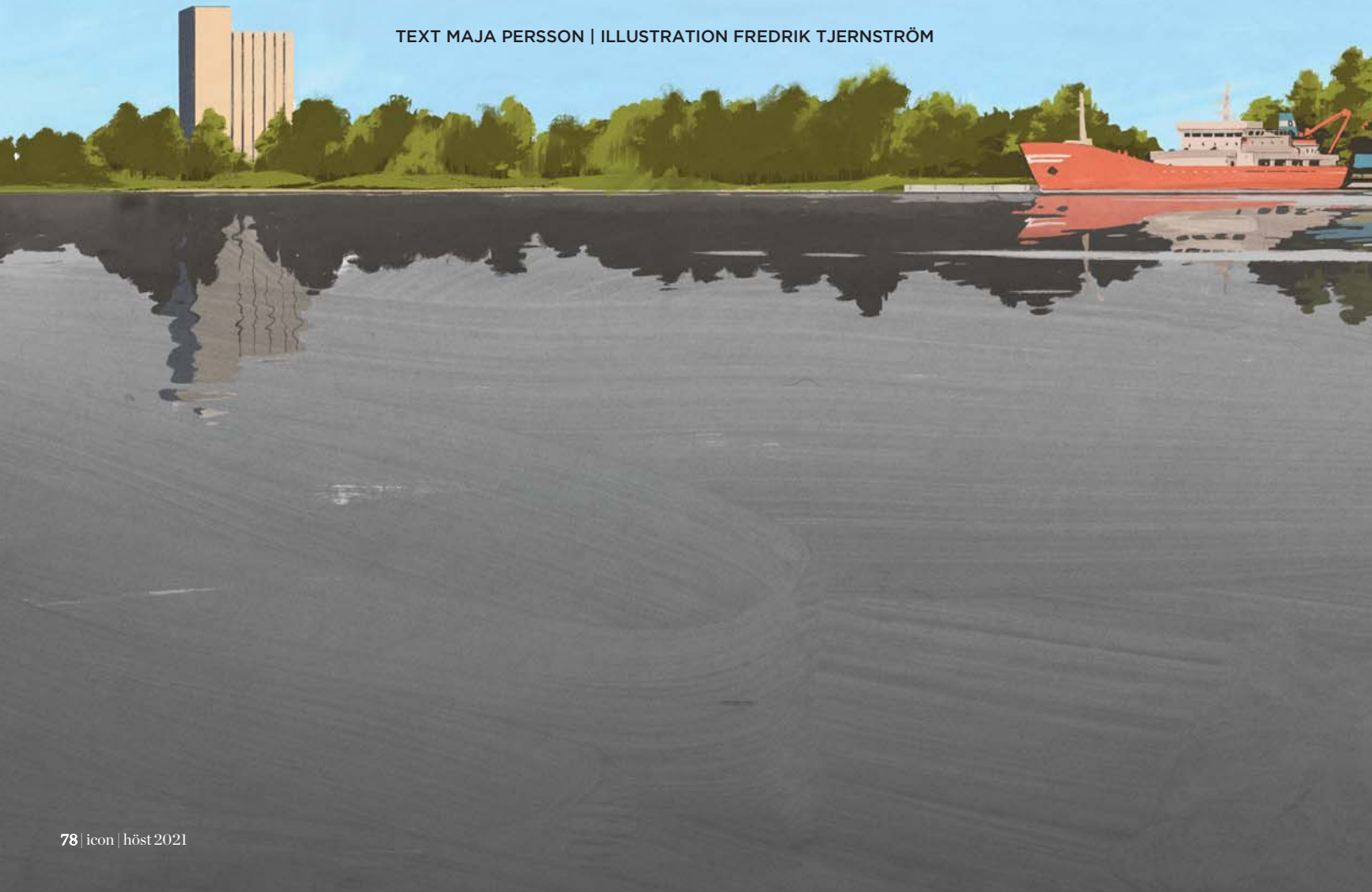
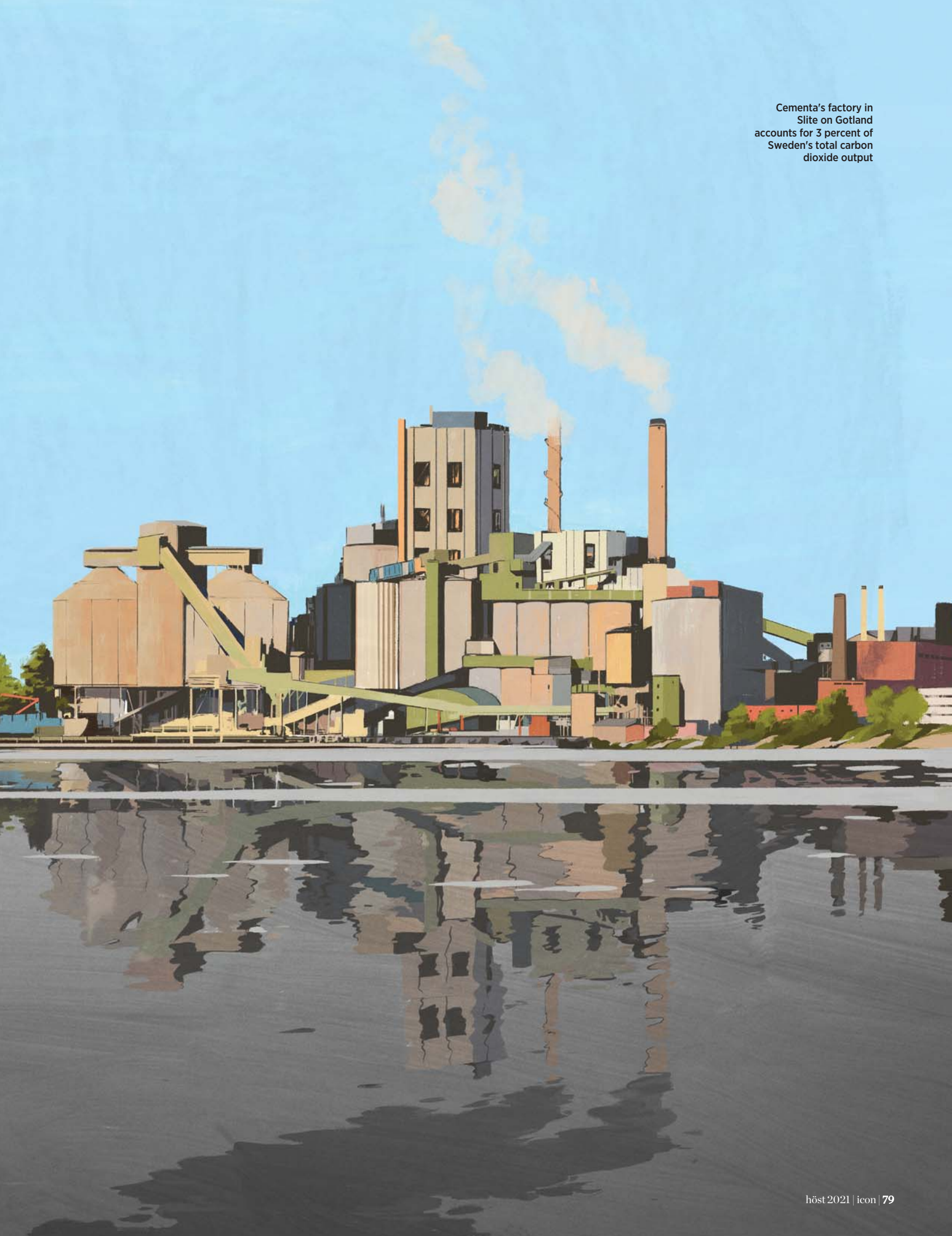
THE INNOVATION BURIED BY AN INDUSTRY

