SALT OF THE EARTH

Researchers in Eindhoven, Netherlands, are working on an ingenious thermal energy storage system for use in the energy transition. The main ingredient is also found in gingerbread

TEXT **TOM RADEMACHER** PHOTOGRAPHY **ROBERT EIKELPOTH**

"We store surplus heat in the cellar"

OLAF ADAN, HEAD OF HEAT-INSYDE

Olaf Adan has many jobs, but no desk. "It would be pointless for me to have one, because I travel around a lot," he says. Adan, a physicist, opens his laptop wherever his work takes him. Usually that's in the labs of Eindhoven University of Technology (TU/e) or in the TNO building on the other side of the city. TNO stands for Toegepast Natuurwetenschappelijk Onderzoek, the Netherlands Organisation for Applied Scientific Research. Eindhoven is home to one of the organization's research centers, where Adan heads the Materials Technology research area. At the TU/e, he is Professor of Applied Physics and heads the Transport in Permeable Media group. In this capacity, he uses retired MRT devices that he has adapted for his purposes in order to examine the interior of concrete parts, for instance. "It enables us to understand why fires cause tunnel ceilings to literally explode, for example."

However, Olaf Adan is currently especially busy as the Head of Heat-Insyde. This development consortium was founded last fall by eleven international project partners, including Evonik. The consortium receives almost €7 million in funding from the EU.

SOLAR ENERGY FOR COLD DAYS

Adan travels through half of Europe on behalf of Heat-Insyde. The countries he visits include Poland, Belgium, France, and Germany. He recently came to Lülsdorf near Cologne, where Evonik produces materials that play a major role in Adan's project. Adan and his team are working on a revolutionary technology that could help store thermal energy for buildings without any loss of energy and as long as desired. This could make the use of solar thermal energy more efficient and reliable. "Whenever the sun shines, we store surplus heat in cellars for use on cold, overcast days," says Adan. The system could store energy for more than just a few residential buildings, because entire communities and even large producers of district heating could use it to buffer peaks in supply and demand.

The Heat-Insyde project is located at the high-tech campus on the southwestern outskirts of Eindhoven. Over a period of two decades, around 200 startups, big companies, and research institutes have settled on this former Philips site, which is clustered around an artificial lake. Almost 40 percent of all the new patents registered in the Netherlands come from here. The researchers' first working heat battery stands in a small conference room on the third floor of the project building. The system uses a thermochemical material to store energy. It is based on the insights gained during two predecessor projects, in which TNO also took part.

One of these projects took place in Poland, where a few years ago a crane lifted a shipping container into the yard of a single-family home in order to provide it with sufficient storage capacity. The new demonstrator is much more compact than this. When put on rollers, it can be easily pushed through a room door. It mainly consists of just four components: a heat exchanger, a fan, an evaporator, and a reactor container. "The battery's simplicity is its biggest attraction," says Adan. The ground-breaking solution is contained in the reactor and consists of a layer of grains of a special salt through which the fan blows hot, dry air. The energy needed for this process can be supplied by roof-mounted solar thermal collectors, for example. Theoretically, any source of electricity could also be used for this purpose. The air heats up the salt, dries it, and releases water vapor into the airstream. The condenser extracts the moisture from the air until the salt is completely dehydrated. The battery is now charged. "The energy remains in the salt as long as I keep it dry," explains Adan. "All I have to do to get the energy back is to add moist air." →

The substance that Olaf Adan uses to coat his salt is a secret

Pim Donkers wrote his doctoral thesis about the thermochemical principle that forms the basis of the heat battery. He found out that potash (below right) is the perfect storage medium

In the heat battery, this role is also played by the fan, which now blows air that is cold and moist through the dry layer of salt. The salt absorbs the moisture from the airstream, heating the air up to over 60 degrees Celsius in the process. This heat can be used for space heating and for heating water. The underlying principle has been known to mankind for a long time: When crystals of certain salts absorb water, they release heat. Adan's co-worker Pim Donkers likes to demonstrate this effect to visitors by putting a glass full of small balls of such a salt into their hands.

