LEONARD

yearbook 2024

Innovation has found its bearings

In a world where the urgency to wean ourselves off an energy model which has made us so prosperous has become the strongest and most troubling of our certainties, the aspiration to innovate has found its bearings. Decarbonising human activity, conserving natural resources, and preserving the living world: there are no shortage of challenges. Yet these challenges are calling out for innovators in the energy, transport and construction sectors to get inventive and use their imagination. Another key word gaining ground is "adaptation," which encourages us to build narratives and implement the transformations needed to put life in harmony with our new living conditions — without ever losing sight of the ambition to lead a fair transition. Our new yearbook offers a sample of trends which are outlining a more resilient world: the huge undertaking that is the energy transition as seen by Xavier Huillard, Chairman and CEO of VINCI; an overview of solutions for adapting urban infrastructure to climate change; mobilities in the net-zero age; and how artificial intelligence can help transform the construction industry, while innovative materials can help decarbonise it. We hope that it will enable you to gain insight into a not-so-distant world where we would have collectively risen up the energy and climate challenge, and that it will inspire you with optimism — and above all new vocations. ●

“The energy transition is a powerful groundswell for our whole business activity”

INTERVIEW

The Chairman and CEO of VINCI breaks down the technical and economic challenges facing the energy transition, whose scope and tangible impact on restructuring energy systems are not always clearly perceived. An economy-wide approach to decarbonisation will lead to extensive modernisation of energy infrastructure and mobility solutions, as well as an improvement on our living environment. It offers an exciting playground for innovation supported by Leonard.

Xavier Huillard

Chairman and CEO of VINCI

The energy transition is gathering momentum in public debate. In your opinion, how big is this trend and how does it help us re-examine our current energy systems?

These days it is common knowledge: the energy transition is an absolute necessity. As shown with the COP28 agreement in Dubai, we must urgently reduce our dependence on fossil fuels in favour of low-carbon energy. To contain global heating, mass electrification is required for all sectors that require energy, such as housing, transport and manufacturing, or to a greater or lesser extent, our whole economy, considering that electric power currently holds a minor share of the energy mix for most countries. Our electrical energy demand is therefore going to be colossal in the years and decades to come, and we do not understand yet the full extent of it. RTE, France’s electricity transmission system operator, regularly re-evaluates upwards its foresight scenarios, understandably with a 2050 forecast horizon where widespread electricity use will have become a reality.

What business prospects does the energy transition represent for VINCI?

With our three main business areas — energy, transport and construction — we have a central position in the energy transition challenge, which constitutes a powerful groundswell for the whole Group. It is both an immense opportunity and a huge responsibility : our expertise in all our business activities means we are meant to be major contributors to the coming decarbonised world. We are thrust into a timeline which has never been so promising and tangible at the same time, because with the climate emergency, the long term becomes an immediate issue with the need to place ourselves as of now on the path towards carbon neutrality by 2050.

Of course, the mass wave of electrification concerns first and foremost our energy business areas, especially at VINCI Energies and Cobra, the two divisions of our Energy branch. We are a global player in this field, present throughout the entire electricity production and transmission chain, since we develop, finance and operate renewable energy production sites, such as the mega-photovoltaic park that we recently opened in Belmonte, Brazil. In doing so, we have gone full circle, showing that the intuition of our founding fathers has incredible relevance. We are renewing VINCI’s original model, which built growth 120 years ago with the then nascent electrical energy value chain, going on to build electricity power plants, and deploy and operate electricity distribution systems under concession contracts — even extending to regional tram and railway networks.

How do things stand for construction and concessions, the other two business areas?

The energy transition is just as promising. In construction, it generates a growing output of civil engineering projects linked not only to energy infrastructure (energy converter stations, interconnecting transnational networks, etc.), but also to transport decarbonisation, with major rail infrastructure construction projects, such as the Grand Paris Express in France and the HS2 high-speed line in the UK, or even giant electric vehicle battery plants. The same goes for our construction and urban development activities in the widest sense, which bring together issues such as energy efficiency and carbon footprint reduction, land take reversion and transforming our lifestyles and the way we work. The city thus

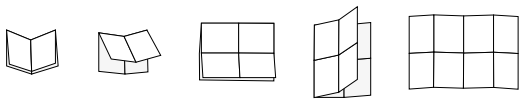
regenerates on itself, which gives rise to multiple projects.
In transport infrastructure concession contracts, the energy transition is both an existential issue and a powerful lever for upgrading our activities. Decarbonising the road and aviation industries is the necessary condition if we are to continue to get around, to travel, to transport goods and to power our whole economy, bearing in mind that transport needs will continue to grow worldwide. Action is already underway, as we are equipping service areas on our motorways with electric charging stations and making biofuels available for aircraft at all our airports.
And tomorrow's technology is already here, be it on motorways — where we are experimenting with dynamic charging for heavy goods vehicules with conductive and inductive systems, or in the aviation industry — with synthetic fuels and hydrogen or eFuels in the medium term. Everything is in motion to fundamentally transform these infrastructures.

