good results. They have to enjoy the process; it’s the same with chemists: enjoy research.” It is hardly surprising that Koebel is also a gourmet and passionate cook in his spare time. And regardless of whether he is cooking up new recipes at home or in the lab, taking pleasure in it always comes first for him. //



Oleg Aseev (left) and Morten Hundt putting the finishing touches to the prototype of the MIRO measuring device.

Nine at one blow

Atmospheric pollutants put a strain on the environment and harbor health hazards for humans. The Empa spin-off MIRO Analytical Technologies developed a technology to simultaneously analyze nine greenhouse gases and pollutants with only one device and at an unprecedented speed and precision.

TEXT: Cornelia Zogg / PICTURE: Empa

Air pollution is a problem that affects us all. However, instruments to measure greenhouse gases and pollutants in the atmosphere are complex, expensive and usually consume a lot of energy as every gas is gaged using a different method. Two researchers from Empa's Laboratory for Air Pollution/Environmental Technology, Morten Hundt and Oleg Aseev, have developed a method that simplifies this process: Using only one device, they are able to detect nine greenhouse gases and air pollutants simultaneously. These also include nitrogen dioxide (NO_2), which until now usually could only be measured indirectly, potentially distorting the results. "Our goal is to make air quality and greenhouse gas measurements easier, more accurate and cheaper," says Hundt.

Pollutants from the exhaust pipe

The sensor developed by MIRO can measure carbon monoxide (CO) and carbon dioxide (CO_2), ammonia (NH_3), nitric oxides (NO and NO_2), laughing gas (N_2O), ozone (O_3), sulfur dioxide (SO_2) and methane (CH_4) with high precision. This may especially become relevant in the course of the political discussions on vehicle bans in cities, like in Germany recently, as a proportion of these pollutants stems from car emissions.

Not only can the high-precision measuring instruments developed by MIRO be used in the context of exhaust gas emissions. As part of the Paris Agreement, the international community of states regularly develops new plans to curb greenhouse gas emissions such as carbon dioxide, nitrous oxide or methane. Whether or not these measures will actually succeed needs to be verified, however. This requires more accurate measurements, which then serve as input values for detailed atmospheric models. These measurements are conducted by scientists from government measuring networks, such as NABEL in Switzerland ("Nationales Beobachtungsnetz für Luftfremdstoffe"). Here, too, the new MIRO technology can make work easier, as Empa researcher and NABEL project leader, Christoph Hüglin, confirms: "The MIRO measuring device is a highly promising alternative to the instruments currently available."

Three double quantum cascade lasers are better than one

The new approach is based on laser absorption spectroscopy and combines three double quantum cascade lasers in one device, which enables various gases to be measured with high precision. The laser's light is absorbed by the gas molecules. "The more light is absorbed, the higher the concentration of the relevant pollutants in the analyzed air sample. In other words, it's a direct and absolute measuring method," explains Hundt. "We selected the spectral range so we didn't have to worry about any cross-sensitivity," adds Aseev.

Hundt and Aseev already demonstrated that their idea works perfectly in the lab; they are now in the process of combining this functionality in a mobile device. Founded in February, the start-up MIRO Analytical Technologies is initially looking to position itself on the climate science and air quality monitoring market with its novel sensor. But the range of potential applications is vast. For instance, its use in industry or in the security sector is also conceivable. //

Empa spin-off IRsweep

MIRO Analytical Technologies is not the only Empa spin-off to use optical spectrometers. IRsweep, founded in 2014, specializes in molecular analyses. The application areas for the spectrometer developed by IRsweep include real-time observations of enzymatic reactions and the monitoring of chemical reactions.

HORIZON 2020

COFUND – the EU co-funds budding scientists

On 19 March Empa once again welcomed 20 postdocs who receive funding by the EU's COFUND program. The junior scientists in the EMPAPOSTDOCS-II group hail from Europe, Asia and Australia, bring their expertise from universities around the globe to the table in Empa's research network and are looking to gain new experiences for their further careers.

