IT CHANGES EVERYTHING
Issue no. 3 – July 2020

CAN ELECTRICITY STILL CHANGE OUR LIVES?

EDF

Electromobili ty, smart cities and co-innovation

Electricity began to arrive in homes 139 years ago, leading to extraordinary progress and a raft of new appliances. Now that the “magic” of electricity is largely routine in wealthy countries, in this Issue no. 3 we want to discuss whether – without actually revolutionising our lives as in the past – electricity can still be a driver of progress.

Overshadowed by disruptive digital technology, electrical innovation is clearly less visible in our lives. But it is nonetheless highly present and more than ever crucial to our future. This is demonstrated in new storage technology and the industrialisation of water electrolysis processes to produce the low-carbon hydrogen that will be used as a clean fuel to transport goods.

EDF is convinced that its role is now that of a facilitator. Only electricity can deliver a solution to the climate emergency by electrifying personal and collective mobility, helping the building sector through its energy transition and speeding up the emergence of smart cities. In such cities, smart grids will allow the main urban functions and equipment to interact collaboratively in order to minimise consumption.

Given that anyone can generate their own green electricity nowadays, we believe that the electricity system – the largest industrial network in the world – offers a unique opportunity to combine efforts and innovations to act collectively for the climate. And

IT CHANGES EVERYTHING

What will mobility be like tomorrow?

How will we travel in the future? What energy and what types of transport will be used? These were the questions put to **Mathieu Chassignet (M.C.),** engineer at Ademe, the French environment and energy management agency, and a specialist in mobility and air quality, and **Patrick Pélata (P.P.),** engineer and an expert consultant in the automobile industry, on 18 November 2019 for the "Ça change tout" podcast hosted by Thierry Guerrier and Yolaine de La Bigne. **Below are some of the discussion takeaways.**

M.C.: For mobility, I don't think **sustainability** can be separate from **solidarity** because mobility has to be acceptable for everyone.

M.C.: To predict tomorrow's mobility, **we have to look back at past trends:** our journeys are becoming longer and longer, 80% are done by car, and cars are using more and more energy.

M.C.: I'm dubious about solutions that rely too heavily on technology: we have to move towards **cleaner vehicles** and develop **alternative, shared transport modes,** but we also need **coherent policies,** at both local and national levels.

M.C.: The starting point is **to think about sufficiency** and how to create **more local solutions.**

P.P.: Why are cars currently used for 80% of trips? Because they meet people's needs and give them **freedom to move around.** To achieve **carbon neutrality in 2050,** the solution is to develop **shared, on-demand transport** that uses electricity to obtain zero CO_2 emissions.

P.P.: Autonomous vehicles will not be mass produced without **help from government authorities:** studies show that, in parallel with the development of autonomous vehicles, there must be a partial halt to access to private cars.

P.P.: Simulations demonstrate that, if we used **shared, autonomous vehicles,** we could have the same level of mobility in cities with **10 to 15 times fewer cars,** and for the same price as that of a bus ticket today.

ÇA CHANGE TOUT

The podcast *"Ça change tout"* is available on all platforms and can be downloaded on Apple podcasts, Spotify, Deezer, Podcast Addict, Google Podcasts and many more, including edf.fr.

Growing urbanisation – 70% of the world's population will live in cities by 2050 – is causing significant demographic, energy and environmental problems for cities. Will the smart city be the ideal solution to these many challenges?

Smart cities

Utopia or an unprecedented opportunity to work together to reinvent everything?

As cities concentrate all the main sustainable development issues, and as we certainly haven't seen the end of urbanisation, it is in cities that the fight for the climate will be won.

The publication in 1972 of *The Limits to Growth*, by the Club of Rome led to the principles of sustainable development. In turn, this created the notion of the "sustainable city", designating a city or urban area compliant with these principles.

In 2007, Rudolf Giffinger, a researcher in urban growth at the Vienna University of Technology, defined the concept of the smart city. He believes that, for a city to become truly smart, progress must be made in six areas of strategic smart action: economy, mobility, environment, people, living and government.

At the same time, the global hyper-connectivity provided by the internet, the explosion in digital data and the IoT have led to the emergence of a more "techno-centric" smart city where digital technology is used to optimise urban planning and management in order to improve the quality of public services sustainably and at affordable cost.

Will life be ruled by algorithms?

This technocratic approach is increasingly contested. Francis Pisani, a journalist specialising in this area, believes that, "to improve our cities, we need to tap into all sources of intelligence: people as well as data"(1). And sociologist Saskia Sassen points out that, "although important, technology can't solve everything. We need to keep our critical faculties on alert to select those ideas that really do bring change" (*see p. 12*). For his part, Thomas Madreiter, head planner for Vienna, explains that the Austrian capital has "adopted its own definition of the 'smart city': 'smart' means everything that places humans at the centre of its concerns"(2).

55%(3)
of the world's population, or 4.2 billion people, lives in urban areas.