With regards to all these applications, what are the technological and economic challenges in the mass rollout of energy infrastructure?
Attention is currently mainly focused on the needs for decarbonising electrical energy production. In fact, solar and wind projects are increasing in number and in their scope. For example, take the huge electric energy converter platforms linked to offshore wind farms that we are now building in the North Sea, projects that are worth billions of euros. We are currently experiencing a nuclear revival, especially in France, where the construction of six and probably even fourteen new EPRs is planned, meaning there are major projects in the pipeline for us. On the other hand, people perhaps do not realise that for every euro set aside for new decarbonised energy production capacities, almost the same amount will need to be invested in reconfiguring, upgrading and interconnecting electricity transmission and distribution networks. The technical challenge will be to ensure a constant balance between production and consumption, by securing electricity supply, even though these networks will have to integrate an increasing share of intermittent renewable energy sources, and electrical power can only be stored by converting it into another form of energy. As with production, our Energy branch is already in action and will continue to increase their work on these multiple operations on the networks. We also aim to focus on storage, which is an essential issue, whether it concerns pumped energy transfer stations (PETSs), or even hydrogen or battery storage solutions.

"For every euro set aside for new green energy production capacities, almost the same amount will need to be invested in electricity transmission and distribution networks."

All these future investments in energy infrastructure — as elsewhere in the decarbonisation of transport infrastructure — are so important that they cannot rely on public money alone, requiring public-private partnerships. This is already the case for a part of the ultra-high voltage transmission lines that we are installing in Brazil and that we are due to build in Australia soon. The energy transition is certainly revitalising our previous model!

In your opinion, what is Leonard's role in the dynamic transformation of business areas brought about by this transition?
Leonard already plays an active role in reengineering activities, and we are carrying this out in all our business areas with regard to the new paradigm of the energy and climate transition.
The majority of innovative projects incubated by Leonard relate to this theme, and many of them have spawned technological advances that have already been integrated into our practices and our offers, in areas as diverse as energy efficiency in buildings and industrial processes, decarbonising construction materials and processes, and even artificial intelligence applied to road traffic management and airport operations optimisation. For the coming years and decades, there are a huge number of areas for which the scope needs to be defined, commensurate with the ground that remains to be covered to collectively achieve net zero by 2050. Our business areas are a fantastic playground for innovators. We need them, and at VINCI they are guaranteed to find an entrepreneurial culture that will enhance their creativity! ●



pp.4-5
Poster
How can we adapt?

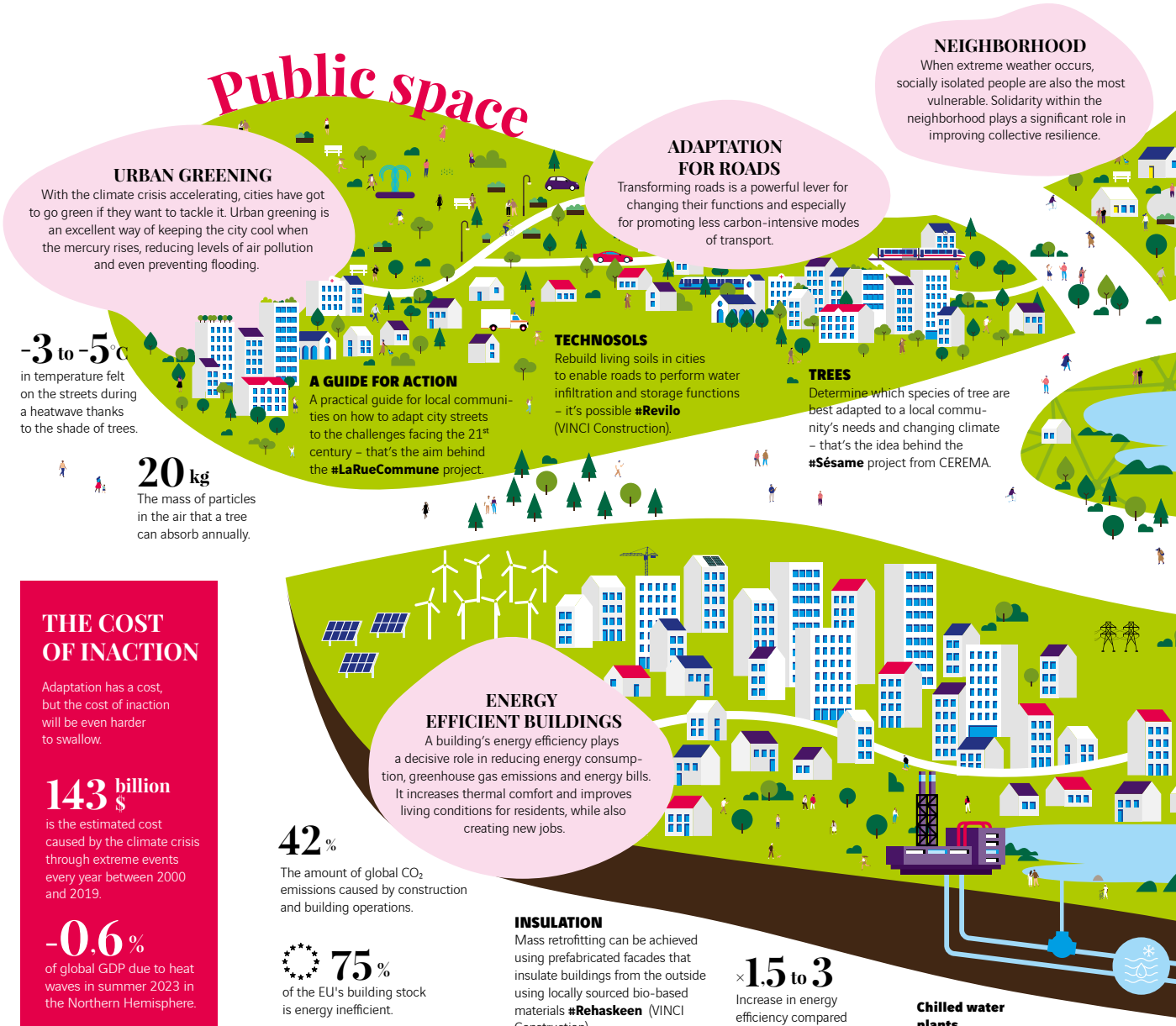
p.6
Artificial intelligence and the construction industry: a marriage made to last?