28 years' ago, Cementa already had an innovation in its hand that could cut the industry's carbon dioxide emissions. Nevertheless, cement production remains one of the World's most polluting industries. So, why doesn't anyone talk about there being better alternatives?

TEXT MAJA PERSSON | ILLUSTRATION FREDRIK TJERNSTRÖM





Cementa's factory in Slite on Gotland accounts for 3 percent of Sweden's total carbon dioxide output

ON AUGUST 10, 2021, Sweden's Minister for Economic Affairs Ibrahim Baylan and Climate Minister Per Bohlund stood at the podium at the Government Offices in Stockholm. With national media invited to the press conference, the assembled atmosphere was deadly serious. The reason? Sweden's looming cement crisis.

Sweden's Land & Environment Appeal Court had ruled that Cementa, which so far has supplied 75% of Sweden's cement, may no longer mine the limestone on Gotland needed for production. Industry representatives and trade unions have warned of a Swedish construction shut down and hundreds of thousands of lost jobs. Over the course of a few summer weeks, the Swedish public was made hugely aware of the enormous role that cement—a material that we all take for granted—plays in Human civilisation.

Cement is the key ingredient in concrete, which is the World's second most widely used material after water. From Rome's Colosseum to today's record-breaking skyscrapers, from roads and bridges to dams and water management systems, there is no doubt that but-for concrete, our built world would have been impossible.

Cement is the grey powder that upon reacting with water, binds together the sand and gravel of the concrete to form a mass of unequalled strength. To make traditional cement —called Portland cement—one needs limestone and clay that are crushed and then heated to 1,450°C in massive rotating kilns to form 'clinker'. That basic process has remained largely unchanged for over 100 years. Why would we ever change something as miraculous as liquid stone?

But along came the Climate Crisis. As is so often the case, one of Humanity's most ingenious inventions turns out also to be one of its most destructive.

When limestone is heated, a huge amount of carbon dioxide is released, meaning that cement production today accounts for about 8% of the World's CO_2 emissions. Each year, the cement industry puts out over 3 billion tonnes of greenhouse gases—more than triple that of aviation fuel. If the industry were a country, it would be the third worst CO_2 emitter in the World after China and the United States.

In August 2021, the U.N. Inter—governmental Panel on Climate Change released its starkest report yet. To solve climate change, huge CO_2 cuts must occur within ten years, else it will be too late.

"IF THE CEMENT INDUSTRY WERE A COUNTRY, IT WOULD BE THE THIRD WORST CARBON EMITTER IN THE WORLD —AFTER CHINA AND THE UNITED STATES."

The World faces two challenges: building infrastructure and housing for a growing middle class, and yet also, preventing the catastrophic climate effects of greenhouse gases.

In February 2021, when Bill Gates held a press conference to promote his book *How to Avoid a Climate Disaster*, he highlighted cement as one of the most pressing Climate Change issues to solve. In his book, he states the CO_2 put out by cement production cannot be fudged: "It's a chemical reaction —limestone plus heat equals calcium oxide plus carbon dioxide", he writes.

Cementa, whose Gotland factory accounts for about 3% of Sweden's annual carbon dioxide emissions, has presented a long-term solution to the problem. By capturing and storing the annual 1.8 million tonnes of CO_2 released when the limestone is heated, in nine years' time it will be the first in the World to produce 'carbon neutral cement'. The captured CO_2 is to be cooled to liquid form and transported on ships to the North Sea—eventually to then be pumped into its bedrock.