ENERGY(4)

- Cities cover **3%** of the Earth's surface and account for **60%** to **80%** of global energy use.
- Urban activity generates over **70%** of the world's CO_2 emissions.

(1) https://www.dedieuprojects.com/entretien-francis-pisani/.
(2) https://www.lafabriquedelacite.com/publications/vienne-et-la-smart-city-lanalyse-de-thomas-madreiter/.
(3) UN DESA (Department of Economic and Social Affairs), 2018 figures.
(4) United Nations, "Sustainable Development Goals – 17 goals to transform our world", 2015.

TRANSPORT[3]

The transport sector accounts for:

- **27%** of global energy use,
- **23%** of CO_2 emissions.

Under this definition, quality of life also involves building relations between inhabitants and understanding their real needs. Such is the case in Dijon, France, which has opted for open data to increase the participation of its residents and make each of them an active contributor to the city. This approach reflects the fact that change will also come from a radical shift in people's habits and practices. The sensors used in smart cities to manage the energy consumption of buildings provide residents with details about their own use, which in turn encourages more environmentally friendly behaviour.

It would seem then that the way is open for a smart city that reconciles technology and human behaviour. Woven City is a prototype of 2,000 inhabitants that Toyota plans to build near Mount Fuji in Japan, with connected infrastructure enabling people, vehicles and buildings to communicate with each other. Fibre technology, 5G, Wi-Fi, Bluetooth and LoRa can now be combined to interconnect the smart city's multiple communicating objects and feed the data collected to a shared platform for correlation. This vision is based on something closer to how cities actually work and seeks to feed applications that will form the basis of new uses for residents.

Energy efficiency at the heart of the smart-city concept

The smart city aims to be part of the solution to climate change and the demands around environmental transition. The word "smart" therefore implies frugal and sustainable – and the drivers already exist. Local energy management can coordinate existing infrastructure and services such as public lighting, space-heating systems, public buildings, electric vehicles and local energy production for more efficient energy management in the smart city. And new technological levers can be used, such as smart grids, which combine electricity networks with IT and telecommunications networks to optimise energy flows against data provided by producers, distributors, suppliers and consumers. In another example, low-carbon mobility can be encouraged by using smart charging(1) and vehicle-to-grid technology(2) supported by electric vehicle charging infrastructure.

EDF, an integrated player engaged in cities and smart regions

Active in energy supply, energy services and connected objects, EDF and its subsidiaries have developed numerous smart-city solutions. With an emphasis on regional governmental authorities, social-housing organisations, economic stakeholders and citizens, EDF group's smart city is focused on the sustainable development of the urban space from three aspects: the low-carbon, connected and responsible city.

(1) "Smart charging" refers to technologies that optimise charging up an electric vehicle, or even uploading the vehicle's electricity back into the grid, in the most efficient, flexible and economical terms. (2) The energy stored in the batteries of electric vehicles can also be used to supply a building or network. The technology is called Vehicle-to-grid (V2G) because the energy can move in both directions. (3) World Bank, 2018. (4) The World Bank's Water Scarce Cities (WSC) Initiative, 2017. (5) UN DESA (Department of Economic and Social Affairs). (6) French Ministry for the Ecological and Inclusive Transition, 2018. (7) Ipsos survey for EDF, March 2019, on a sample of 1,400 social workers and 200 managers of social work organisations.

WATER[4]

- **25%** of the world's population lives in countries with scarce water resources.
- **500** million urban dwellers suffer from seasonal water shortages, rising to **1.9** billion by 2050.

Eko Atlantic in Nigeria, Forest City in Malaysia, Neom in Saudi Arabia… over 120 new cities are on the drawing board worldwide.

By 2030, **43** megacities(5) around the globe will have 10 million or more inhabitants.

Smart and inclusive

Some 3.8 million(6) households in France experience difficulty in paying their electricity bill or go without heating. To provide a solution to suit each situation, EDF calls on the social innovation capabilities of digital sector actors and technologies. Since 2017, through its partnership with Ashoka, the leading global network of social entrepreneurs, the Group has been co-authoring and financing calls for solutions that then help local entrepreneurs put together their own project. In one such project, the JIB startup has designed a very affordable connected home turnkey solution to make it easier for disabled people to remain in their home. In the United Kingdom, EDF Energy is working with IncomeMAX, which uses artificial intelligence to help households in difficulty make sure they access all the public assistance to which they are eligible.

In France, 95% of social workers(7) are satisfied with EDF's social inclusion actions. Its online platform provides quick access to state aid co-funded by the Group and to its 300 inclusion experts working in the field. In 2019, an "energy cheque" was sent out to 5.8 million households to enable them to pay their electricity bill.