p.8
The burgeoning world of low-carbon construction materials

p.11
Imagining mobilities in 2050

How can we adapt?

A range of solutions for resilient spaces



THE COST OF INACTION

Adaptation has a cost, but the cost of inaction will be even harder to swallow.

143 billion $
is the estimated cost caused by the climate crisis through extreme events every year between 2000 and 2019.

-0.6 %
of global GDP due to heat waves in summer 2023 in the Northern Hemisphere.

€2 to €10
This is the amount of economic losses avoided for each euro invested in climate change adaptation projects.

60 km
is the distance in which many residents have been relocated from their homes in Isle de Jean Charles (Louisiana) in 2023, illustrating how coastal erosion has dramatically sped up worldwide.

Solidarity

NEW FORMS OF SOLIDARITY
One for all, all for one: mutual aid is the best strategy for resilience and adaptation in times of crisis. In the future, new forms of solidarity will develop to overcome major collective challenges.

NATIONAL /INTERNATIONAL
More temperate zones can prepare to accommodate climate migration on national, regional and international scales.

REGION
Adaptation is also possible on a regional scale. For example, by encouraging farmers to convert to organic to protect drinking water resources.

SEVERAL INITIATIVES ALREADY UNDERWAY
#Old shipping containers can be transformed into emergency or temporary accommodation to house climate refugees.

12 500 ha
converted to organic since 2020 with the help of water agencies **#Eau de Paris** and **Seine-Normandie**.

9 %
of North Africa's population could be forced to move to survive over the next 30 years.

CITY
With many buildings left temporarily vacant, temporary urbanism can be used to create emergency housing and help those in need reintegrate by creating a link with the local neighborhood.

Utility networks

WATER POLICY
#Mobilize all drainage basin stakeholders to contribute to maintaining watercourses and pipes.

PREDICT POWER CUT FREQUENCY
based on climate events and power grid vulnerability using **#AI**, a project developed by Leonard and Omexom in New Zealand.

PROTECT ROADS
To avoid road closures, particularly linked to flooding.

WATER RESOURCES MANAGEMENT
As the global fresh water demand will outstrip supply by 40% by 2030, better management of available resources is now crucial.

20 %
of water is wasted due to leaks in France's supply systems.

DIGITALIZE WATER-BASED ASSETS
To locate leaks and reduce water consumption, including for sanitary appliances and treatment systems **#Droople**.

Buildings: renovate, complete, develop

AIR CONDITIONING
District cooling networks can be developed in dense urban areas to help homes stay cool, removing the need for individual air-conditioning systems.

DATA MANAGEMENT
A digital twin can provide a virtual model of an area while also collecting and analyzing operating data from numerous urban utility networks via a single interface.

SUNSHINE AND SHADOW ANALYSIS
done using a digital twin by the city of **#Helsinki** when building the Kalasatama neighborhood.

BIOMIMETIC BUILDINGS
Imitating living things is a fertile opportunity to reduce the construction industry's ecological footprint and design equipment able to cope with change and bad weather.

Chilled water storage
is used to accumulate reserves so as to reduce pressure for demand at plants during peak hours.

The utility network
Chilled water is distributed between buildings via a network of pipes.

30 % When used an alternative to glass, an ETFE (ethylene tetrafluoroethylene) membrane, which is inspired by termite mounds, can reduce energy costs by this amount.