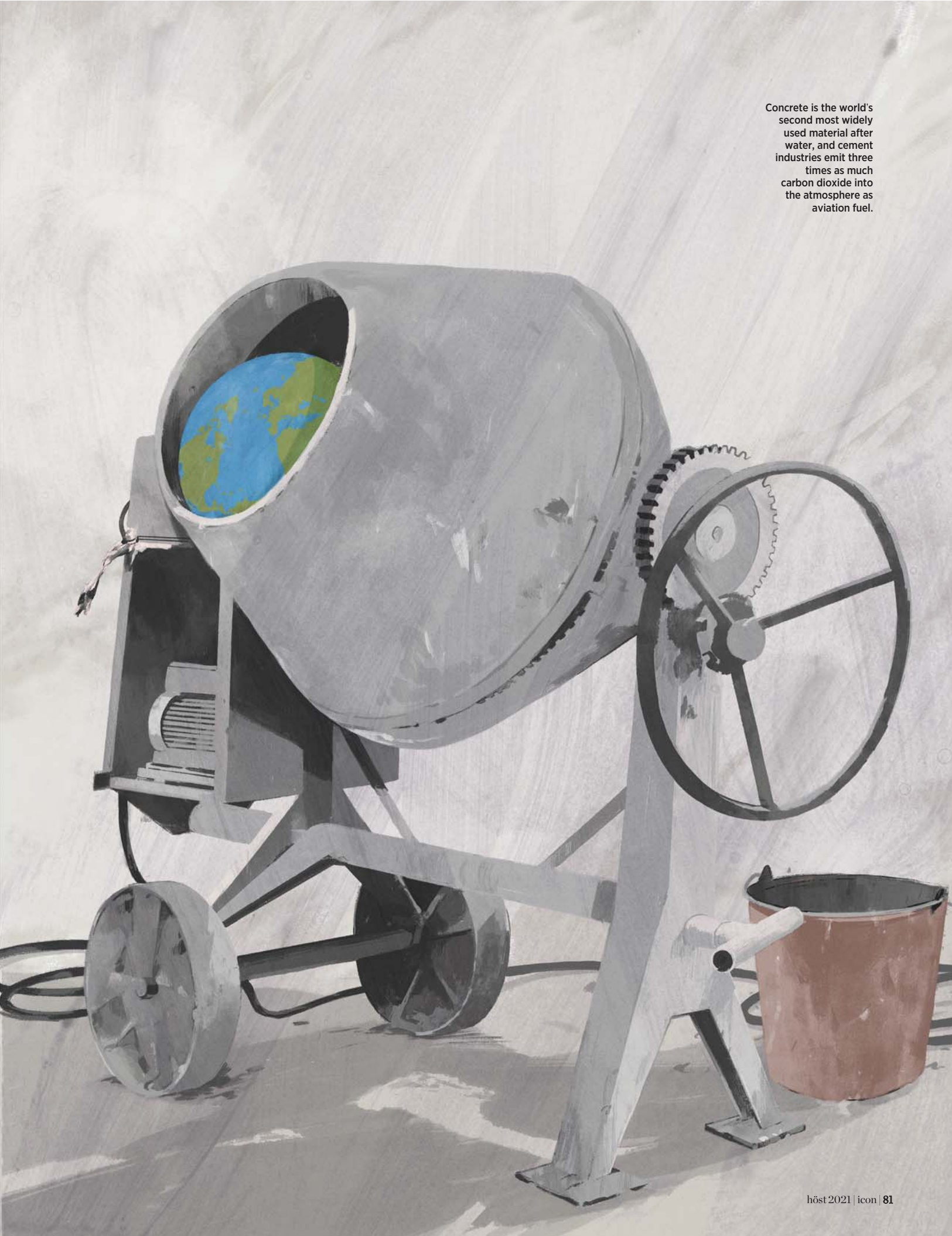
The Swedish government has stated it will support Cementa's plan to the extent of bankrolling it with taxpayers' money—costs believed to hit several billion SEK. This is despite the fact that such solutions carry warnings. A report by the Australian Climate Council —a working group that contributed to an August 2021 U.N. report—warns of "far-off, vague *net-zero* targets", and, from "relying on separating carbon dioxide from the atmosphere".

During their press conference in August 2021, Ministers Baylan and Bohlund declared they would amend Sweden's Environmental Code so to extend Cementa's permit to mine limestone on Gotland temporarily —an urgent solution to avoid the crisis the industry has being warning about.

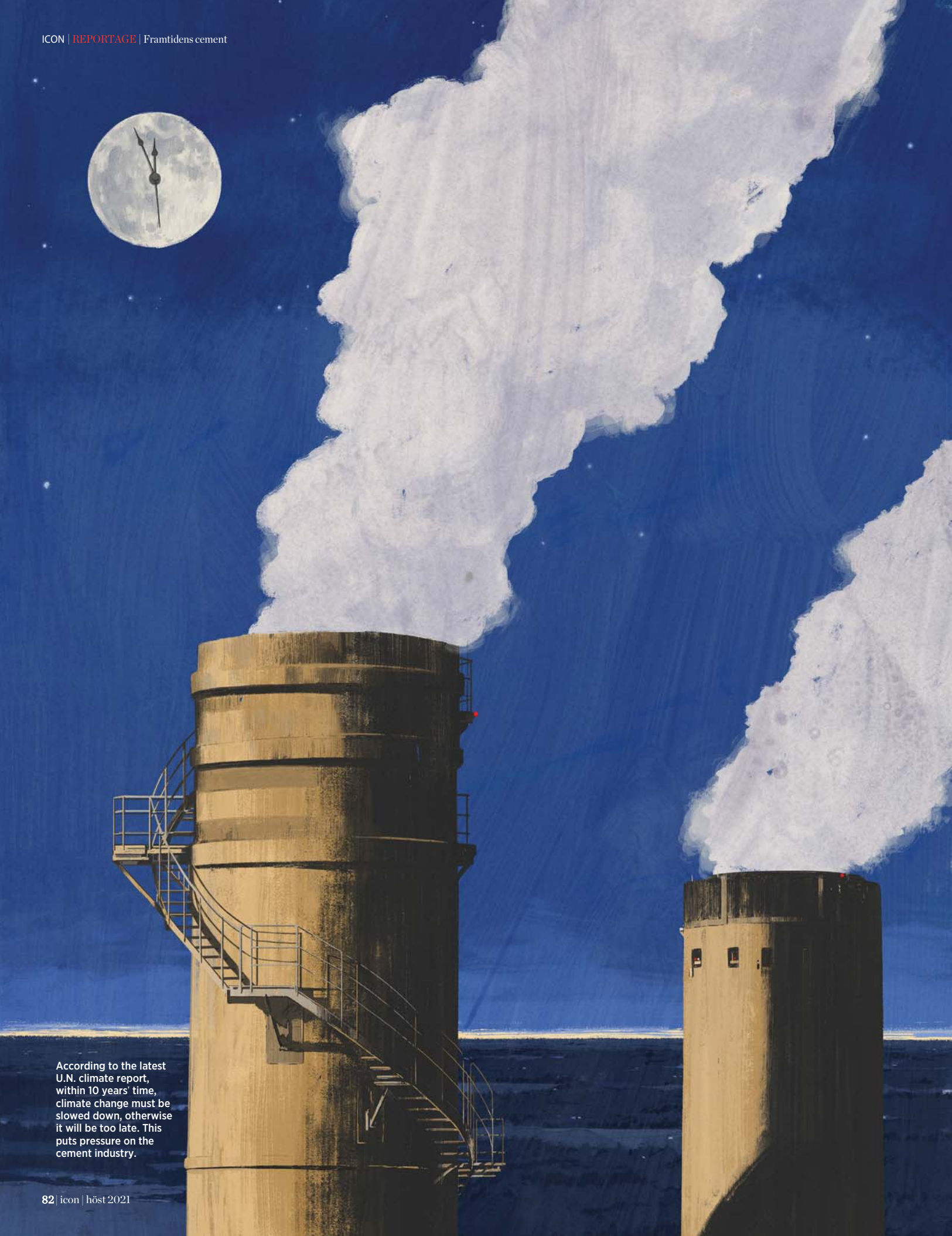
—The situation has clearly exposed a serious vulnerability, Ibrahim Baylan said.