He then squirts a good shot of water into the glass from a bottle. The water immediately disappears into the salt and the glass heats up. Five years ago, Donkers wrote his doctoral thesis about this surprising effect. To do so, he investigated almost all of the salts that could conceivably be used for this purpose. "Copper salts were my personal favorite," he says. "Unfortunately, they are much too expensive." Some of the other salts proved to be unstable or corrosive, or they even produced toxic gases. This made all of them unsuitable for a system that was meant to operate for decades in the cellar of a single-family home.

THE MAIN INGREDIENT: POTASH

Donkers eventually tested a salt that has a very high energy density and that can be very well hydrated and dehydrated at household temperatures. This salt is stable, harmless to use, and comparatively inexpensive. Its chemical name is potassium carbonate, and it is also known as potash. Potash is used in innumerable applications, ranging from cocoa processing to the production of crystal glass. In Germany, one of the best-known applications is in gingerbread production, where potash is used as the leavening agent. "This shows how harmless the material is," says Georg Dürr, who works at Evonik's Application Technology unit in Lülsdorf. The plant there has been manufacturing potash for the past 70 years. Evonik has an annual capacity of around 60,000 tons per year, making it one of the world's leading producers of potash. Potash is manufactured from potassium hydroxide, which Evonik produces itself using a very resource-conserving electrolysis technique. The base material is potassium chloride, which, like table salt, is mined in Europe and other parts of the world.

A BUILDING BLOCK OF THE ENERGY TRANSITION

Whereas baking enthusiasts can buy 15-gram sachets of potash in supermarkets, Evonik only sells the material by the truckload. That's why Dürr only found out about Heat-Insyde because he received an unusual inquiry from a distributor. "They wanted to have small product samples and asked us very unusual questions," recalls Dürr. After writing a few e-mails and making some calls, Dürr was on the phone with Olaf Adan himself. Shortly thereafter, Dürr drove the two-hour stretch to Eindhoven. A back-of-the-envelope calculation had made Dürr and his superiors sit up and take notice. According to the Bundesverband Solarwirtschaft (German Solar Association), there are almost 2.4 million solar thermal energy systems in Germany alone; 71,000 were installed in just one year. "Even if we can only reach one percent of that, it would still be a respectable market," says Dürr. "You have a product that is extremely versatile but also very well-known and seemingly refined as far as it will go. But suddenly you don't just find a great market opportunity but also realize that it could possibly be a key component for the success of the energy transition."

The high-tech campus on the outskirts of Eindhoven is home to numerous tech companies, including Heat-Insyde

PROTOTYPES IN SEVEN HOMES

However, much still needs to be done before this can be achieved. Although potash from Evonik has proven to be extremely suitable for this application due to its high purity, the demonstrator still has to be turned into a marketable product. This device should be no bigger than a washing machine but even simpler to operate. "You don't really need more than an on-off button," says Adan. The high energy density of potash, combined with the system's simple design, make the technology very appealing. "We expect that our heat battery will be only half the size of today's storage systems that use lithium-ion batteries, even though it will have the same output and cost only a tenth as much," says Adan. Although other common storage systems such as those that store heat in insulated water tanks are similarly inexpensive, they are about ten times bigger and also less effective. Moreover, the Heat-Insyde storage system would produce little noise and require little maintenance because it has only a single moving part: the small fan. Another bonus is that the salt can be completely recycled.

As is often the case, this ingeniously simple technology is the result of lots of scientific research. The salt is turned into a composite in order to keep it stable for decades and hundreds of charge-discharge cycles. The composite's composition is a carefully kept trade secret. In addition, the researchers are still working on an optimal structure for the salt layer and the particle size so that the airstream can flow through the reactor as effectively as possible. Another doctoral thesis being worked on in Adan's department focuses on doping—the intentional addition of impurities in the salt's crystal structure in order to improve its absorption rate and storage capacity.

The system's parameters are based on a typical range of requirements. "In our climate, you practically never have to store energy from solar thermal systems for more than 12 to 14 days," says Donkers. In order to demonstrate that the Heat-Insyde storage system can enable a four-person household to get by very well for two weeks in winter, near-series-production prototypes will be installed in seven homes in France, Poland, and the Netherlands by the summer of 2022 at the latest. "We have already been overwhelmed by applications," says Adan before departing with his laptop under his arm to his next appointment at the university.

Olaf Adan (left) and his team are working together with Evonik. The Group's plant in Lülsdorf produces potash, for which Georg Dürr is trying to find new areas of application