Artificial intelligence and the construction industry: a marriage made to last?

How can AI contribute to the construction industry's transition to a low-carbon future? Better designed building plans, streamlined time management, controlled carbon emissions... These are just a few of the levers that this technology can give sector-wide.

According to the Global Alliance for buildings and construction, the buildings and construction sector accounted for around 37% of energy and process-related CO_2 emissions, and over 34% of global energy demand in 2021. As such, the industry must considerably reduce its emissions if it hopes to achieve carbon neutrality by 2050. The challenge for the industry therefore lies in improving efficiency in order to build frugally and at competitive prices.

"AI excels in optimisation problems, aiming to do better with as many or fewer resources."

To resolve this challenge, over the past few years, the construction industry has looked to "contech". A contraction of the words *construction* and *technology*, this term refers to the application of technology to help the construction and infrastructure sector improve productivity and safety, and reduce its carbon footprint. From the range of technological solutions out there, artificial intelligence (AI) is among the most promising.

AI FOR SMOOTHER OPERATIONS

AI excels in optimisation problems, aiming to do better with as many or fewer resources. That's good, because the construction industry is riddled with them. Let's start from the beginning, namely construction plans. When applied to the latter, AI can be used for generative design, to optimise plans based on a number of criteria. While humans know how to solve this type of problem very well, AI can be used to examine a much higher number of combinations, and therefore find the optimal solution based on the available data. "*Doing the calculations by hand takes time, sometimes several weeks. Faced with this amount of work, we often select a functional solution, but not necessarily the optimum solution. With AI, we can explore tens of thousands of options and choose the best one*", explains Alexandre Cousin, founder of Synaps'Up, a team dedicated to generative design using artificial intelligence at VINCI Construction, developed as part of Leonard's Intrapreneurs programme.

Once the plans are produced, next it's on to the construction site planning, to maximise the use of available resources and avoid waste — another optimisation task that AI takes care of. "*On a construction site, the aim is for a crane to be in use 100% of the time, because they're expensive to rent. The more it is used, the more savings we make,*" explains Bruno Daunay, head of the AI programme at Leonard. AI can help make this objective a reality, by optimising logistics. For example, this may involve determining the optimal time on the construction site to install formwork for pouring concrete, to avoid having to then move them several times with the crane. It can even be used for optimising inventory management. "*When we build a building story, we store elements (reinforcement, boards, etc.). AI can help determine the ideal place to put these elements so that they don't get in the way of workers and so that we don't have to move them. We're optimising logistics on site.*"

When it comes to building materials, AI is a powerful tool for managing onsite supplies. It can be used to analyse data on

purchases, for inventory management and to anticipate demand to optimise building supplies deliveries to the site, and reduce waste.

AI FOR MANAGING CONSTRUCTION SITES AND INFRASTRUCTURE REMOTELY

AI does not just optimise existing tasks: it also allows us to imagine new uses and innovative applications. Everyone knows that time management is crucial in construction: prolonged construction means additional costs that threaten the viability of the project. This is why engineers specialising in chrono-analysis are responsible for monitoring a construction site, to check that everything is running on schedule.

What's more, AI can process a greater volume of data from different sources, therefore making more precise estimates. As such, by fitting building site machinery with cameras, we can analyse the images captured using AI to provide a daily estimate as to what extent construction is on track compared to the initial planning. "*We are rationalising the process: an engineer can supervise several sites remotely and estimate with detailed precision any delays or advances made*," says Blanca Payas Puigarnau, Sixense Iberia & Satellite managing director.

When used in combination with other innovative technology, such as Building Information Modeling (BIM) or virtual and augmented reality, AI can truly express its full potential. These technology solutions can be used together to produce an immersive visualisation and simulation of a construction project. As such, architects, designers and site managers can obtain a clearer and more detailed view of a project, which facilitates communication and collaboration.

AI and satellites are another good combination: when used together, the two technologies make it possible to carry out predictive maintenance on infrastructure, thus preventing breakdowns, accidents or damage. "*AI algorithms analyse satellite-produced images and identify any warning signs of ground instability, landslide or subsidence (displacement, deflation, sinking) near infrastructure. We can then act to avoid it.*"

AI TO AID DECARBONISATION

There are several AI applications which are more specifically focused on reducing greenhouse gas emissions. One consists of using this technology for predictive maintenance. "*Maintenance is currently carried out on the basis of accumulated professional experience: on a concrete road, it has to be carried out every five years, for example, so we put in place a systematic maintenance approach. AI-powered data processing can be used to fine-tune this knowledge with the reality on site to optimise maintenance. That way, we can discover that a wearing course can last two or three years longer than we initially thought… Which reduces the need for renovation and in turn emissions,*" explains Bruno Daunay.