But what neither Baylan, Bohlund nor Gates seem to know, is that Sweden and the World had the opportunity, with Swedish innovation, to avoid the cement industry's carbon dioxide emissions in the first place—over 28 years' ago.

In 1991, a technology was developed at Luleå University of Technology, carrying the potential to replace up to 70% of the usual Portland cement. But the scientist behind that innovation would soon face a most powerful adversary: one of the World's largest—and most polluting—industries. ▶



Concrete is the world's second most widely used material after water, and cement industries emit three times as much carbon dioxide into the atmosphere as aviation fuel.



According to the latest U.N. climate report, within 10 years' time, climate change must be slowed down, otherwise it will be too late. This puts pressure on the cement industry.

IN NOVEMBER 1991, Dr. Vladimir Ronin came to Luleå with his family. A professor of cement and concrete technology—and nearly 20 years as the head of department at the Research Institute of Construction Materials in the Soviet Union—he came to Luleå University of Technology as a guest researcher.

—I had been in charge of a team of 20-30 people who were all involved in applied research to support the Soviet industry, he said. So from a scientific and industrial perspective, I perhaps had a broader experience than many Western researchers, who often carry a narrower focus, says Dr. Ronin.

Luleå University of Technology had been established in 1971 as a scientific flagship in northern Sweden, where many young ambitious researchers came from Sweden and the rest of the World.

—There was an incredible level of equipment, especially compared to the Soviet Union where I came from, he says. I was very happy to investigate things that interested me without any admin responsibility, Dr. Ronin recalls.

In 1990s Sweden, we were still blissfully unaware of the impact of cement on the climate, and instead the construction industry's focus was entirely on making the concrete as high-performance as possible. Prof. Lennart Elfgren, professor of construction at the Luleå institution Dr. Ronin had visited, describes a high national commitment for making concrete stronger.

—This was a national centre for high performance concrete started by several companies in the industry, including Cementa, Skanska and NCC. We had national contacts and seminars, he says.

Vladimir Ronin experimented with the university's high-tech equipment, including a type of vibrating mills that process every small particle of the material added.

—When I drove the Portland cement through the mills, along with other common concrete additives, I started to see outstanding results, he says. In one day, I was able to get a concrete strength that usually takes 28 days to develop. I was 40 years' old, with over 18 years' research experience and I don't believe in miracles. My first reaction was that this was simply too good to be true.

However, after several system cleans and about a hundred repeated experiments, it then became clear to Dr. Ronin and his colleagues that the discovery carried huge importance.

—First of all, it's a pretty simple arrangement, he says. You don't need to design new machines, but only use adapted machinery already used in other processes. The technology uses only one-tenth of the energy consumed in ordinary cement production, and it doesn't release any CO_2. When I looked at the materials' performance, my first reaction was that that there had to be contaminants in the mill's chamber.

"THE TECHNOLOGY USES ONLY 10% OF THE ENERGY CONSUMED IN ORDINARY CEMENT PRODUCTION AND DOES NOT RELEASE ANY CARBON DIOXIDE."

— VLADIMIR RONIN, researcher and founder of EMC

The new technology was named EMC, which is short for 'Energetically Modified Cement'. The said energetic modification means that the material supplied to the vibrating mills is activated. It enables as high a strength development of concrete made with Portland cement—but with much greater durability and without the CO2 emissions or other pollutants.

Professor Lennart Elfgren, whom with Dr. Ronin wrote several scientific monographs on the newly-minted innovation, also saw great potential: ▶

FACTS: CEMENT AND THE CLIMATE

The heating of limestone, called calcination, counts for about 60% of cement production's carbon dioxide emissions. Over 3 billion tonnes of CO_2 are emitted annually through this process. The cement industry accounts for about 8% of Global CO_2 emissions.

Tasked with accelerating the Swedish climate transition, in 2018 the initiative Fossil Free Sweden, invited a number of industries to set out their roadmaps for a fossil-free future and increased competition. Cementa's roadmap, which also represented the entire Swedish cement industry, stated carbon capture and storage are to play a crucial part. Cementa then requested governmental support to be able to capture and store the carbon dioxide emitted by production, and then ship it and store it deep into the bedrock of the North Sea. The goal is to become, by 2030, the first in the World with a "carbon neutral" factory.

Concurrently, criticism has been levelled at the plans. In June 2021, Carl Schlyter, campaign manager for System Change and Climate at Greepeace, and former vice-chair of the EU Parliament's Environment Committee, recently told *Dagens PS* that the proposed process is a "false solution" and "greenwashing". Cementa's Sustainability Manager Karin Comstedt Webb responded to the criticism, saying amongst others, that this is a "crucial tool for achieving climate neutrality and our common climate goals".

In August 2021, the Intergovernmental Panel on Climate Change published a report showing that global warming is more acute than previously known. Ten years from now, we won't even have a theoretical chance of avoiding a warming to 1.5°C previously set as a limit. A report by the Australian Climate Council, the working group that contributed to the UN report, warns of "distant, vague 'net-zero' targets", and the real dangers of relying on the removal of emitted carbon dioxide from the atmosphere (as opposed to CO_2 avoidance) as a solution.

Sources: Dagens PS, Climatecounsil.org.au.

—It was a way to make concrete structures more efficient, he says. With a smaller proportion of cement, similar properties could be obtained.

Dr. Ronin received funds from a local winter concrete plant to test the material. Results showed that it cured even in Norrbotten's low temperatures.

—Understanding the construction industry, I concluded that this could have enormous commercial benefits. "Super-cement", says Dr. Ronin.

Dr. Ronin immediately applied for a patent on his discovery, and formed a company. With money from the Luleå Municipality, a pilot unit was built that could produce one tonne per hour of the new material. Local contractors built several projects with the new 'supercement', including a freshwater pond and a swimming pool.