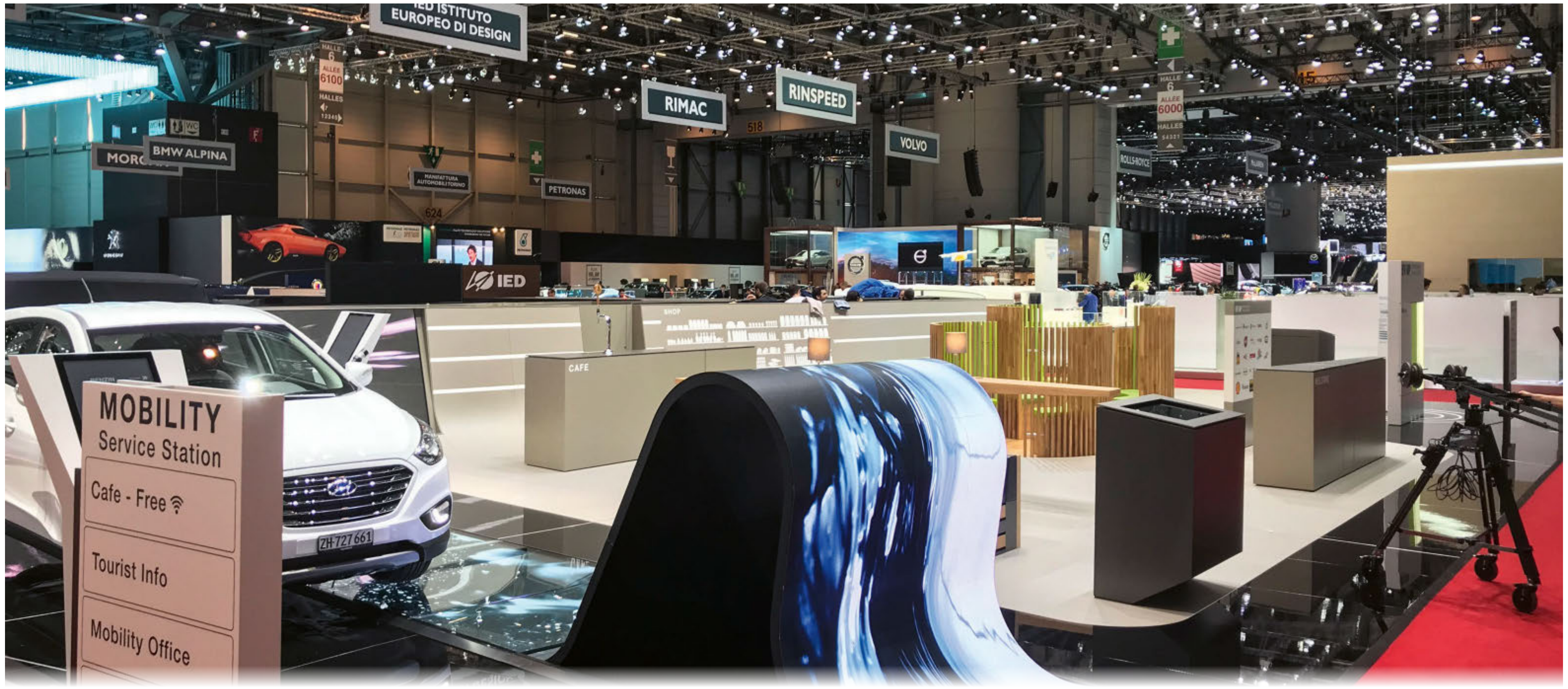
In February 2017 the EU approved Empa's COFUND application to the tune of over EUR 3.5 million. It had already been the second time Empa (successfully) applied for the funding scheme. The EU is co-funding a total of 50 postdoc positions at Empa on a roughly one-third basis for a period of five years within the framework of its Marie Skłodowska Curie program. The great news: of 68 applications from all over Europe, Empa's proposal was given the highest mark – 99.2 points out of 100.

The 20 junior scientists who just started are the first group of COFUND fellows. They are involved in practically every walk of Empa research: novel batteries, additive manufacturing (AM), carbon-based electronics, noise-absorbing metamaterials, nanocomposites, synthetic skin, wound-healing gels, textiles, concrete research and monitoring greenhouse gases in the atmosphere.

Empa CEO Gian-Luca Bona advised the new Empa researchers to network as well as possible: "Leave your labs and talk to colleagues about the problems you face. Research is not predictable – and someone out there might well have a smart idea on how you could proceed."

Anyone interested in COFUND postdoc positions at Empa can apply for the second wave of the EMPAPOSTDOCS-II program between 1 June and 31 August 2018. Further information is available at

www.empa.ch/web/empa/empapostdocs-ii



Gas station of the future at the Geneva Motor Show

TEXT: Rainer Klose / PICTURES: Empa

At the Geneva Motor Show in mid-March Empa showcased the "gas station of the future" in cooperation with the Swiss Oil Industry Association (Erdöl-Vereinigung) and Hyundai. Visitors could try their hand at refueling a fuel cell-powered Hyundai iX35 with hydrogen on a realistic simulator, which had been built by specialists from Empa. Federal Councilor Guy Parmelin also dropped by on opening day and listened to Empa CEO Gian-Luca Bona explain the refueling process and the scientific background.

Fuels made of surplus, renewable electricity

At Empa's info stand, experts explained why hydrogen will be ideal as a fuel for cars in future: In the summer of 2035, if the forecasts are anything to go by, Switzerland will be "harvesting" much more green electricity than it can consume. This surplus energy can be converted into hydrogen and used for mobility, which will mean that solar and wind turbines can keep running at times when they are particularly productive.

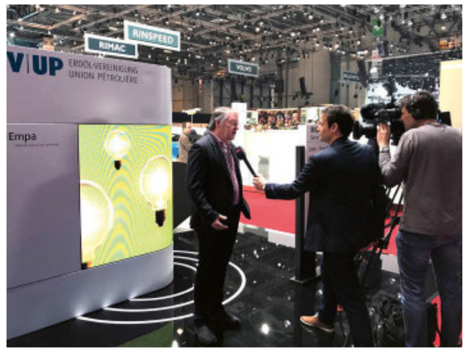
This is already being tested in move, the future mobility demonstrator on the Empa campus in Dübendorf. An animated film at the Empa stand informed visitors about the set-up and function of move. //

Top
The pristine stand of the Swiss Oil Industry Association (and Empa) shortly before the Geneva Motor Show opens.

Center right 1
Federal Councilor Guy Parmelin and Motor Show Director André Hefti treated to a hydrogen refueling demonstration by Empa CEO Gian-Luca Bona.

Center right 2
Empa's touchscreen explains how hydrogen is produced from surplus electricity.

Bottom right
Preparation for the press conference: (from left to right) Daniel Hofer, President of the Swiss Oil Industry Association; Brigitte Buchmann, Head of Empa's Mobility, Energy & Environment Department; Nicholas Blattner, PR Manager at Hyundai Suisse; and David Suchet, Head of Communications at the Swiss Oil Industry Association.



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4. – 6. Juni 2018
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19. Juni 2018
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