AI can also be used to optimise the choice of materials used in the construction, by performing simulations to determine the best combination based on factors such as cost, deadlines and environmental impact. "*Low-carbon alternatives may not have the same strength as traditional concrete, so using them involves recalculating the infrastructure. AI can be used to automate these types of calculations and choose the ideal combination.*"

However, AI is not a miracle solution. Above all, it makes it possible to improve the efficiency of human experts. "*These are things that we have always done, technology simply allows us to slightly improve the level of performance. It's about optimisation rather than a revolution,*" concludes Bruno Daunay. ●

ARTIFICIAL INTELLIGENCE: A COMPETITIVE NECESSITY?

According to the international network BuiltWorlds, of which Leonard is a partner, at least $4 billion in venture capital funding has been injected into the development of artificial intelligence technologies for building and infrastructure construction and operations from the start of 2021 to the first semester of 2023. Artificial intelligence is now "a competitive necessity" for all startups offering software as a service, explains Tyler Sewall, BuiltWorlds' senior director of research.
In the 2024 cohort of Leonard programmes, 25 of the 39 selected projects include artificial intelligence building blocks in their solutions.

The burgeoning world of low-carbon construction materials

CONSTRUCTION INDUSTRY: A RESOURCE CONSUMPTION JUGGERNAUT

between 4 and 6 times

Stress on resources does not only concern construction aggregates and is not always measured in billions of tons. According to the Organisation for Economic Co-operation and Development, the demand for critical minerals is expected to grow by at least four times between 2020 and 2030. In 2023, 10% of global exports of critical raw materials faced at least one export restriction measure, in a context of shortage and national isolationism. *"Lithium and rare earths are already replacing gas and oil at the heart of our economy,"* explained Ursula Von der Leyen, the European Commission president, during her 2022 State of the Union address.

230 billion square meters

This is the surface area of new buildings expected to be constructed over the next 40 years. According to the United Nations, 40% of the world's population will need access to more adequate housing by 2030, which means providing 96,000 affordable and accessible housing... every day! On top of new constructions, renovation rates should be significantly increased on a global scale too. As such, China has announced its aim to renovate more than 100 million square meters of residential buildings and 250 million square meters of public buildings as part of its latest five-year plan.

50%

According to the International Resource Panel, annual global extraction of resources grew from 27 billion tons in 1970 to 100 billion today, and is expected to reach 190 billion in 2060 if nothing is done to change the course. The construction industry consumes around 50% of these resources, the equivalent of around 50 billion tons of raw materials each year.

13%

According to the World Green Building Council, this is the percentage of materials delivered to a construction site that are being sent directly to landfill without having been used. Apart from being purely and simply a waste, the reuse rate remains low. Today in NW-Europe, only 1% of building elements are reused following their first application. Meanwhile, waste valorisation fluctuates between 48 and 64%, but this still mainly concerns backfilling operations used to make roads, rather than "high-grade" recycling applications (materials that can be used in concrete production, but also for inorganic polymers, glass ceramics, etc.).

36%

This is the share of CO_2 emissions for which buildings in the European Union Countries are responsible, according to the European Commission. Concrete production alone represents between 7 and 8% of total global CO_2 emissions. However, the equation is complex: while global cement demand is estimated to grow by 2050, the concrete industry must reduce its overall footprint to help decarbonise the economy at breakneck speed.

How to solve a problem like the resource-intensive construction industry? Well, technical and practical solutions do exist. Apart from introducing standardised circular practices across the sector, the impact of the construction industry's activities could be significantly reduced by developing innovative materials. From low-carbon concrete to biomimetic solutions, there are various promising opportunities out there.

CONCRETE SPEARHEADING THE TRANSITION

Global concrete production represents around 2.9 gigatons of CO_2 emissions per year. It is by far the most polluting construction material, yet it is also the one on which the most significant decarbonisation gains could be made. Right now, there are three solutions that are shaping the future of low-carbon concrete.

The first is to reduce the amount of clinker used (which is the main binder of concrete) in cement. Clinker production is in fact responsible for the majority of carbon emissions from cement plants, with traditional cements still being composed of 95% of clinker. According to the IEA, reducing the proportion of clinker in cement to 60% would reduce current CO_2 emissions in the sector by 35%. The second option consists purely and simply of replacing traditional cement as a concrete binder. Alkali-activated alternatives, geopolymers or calcium sulfoaluminate cements currently promise emission reductions of around 90%, but they have yet to demonstrate their performance and their ability to scale up. Finally, by transforming industrial processes, especially through carbon sequestration at factory level, significant CO_2 emission reductions from concrete could be achieved.

SMART MATERIALS

Having long been restricted to being used only in demonstrations, smart materials are now set to develop. For example, shape memory materials can be deformed to the extreme and are widely used in the aerospace and healthcare industries, yet they are struggling to make a name for themselves in construction. Applications for certain materials are still in the experimental stage, playing around with the laws of thermodynamics. This is the case for UE Power's solar coating, which when applied, transforms a window into a working solar panel! Its piezoelectric properties are also promising, enabling us to envisage materials capable of generating electricity from mechanical stress, such as the vibrations of a building.