—From a societal point of view, there was a lot to be gained from this new technology. But the cement producers were not so enamoured, because Vladimir could either make much stronger concrete with the same amount of cement as before, or he could make equally strong concrete with less cement, says Professor Elfgren.

IN THE SPRING of 1994, a TV feature was broadcast on SVT's *Actuellt* about the 'supercements' that had been invented in Luleå.

–Suddenly you were a celebrity at university, Ronin says, laughing. Interest exploded and I immediately received a call from Cementa, who said they wanted to test the material.

According to Dr. Ronin, Cementa paid for a trip to Slite, where it had its own laboratory and research centre.

—The tests showed our material had nearly twice the compressive strength as to what Cementa could produce, he says. It totally shocked them.

Dr. Ronin started receiving calls from Cementa's then Vice President, Fredrik Winberg.

—He offered me an 'adjunct' role with ties to Cementa, and that they would pay me a pittance to transfer the innovation over to them, he says.

Paying researchers salaries to link their research to the interests of the cement industry is not uncommon, either nationally or internationally.

—It's a big problem that researchers run the cement industry's business and become biased, Dr. Ronin says.

Cementa's then Vice President, Fredrik Winberg, does not currently work in the cement industry. He says he remembers Vladimir Ronin and his innovation as one of the many new ideas Cementa wanted to explore.

> **"MY DISTINCT FEELING WAS THAT CEMENTA WANTED TO BUY MY PATENT ONLY TO PUT IT ON THE SHELF AND THEN LET IT FALL INTO OBLIVION."**
>
> — VLADIMIR RONIN, researcher and founder of EMC

—It's been a long time now, so I don't remember all the details, he says. But when you find out new ideas in the Group, you naturally make an assessment of whether or not this is commercially viable. I remember we were trying to find out what this was, and we didn't really get clarity on it. There wasn't full transparency in the whole thing. And I remember we had a discussion with Ronin about working together, which he turned down.

Dr. Ronin describes it as Cementa making an utterly shameless bid:

—To transfer my innovation to such a small player compared to large international cement producers such as Lafarge and Holcim, from whom I also received calls ... I couldn't do that. My distinct feeling was that they wanted to buy my patent only to put it on the shelf and then let it fall into oblivion.

Lennart Elfgren, then a full-time professor at Luleå, recalls that it was difficult to get the cement producers on-track at an early stage.

—To do this on a large scale, it'd be preferable to be a cement producer that switched on and integrated the technology into its production. EMC had some EU projects in the pipeline, but cement producers did not see this as a great opportunity, but rather as a competitor, Professor Elfgren says.

From the perspective of the cement producers, Vladimir Ronin sees it as their natural reaction.

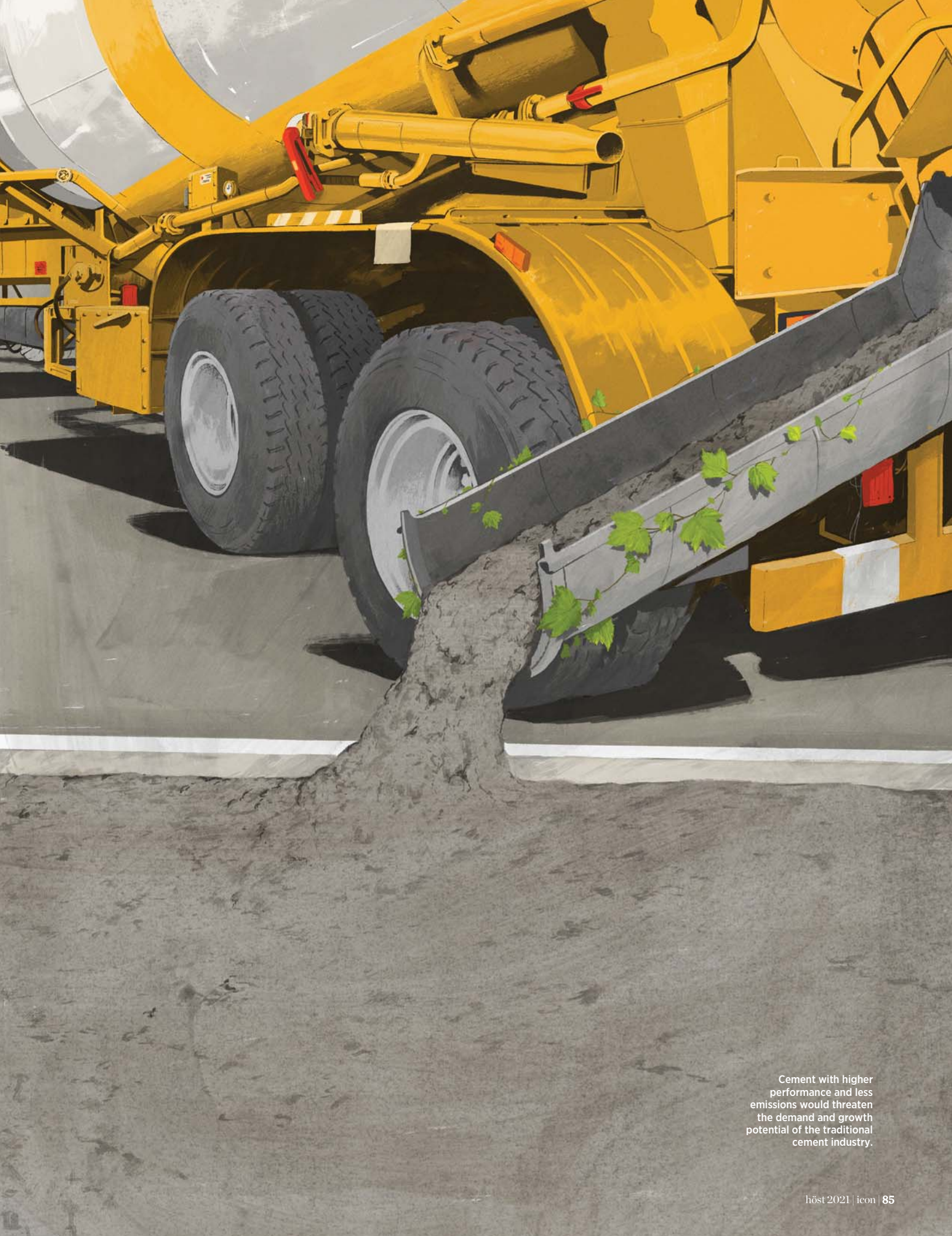
—A cement plant producing just 1 million tonnes a year costs $200–300 million, he says. So, can you imagine the finances of those companies that have the capacity to produce 50 or 100 million tonnes per year? And suddenly along comes a small company from Norrbotten's wasteland, with a unique technological solution that would halve the need for Cementa's core product? In addition, a technology that requires only 10% the energy consumption, a quarter of the capital costs, has zero CO_2 emissions and then the results are superior technicals? It's going to pose an existential threat to the incumbent Portland cement companies.