BIOMIMICRY, OR NATURE'S R&D

Nature proves to be an inexhaustible source of inspiration for the construction world. Biomimicry is based on millennia of nature's R&D, enhancing certain properties found in the living world. A startup like Strong by Form offers ultra-light composite materials inspired by the natural fiber alignment in trees. The hydrophobic properties of lotus leaves have inspired the construction sector to create low-maintenance surfaces. Equally fascinating are self-healing concretes, which harness the properties of certain bacteria to mineralize calcite, making them the focus of various research programs.

INNOVATING REUSE POTENTIAL

Most of the time, resource reuse does not offer up particularly innovative materials. However, what does deserve a mention is the innovative ways in which they're being used. Apps like R. Used, developed and used internally by VINCI, aims to become the marketplace for the reuse of construction site materials. IaaS (Infrastructure as a Service) models are also gaining ground. By making the project manager the building manager for an agreed duration, it fosters the use of high-quality, sustainable and low-maintenance materials. It also encourages buildings to be designed with disassembly and deconstruction in mind.

"The main challenge now involves moving away from experimentation to scale up and roll out solutions."

THE CHALLENGE OF SCALING UP

Innovative materials are now becoming more and more mature. Circular solutions exist and are proving to be effective. The main challenge now entails moving away from experimentation and Proof of Concept to scale up, roll out the solutions and see a significant environmental impact. However, a certain number of obstacles still need to be removed to achieve this.

Regulatory levers Right now, regulations are being reworked in two ways: The first is to simplify and clarify. The lack of clarity surrounding materials is regularly cited as an obstacle when trying to roll out a circular economy and innovative materials. The second, which is currently being structured, involves introducing incentive regulations.

With a plan such as RePowerEU — whose objective is to end Europe's dependence on Russian fossil fuels — the EU is clearly positioning itself on the issue of circularity. While in France, the RE2020 national regulation is also proving to be an ally for more sober materials, and in particular low-carbon concrete, thanks to its tight environmental requirements.

The cultural aspect The construction industry comes up against strong resistance, caused by deep-rooted practices and habits. If this is to be overcome, two levers must be activated simultaneously. The first step is to raise awareness of new materials and circular solutions. It is crucial to build up trust, to reassure those in the sector on the quality of reused materials and on the reliability of innovative materials. Julie Neuville, co-founder of Materrup, a technology platform enabling raw clay cement production, explained to Leonard that the company's first challenge was to "*get people to accept the very idea of a deeptech for clay.*"

> ***"To generalize circular economy practices, we need to change standards and habits."***

The industry effect The price of reused materials currently remains higher than that of new materials, which can naturally seem unacceptable to those in the construction industry. This situation is largely due to the circular economy having a lack of structure, which means it cannot benefit from economies of scale. The new materials sector is experiencing a similar problem, as it struggles to gain traction as an ecosystem. "*We must learn to talk to each other and use the same language. It's up to us to convince insurers, building contractors and architects,*" explains Armelle Langlois, head of sustainable performance at VINCI Construction. In this context, adopting a proactive attitude is essential, as well as taking into consideration the impact of reuse beyond its economic value, for example, by promoting the social and environmental benefits of circular solutions.

Facing the climate emergency, the construction world is currently overcoming resistance and the accustomed status quo. In the materials sector, this transformation can be seen through breakthroughs in research and innovation, as well as exploring new avenues that are less carbon-intensive or inspired by nature. It also involves radically changing the supply chain and waste management models, from a traditional linear approach to a circular future. ●

Imagining mobilities in 2050

TELL ME HOW YOU GET AROUND?

Mobility is at the center of social, economic and environmental transformations. While it accounts for 30% of greenhouse gas emissions in France, it also represents an exciting breeding ground for technological and regional innovation. As such, Leonard, La Fabrique de la Cité and VINCI's divisions wanted to put forward a realistic and pragmatic vision based on credible needs, and thus launched a long-term foresight approach in 2023. "*We wanted to stimulate ideas by exploring opposing viewpoints,*" explains Isabelle Lambert, head of foresight at Leonard. "*By putting around the table local authorities, transport and logistics sector leaders, and mobility researchers and thinkers, our approach brings together multiple visions for mobility, to compare and tackle them head on in order to find credible common ground.*"

This convergence of ideas and meeting of minds brought to life scenarios which outline a plurality of mobility solutions.

"*Our main interest was to position these possibilities on a matrix according to two factors which, for us, seemed to provide structure for thinking about the future of mobility. On one side, you've got the lengthening or shortening daily commutes, which touches upon the issues of urban sprawl, public services restructuring, manufacturing reshoring and hybrid work models. While on the other, there's the implementation — or not — of real intermodality; here is an issue that's both technical, regional, financial and economic, all at the same time, and which conditions what is possible to envisage*," **says Isabelle Lambert.**

These are all questions which offer structure, providing a framework for imagining credible transport solutions. While we wait for the outcome of the study, Leonard already explores in this article part of the outline for mobilities in 2050...

Are you rather "sky filled with flying cars", or " an army of cargo bikes flooding the streets"? The gentle purr of an electric motor or a chorus of birdsong? When it comes to mobilities, there doesn't appear to be a grey area: technological dreams or eco-friendly utopias, the two ends of the spectrum remain defiant as they size one another up, yet between them lies an unchartered land waiting to be explored. Stuck between these two polar opposites, how can we imagine a credible future for mobilities?

There's no lack of imagination when it comes to mobility. But what it really needs is quite the opposite: a good dose of reality. Private car use accounts for the overwhelming majority of personal journeys, and cycling, although on the increase, accounts for only a fraction of all journeys. All-electric is still a distant horizon — and it could remain unaffordable for many of us. Car-sharing is still rather niche and self-driving vehicles are still yet to fulfill their promises.

If the scenarios diverge, this is because mobility isn't a spectrum, but rather a multi-variable equation. To visualise it, we need to create a dialogue between the often-conflicting issues, and put on the table complex realities, completely opposing regional geographies, and ambitions which snub one another. This is the price to pay to be able to be able to start drawing not one, but several credible mobility solutions, solutions which are far from being fantasy and pie in the sky, but which are looking towards feasible possibilities that will leave no one by the wayside. Here's a brief look at the issues that need taking into consideration.

CHALLENGE #1 ADDRESS THE PRIORITY OF ENVIRONMENTAL SUSTAINABILITY

In 2023, when we think of "mobility," carbon springs to mind. In our Mobilities 2050 study, the environment is the angle that stakeholders address the most, across the board. Cars, lorries, trains and planes, they all hide the pollution we no longer want to see. All modes of transport are capable of doing it: from low-emission driving zones to hydrogen vehicles, as well as electric cars and biofuels. Transport is an obvious lever for the climate transition, since it alone represents 30% of the country's greenhouse gas emissions, coming in ahead of industry and agriculture.

So, what does credible mobility for 2050 look like? Well, it's a transport solution that has found ways to reduce its environmental

impact. This isn't merely a technological issue, it's a cultural and regional one too. Decarbonising at the wave of an electric wand would not necessarily resolve the tricky question of our resilience in the face of climate change. For the sake of completeness, we must conduct the discussion by questioning how and why we get around. The idea is not to swap one dogma for another, going from hypermobility to total sobriety. Instead of trying to get about less, we need to look at moving about better, empowering people and giving them choice rather than restrictions. Which journeys are really necessary? How often? How far? And how fast? If, in many dense areas, a large number of car journeys are less than 5 kilometres, perhaps we first need to tackle everyday mobility. Providing the keys to fluid mobility, intermodal solutions that make life easier. Making for a positive and desirable transition that is more likely to succeed.

> *"We cannot talk about frugality or technology deployment in mobility without considering the impacts on the circulation of goods and people."*

CHALLENGE #2
PRESERVE THE FREEDOM TO COME AND GO

"*The full-scale lockdown experience has reaffirmed the almost sacrosanct nature of freedom of movement. The freedom to come and go is confirmed as an inalienable right,*" says Isabelle Lambert, head of foresight at Leonard.

As a condition for exercising other freedoms, mobility must not create new inequalities or widen those that already exist. On the contrary, it should help to mitigate divides already found. Therefore, we must imagine mobility within everyone's reach. It can be multi-speed and multimodal, but it must maintain and encourage equal access to opportunities, whether professional (finding and keeping a job), personal (going shopping, going to the doctor, taking your children to school), or social (visiting family, friends, meeting new people), regardless of social class or post code.

> *"If scenarios diverge, this is because mobility isn't a spectrum, but rather a multi-variable equation."*

CHALLENGE #3
SUPPORT ECONOMIC DEVELOPMENT

Mobility is a value creator. It conditions, among other things, regional and industry attractiveness, talent acquisition and retention, the size and distribution of public services (and their civil servants), the proper functioning of industrial, academic and scientific hubs, and the survival of entire sectors — such as the tourism industry.

Because it acts as the support for all these exchanges, we must therefore consider mobility in all its complexity, sector-specific and territorial, and move away as far as possible from political, economic or cultural dogmas. Because to get about is to set in motion, and everything in the economy is movement, mobility must inevitably cross paths with the economic challenges facing people and local regions. We cannot talk about sobriety or technology deployment without considering the impacts on the exchange of goods and people.

CHALLENGE #4
CONTRIBUTE TO SOCIAL AND TERRITORIAL INCLUSION

In many countries, expenditure for transport is a significant spending item for French household budgets, but it does not carry the same weight or in the same way for everyone. To be credible, mobility must enable more than it limits. Considering "fair" mobility means thinking about mobility flows as a whole, a whole that repairs divides and help erase inequalities. Access to employment, leisure and services: mobility must be thought of as an equaliser of opportunities. Therefore, it must be plural and regionalised.