Fredrik Winberg does not recall seeing Dr. Ronin's invention as a threat to Cementa's core business.

–But a company has to assess based on what is good for the company. You have a duty to the owners. Nowadays, I'm working on a new innovation –advanced composites– and so I don't turn to the companies for which I think it may be a disadvantage.

Vladimir Ronin soon realized that his innovation would meet powerful resistance from the industry.

—Lennart started saying that I needed a lawyer. He was right. When I declined to co-operate, Cementa then blocked every opportunity. My venture found itself in a precarious situation. ▶



Cement with higher performance and less emissions would threaten the demand and growth potential of the traditional cement industry.

FACTS: CEMENT

Cement is a hydraulic binder in concrete, meaning it hardens when it comes into contact with water. It is cement that binds together the aggregates in concrete, such as gravel and stone, into a hardened mass.

The ordinary cement used today is called Portland cement, developed in the 19th century in England. To produce it, a mix of limestone and clay is burned in a huge 1,450°C rotating furnace, usually heated by coal, to form cement clinker (small balls). The cement clinker is then cooled and ground into a powder, then sold as cement.

FACTS: EMC

The EMC Cement Group:

Founded in 1996 by Dr. Vladimir Ronin and Atle Lygren. C.E.O. Lygren has now invested well-over $20 million in EMC. Peter Hoddinott and Dr. Paul Toyne also work within the Group.

In 1996, EMC was awarded the *Médaille d'Or avec Mention* by the EU organization EUREKA at the 45th World Exhibition of Invention, Research and Industrial Innovation, held in Brussels.

In 2014, the technology won the first prize in the competition Bygginnovationen — a collaboration program between the civil engineering sector and Vinnova. The jury's verdict read: "Energetically modified material lowers the environmental impact of concrete production significantly, as less cement needs to be used. Changes in the regulations allow this Swedish invention to be introduced in Sweden, to contribute to the fulfilment of Swedish environmental goals and provide new commercial opportunities for Swedish industry."

EMC Technology:

EMC, or energetically modified cement, is a technology discovered in 1993 at the Luleå University of Technology.

By grinding alternative materials such as fly ash, slag or volcanic ash using rotating and vibrating ball mills, it is possible to increase the chemical reactivity of those materials. According to the authors, these alternative materials can replace up to 70% of the usual Portland cement in concrete. The energy consumption of is ten times lower than in the production of ordinary cement, and it does not release any carbon dioxide.

A FEW YEARS' later, Vladimir Ronin came into contact with Norwegian investor and entrepreneur Atle Lygren, whom previously had built several successful shipping brokerage companies. On a cold snowy afternoon in Luleå, Dr. Ronin told Atle Lygren about the EMC technology that could reduce the amount of Portland cement in concrete by almost 50%.

—I listened and listened, and after a while I got goosebumps on my arms, Lygren recalls. I realised that if what he told me was true, I could be involved in transforming one of the World's largest industries, contributing to a huge reduction in its carbon emissions and other pollutants, and at the same time making a lot of money. I also understood that his company was out of money. At the time, I knew nothing about the economy around cement, but I was very anxious I'd read in the newspapers that someone else had seized the opportunity to support him.

Two months after Atle Lygren had returned home to Verbier, he invested SEK 20 million in Ronin's technology.

—Since then, I've invested at least 10 times more, says Atle Lygren. Today we have an industrially-proven technology that can reduce the cement industry's CO_2 by at least 70% ... a Worldwide potential of 3 billion tonnes CO_2 a year.

Later that year in 1996, the innovation won the *Médaille d'Or avec Mention* at the 45th World Exhibition of Invention, Research and Industrial Innovation.

By now, a patent battle had been brewing that would come to last 9 years. A few months after Dr. Ronin gained a patent for his invention, Cementa then applied to patent a similar approach. Cementa's application was rejected, after which Cementa then applied to cancel Dr. Ronin's patents by claiming that the technology was already known.

—The Swedish Patent Office rejected Cementa's objections, and so then they went on to the European Patent Office in Munich, explains Vladimir Ronin. This process, by which Cementa objected to my patent, went so far as to obtain a final decision in EU patent law, which took till 2002, where once again we were proven right. From 1993 to 2002!

Cementa's then Vice President Fredrik Winberg points out that it is not uncommon to challenge patents in the industry in which it operates.

—I don't think it was the only time we objected to patents, Winberg says. Typically, this is done when a patent application comes in. You look at it and if you don't think it's new, you point it out.

According to Professor Lennart Elfgren, the development from small to large scale was also hampered by the EU cement standard, itself based on the activities of the cement giants.

—They were designed to describe how the cement would be composed, what its contents would be and how much of the various ingredients there'd have to be, Elfgren says. It was Europe's cement industry that was behind that. It didn't go for performance but instead described content and production techniques. And this new energetically modified cement did not fit-in with that EU standard, as it could deliver similar concrete properties but in a completely new way, explains Professor Elfgren.

INSTEAD OF FIGHTING for support in Sweden and Europe, Messrs Lygren and Ronin went to the United States, where standards focus on the final function and results of the concrete, rather than on ingredients and cement-production techniques.

By now, the World was also slowly becoming aware of the carbon dioxide emissions problem of cement kilns.

—In the 1990s, greenhouse gas use had never been a factor, Dr. Ronin says. At the time, it was only about making the concrete as high-performance as possible. If it was also good for the environment, then it was just a bonus.

But that bonus, which via Dr. Ronin's invention also meant greatly reduced carbon dioxide emissions, would now become even more pressing ... ▶

As EMC technology means the material does not need to be heated but instead is made reactive with the use of vibrating mills, the carbon dioxide emissions that inevitably occur in Portland cement production can be avoided. Thus, if 70% of Portland cement is replaced by an energetically-modified material, current CO_2 emissions from the industry would be reduced by 70%.