But each region has its own unique geographical, economic and demographic situation. If the impetus must come from a national level, it is up to the local level to implement it, as close as possible to the local reality. The question of inclusion therefore comes up against those of mobility governance and financing. But what is the most relevant scale? By region? By city? Or inter-municipal cooperation? What are we doing to ensure transport remains fluid at the borders of these zones? If intermodality stops at the edge of a regional border, is it really effective? Are local authorities properly equipped in terms of skills and resources to make these transitions? Are we not at risk of creating multi-speed countries depending on the political will and economic capacity of each region? And who should bear the cost of this transition? Customers (private service provider mindset)? Users (public transport)? Taxpayers (by making local

authorities mobility operators)? These are just some of many issues that debates on mobility must be able to put on the table, in a discussion involving many public, private and citizen stakeholders.

"Mobility must serve everyone, everywhere. As such, there cannot be a single answer because there are multiple situations. We must open the conversation to try to address all the issues, all profiles, and engage all those concerned, from decision-makers to users. It's a social project that underpins all the others," concludes Isabelle Lambert. ●

Scenario 1
TRAVELLING IN 2050

"*Don't tell me you've forgotten your toothbrush yet again?!*" snaps Agathe at Julien, from their hotel bathroom. It's the third time – in three trips! The retired couple left Toulouse, their adopted city in the South of France, barely two hours ago to join the first part of their holidays in Luchon, in the heart of the Pyrenees. Like last year, they've decided to go slow. Not because of their physical capacity, but because Agathe and Julien are fans of slow travelling, like millions of other French people. Travelling slowly, less far away, but taking the time to discover, while having a clear conscience, this approach won over the tourism industry about ten years ago now.

That said, the carbon budget also has a lot to do with it. Launched in the 2030s, this points-based system means everyone has an annual quota to spend. Rather than stigmatising behaviours or consumer spending, the choice was made to make citizens responsible for their actions in the face of the climate emergency. By travelling closer to home and promoting multimodality (hydrogen-powered local trains, then electric bikes and carbon-free shuttle buses once there), Agathe and Julien stay within their budget and are even rewarded with a carbon bonus offered by their region to encourage local tourism. The other winners are hospitality workers, as the initiative has helped diversify supply to meet an ever-increasing clientele.

Scenario 2
TRANSPORT OF GOODS IN 2050

Ellie takes another look at her watch. It's 8:32 am. Her eyes are fixed on her street corner, she's on the lookout for the timely arrival of the bus. However, Ellie isn't a teacher, nor a parent. Ellie is the happy owner of a small book shop in the centre of Oxford (UK), and if she's waiting for the bus so impatiently, it is because it is supposed to be delivering the latest literary releases that she's to put in the shop window before the store opens that morning. A bus that delivers books? This "last-mile public service" is a micro-logistics network ran by an inter-municipal cooperation which puts public transport to good use. The school bus baggage hold was empty 99% of the time, so it was used to provide a link between the logistics hub located on the outskirts of the city and small businesses in the city center.

Ellie rents storage space at the hub which is managed by the city council. It enables her to receive deliveries from her suppliers without having to worry about storage space or adding to traffic congestion. By functioning in this way, it helps to limit the number of delivery lorries on the roads and give power back to local communities to manage traffic in their local areas. The result? Now decarbonized just like the rest of the transport industry, logistics are better coordinated at a local level and the costs are advantageous for Ellie and other small businesses.

Scenario 3
DAILY COMMUTE IN 2050

It's Thursday, Philippe's favourite day of the week. It's the day where he can sit in front of his window as he works remotely from home, looking lovingly at his garden. In the small town of Leuhan, with a population of 800 in the heart of the French Breton countryside, around 30 kilometres from Quimper, Philippe, his wife Sarah and their two children do not at all feel cut away from everything. The family hasn't owned a car for several years now, ever since the local council set up an on-demand car-sharing service. They can book an (electric) vehicle for an hour, half a day or a weekend, whenever they need one. It is practical for whenever they need to do a big shop or take the kids on a mini road trip along the dramatic coastline!

To get to work in Quimper, every morning Sarah carpools to the nearest local train station. Meanwhile, four days out of five, Philippe is picked up by his company's self-driving shuttle bus which goes around the area like a school bus. On Thursdays, he takes advantage of being at home to go to the local public services point, which is in his village square. Here he can renew children's passports, vote for the participatory budget, or ask a question to the tax advisor — all in one place! The building also has a small community café where serves as a co-working space, which he loves to go to from time to time, to keep up to date with his neighbours' latest news. ●

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USBEK & RICA

EDITORS
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Arnaud Pauchenne
Guillaume Renouard

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Sébastien Plassard (cover)

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FIND US AT LEONARD:PARIS!
6, Place du Colonel Bourgoin
75012 Paris (France)
contact.leonard@vinci.com

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