In the year 2000, the pair's jointly owned EMC was invited to an expert conference in Washington DC on 'Low Carbon Cement' convened by the American Society of Civil Engineers.

—It was probably one of the first national conferences on the subject, says Vladimir Ronin, who by then was now an adjunct professor at Luleå.

Through the conference, they met a large owner of coal-fired powerplants, headquartered in Houston Texas, that could supply fly ash. In time, they also contacted the Texas Department of Transportation, the U.S. Federal Highway Administration and a family-owned firm in Texas that produced ready-mixed concrete.

By 2004, the EMC fly ash facility could operate to full industrial scale. The Texas Dept. of Transportation became customers, the U.S. Federal Highway Administration a year later. EMC fly ash was now widely used, from public infrastructure works—such as motorways, bridges and ports—to commercial construction and housing. The Spanish civil engineering giant Ferrovial and also the Irish materials giant CRH became customers.

Within two years, the firm became profitable. Across seven years, several million cubic meters of concrete were poured using 50–60% EMC fly ash.

Until then, the firm had used fly ash from coal-fired powerplants to make its energetically modified material. But with changes to environmental law looming, Lygren and Ronin realised that soon fly ash would not be a long-term source for raw materials. They began to investigate the possibility of using natural pozzolans—volcanic material that is found where volcanic activity has taken place.

USING VOLCANIC ASH to make concrete is hardly new. In the Roman Empire's building structures, cement was made using a type of volcanics called pozzolans—named after the Pozzuli peninsula where the Romans dug it out. The ancient concrete, called concretum, was used for amphitheatres, aqueducts, buildings, ponds and ports. Many, such as Rome's Pantheon, still stand today.

"IF WHAT HE TOLD ME WAS TRUE, THEN I COULD BE INVOLVED IN TRANSFORMING ONE OF THE WORLD'S LARGEST INDUSTRIES."

— ATLE LYGREN, investor and C.E.O. of EMC

The fly ash that Ronin and Lygren had used up until now had come from coal-fired powerplants. But they also understood that the typical chemical composition of volcanic ash is very similar to fly ash, and that it was part of the material standards for concrete and cement in both the U.S. and Europe.

—We realized that along the west coast of the U.S. and parts of Canada, almost all the way from West Texas to Alaska, there's virtually unlimited volcanic deposits, says Atle Lygren. So then we started a pilot plant for R&D in California. We ran extensive tests on various deposits. We wanted to be 100% sure we could achieve the same results as with fly ash. In 2014, a patent for the volcanics process was granted.

A Californian investment fund offered to invest $50 million in EMC's new California company to build two factories in Northern and Southern California, where they would activate volcanics using the EMC technology.

—They claimed Abu Dhabi's Royal family would be one of the investors, and bragged that they had contacts at the highest political levels, Ronin recalls. We negotiated an agreement where each would own about 50% of our Californian company. But as the due diligence progressed to confirm EMC technology, they became so utterly obsessed that they demanded then the rights to invest throughout North America and half the World. In the end, we lost trust in their aims and so we had to end the negotiations.

There was no investment. What happened next is described by Vladimir Ronin and Atle Lygren as scandalous.

—The investment fund guys went behind our backs to our so-called 'friends' in Texas, Ronin says. They colluded to put our EMC Texas firm into liquidation—only to then buy the contents of the factory and pay-off our Texas partners. They wanted to steal our trade secrets—and then form their own concern using EMC technology.

Lygren and Ronin sued them in a District Court in Texas, where they won with a large sum in damages.

—The jury hugged us and said they were ashamed something so corrupt could happen in Texas, Ronin recalls.

The defendants went to the Texas Court of Appeal in Waco, where they lost again. So then they went all the way up to the Texas Supreme Court.

—At first, the Texas Supreme didn't even want to look at it and flat out rejected it, Dr. Ronin says. But then the investment fund guys got it to take a look again, with the shocking end result that we lost both our factory and our damages. That final verdict almost gave me a heart attack!

What's happened since—they can't use technology you've a patent on, can they?

—They thought they could replace our vibrating ball mills with a different system and get similar results, at a ▶

competitive cost. We don't have all the details. Their plant is still running but their product's technical and economic potential seems limited even if they're infringing our patents, says Atle Lygren.

DURING THE TIME when EMC was operating in the U.S, the dynamics in Europe began to change radically. Now, the Climate Crisis has placed the cement industry into the spotlight, and there is a greater pressure to find alternatives to traditional cement and concrete.

Svante Axelsson, an environmental economist and national coordinator for Fossil-Free Sweden, believes that there is now an increased demand for solutions such as EMC.

—Cementa wants to produce net zero cement using carbon capture. It will be 70–100% more costly, he says. That's when alternatives will find their opportunity. Already, the construction industry has started to streamline because it will be so costly, and it will then be even more expensive.

What does it take for large concerns that have a huge cash turnover, to transform all or part of their business even if less profitable?

—It's a lot about competition, says Axelsson. The State's task must be to keep competition alive and not to preserve market oligopolies and monopolies that have a conservative market effect. It's interesting that without Elon Musk we wouldn't have had as rapid a change in the car sector. They really didn't want to change tack, they wanted to wait a while longer with internal combustion engines. When they saw Elon Musk could sell so much and there was a public attraction to the electric car, they simply had to change.

How do you get new innovations into an old industry?

—We have created a seminar series where we invited start-ups and asked whether it's the case that the old kills the new. Like in an old forest, where the new plants don't get enough light. Innovation has been a Swedish journey of success for a long time, so we must not stagnate. We must have business dynamism. We're quite good at giving support to innovation at the demo stage, but moving from that to large-scale operations requires risk-takers above all else. There's an enormous amount of money in the system now that's looking for sustainable solutions. But most people would like to slip-in after someone else has taken that risk. In this transformative age, therefore, the State needs to develop its role.

Ronny Andersson, Head of Research and Innovation, has worked at Cementa for over 30 years. He believes now is an exciting time in the industry.

"AFTER THE TRIAL, LITERALLY THE JURY HUGGED US AND SAID THAT THEY WERE ASHAMED THAT SOMETHING SO CORRUPT COULD HAPPEN IN TEXAS."

— VLADIMIR RONIN, researcher and founder of EMC

—Outwardly, there's a lot of focus on the cement industry's carbon capture in order to become completely climate neutral, he says. But internally, we're also working feverishly on solutions for successful improvements that may be implemented within five years. There's a huge focus on various natural raw materials such as heat-treated calcined clays and volcanic ash that are already naturally heat-treated. With the right chemical composition, they can be used. As I understand it, that's what EMC's working on. For sure, it could be used in very many places that have large deposits of such materials.

Andersson states that knowledge of natural materials has been around for some considerable time.

—For example, I've myself worked with volcanic ash when it was popular as an alternative to light clinker, he says. Then one got to see the clear benefits of such materials. But in the past, somehow there's been no real drivers for their use.

Ronny Andersson mentions two factors that he believes have changed the conditions for new alternatives in concrete construction. One is that the standards for concrete have changed.

—We've just passed a standard that allows for an increased use of additives, he says. One wants to switch to the performance of concrete, instead of its material specifications. And it's a real possibility to directly make relatively large reductions in climate impact emissions, without affecting the life or performance of the concrete.

The second factor has to do with the EU's emissions trading scheme (ETS) for industry. If the cement industry violates an emissions limit, CO_2 permits must be bought from the EU-ETS market.

—Since 2005, the EU's been tightening the ETS more and more every year, so every year we have to reduce clinker production CO_2 outputs, Andersson says. But with the same amount of production, it has a big impact on our business.

PERHAPS THE TIME has finally arrived for Vladimir Ronin's EMC innovation.

—Vladimir and I have been working our way through these 25 years, says Atle Lygren. Despite all the obstacles that the cement industry has put up against truly revolutionary innovations such as ours, for example by trying to control concrete standards, we have finally reached a point when we can say we have an industrially-proven technology, and a product that can account for a 70% reduction in the cement industry's emissions. We're involved in a number of processes to finance a large-scale implementation of this technology. Hopefully we'll now be rewarded for all these years' sacrifices, which we've mostly made on our own. ▶

In August 2021, Cementa's limestone mining permit on Gotland was extended for eight months. A few weeks' later, the Supreme Court announced that it would not grant Cementa leave to appeal. They could be forced to shut down if they do not get a new permit within less than a year. Cementa's Sustainability Manager, Karin Comstedt Webb, announced their 'Plan B' to *Svenska Dagbladet*: to import the required limestone from external suppliers during a transitional period.

But the warnings of a cement crisis and national construction shutdown raise the question of why wouldn't Cementa be able to import and distribute cement clinker—instead of buying or mining more limestone? German Heidelberg Cement, which owns Cementa, has over fifty sites in Europe and North Africa alone and is also a Global cement trading business. Surely it could supply Sweden with the two million tonnes of cement that the Slite plant has previously produced?

Karin Comstedt Webb, Cementa's sustainability wonk, paints the picture:

—It's mainly about three things, she says. First, there is currently enormous pressure on construction products throughout Europe, so there is no over-capacity anywhere. So, neither from a short nor a long-term perspective can we rely on imports. Then there are very large volumes of heavy material that require logistics in the form of port capacity, terminals and transhipment. We assess it would take at least three to four years to get imports in place, and then Swedish supply will be exposed to completely different uncertainties linked to security of supply. Third, all cement and concrete mixes in Sweden are based on the Swedish cement that has been developed and adapted for many years. So, it's possible that an import solution could be found, but it's a few years into the future. All-in-all, it would lead to greater risks linked to Swedish supply and readiness, and we'd deal ourselves a significantly worse starting-point for meeting climate goals.

Comstedt Webb points to the same vulnerability that Minister Baylan has now exposed: several construction firms state they want to be less reliant on a single cement supplier.

Atle Lygren says that the closure of Cementa's factory would offer a golden opportunity for Sweden to lead the development in reducing the industry's carbon dioxide emissions. With his experience in maritime transport, he does not see importing the cement clinker in the first place, instead of limestone, as complicated.

—According to our studies, there's a remarkable over-capacity in cement production in Europe, and also in Turkey, North Africa and so on. Imported cement clinker would use the same distribution network as the current one used for Slite's outputs. As far as I know, the cement produced in Slite is nothing special compared to cement from a number of other sources, and simple modifications could always be made.

"INNOVATION HAS BEEN A SWEDISH SUCCESS STORY FOR A LONG TIME, SO WE MUST NOT STAGNATE."

— Svante Axelsson, environmental economist and national coordinator for Fossil-Free Sweden

Mr. Lygren refers to a factory in the Netherlands, also owned by Heidelberg Cement, which recently underwent a similar conversion. The plant has a similar cement capacity to Cementa's, and in 2019 closed its clinker production to instead import clinker, grind it into cement and distribute in the country. According to Globalcement.com, only fifty employees lost their jobs.

—The Netherlands consumes at least twice the cement as Sweden does, Atle Lygren says. If they can live on cement imports, so can Sweden, and if Heidelberg has solved that, then they can solve it in Sweden too. If they do not, we can offer a solution: close the limestone and clinker production, and as a short-term solution, import the clinker into Slite and grind it into Portland cement. The limestone quarry and the CO_2-emitting part of the plant can then be closed, and we can use most of the remaining equipment to grind both the imported clinker into cement (45 percent) and volcanic ash (55 percent). The volcanic ash can then be activated with the zero-emission vibrating ball mills, to be mixed with the ground cement clinker to be certified as a cement that can finally be sold to the whole of Sweden—via the same value chain and distribution channels that Cementa uses today. As soon as the concrete and cement standards allow it, we can then replace 70% of the cement with our material, hence one then only needs 30% cement clinker. According to our calculations, such a change would not cost the Sweden any more than cement production does today.

Such a solution would be beneficial to your business interests.

—Clearly. But we must make a much broader definition by what we mean as stakeholders. The first and foremost stakeholder is Mother Earth and all life here. Number two are the people who can make an actual difference. Over 28-years' ago, Sweden had this golden opportunity already in its hands, with a Swedish invention, to drive the industry towards zero carbon dioxide emissions from cement production. Had it seized that opportunity back then, by now we would have finished that process, or at least much of it. We're hoping Sweden will exploit the opportunity this time around. ⊙

Maja Persson | *is a journalist. Her favourite concrete constructions are the Pantheon and a cake platter made by her mother.*

Fredrik Tjernström | *is an illustrator. He is hoping that the time has now come for EMC's cement to be used on a large scale.*