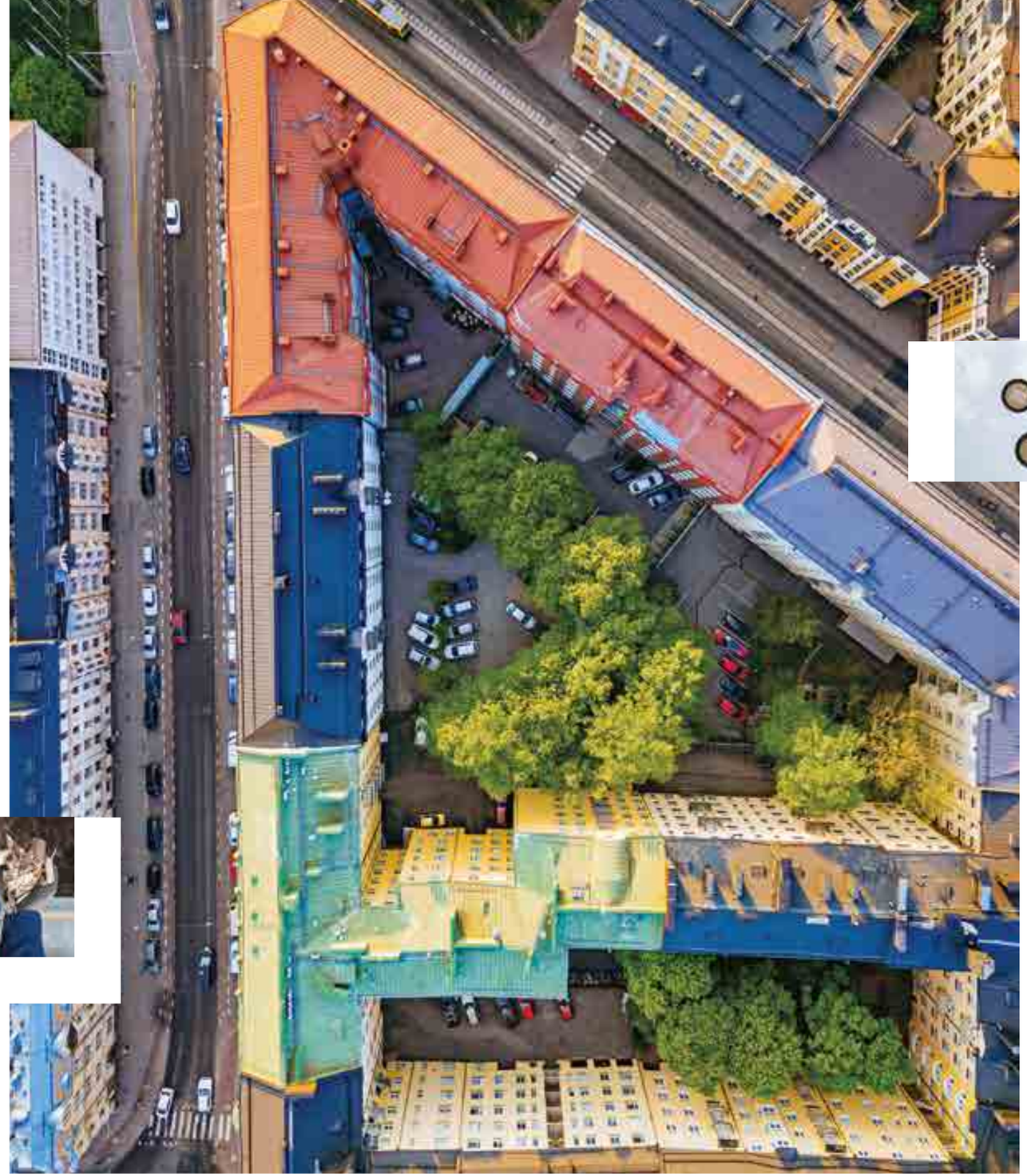
To be or not to be smart?

Michel Eltchaninoff, editor-in-chief of *Philosophie Magazine,* believes that, "while we may be able to glimpse the possibility of a hyper-connected city where IT and networks might resolve everything [...], this prospect does not take into account that there are always surprises, errors and, above all, people who go off in directions that are neither expected or desired.

"For EDF, a smart city is a responsible, low-carbon and connected city – and must therefore be based on inclusiveness."

Marc Benayoun,
Group Senior Executive Vice President,
Customers, Services and Regions

For these reasons, the smart city is a utopia"[1]. Faced with the expectations of a more sustainable society, the smart city opens the door to a broad range of responses and solutions. But inventing the smart city of the future will clearly require reaching out to and involving inhabitants, who will no longer be considered as service users but rather as partners and stakeholders in their city's development. The smart city is an enduring topic for the foreseeable future, and one that is undoubtedly set to undergo many permutations.



WASTE[2]

- **2.01** billion tonnes of solid waste are produced each year in cities (2016 figures).
- **33%** of waste is not managed in an environmentally sustainable way.

AIR QUALITY[3]

- Over **50%** of urban dwellers are exposed to air pollution levels at least **2.5** times higher than what is deemed safe.

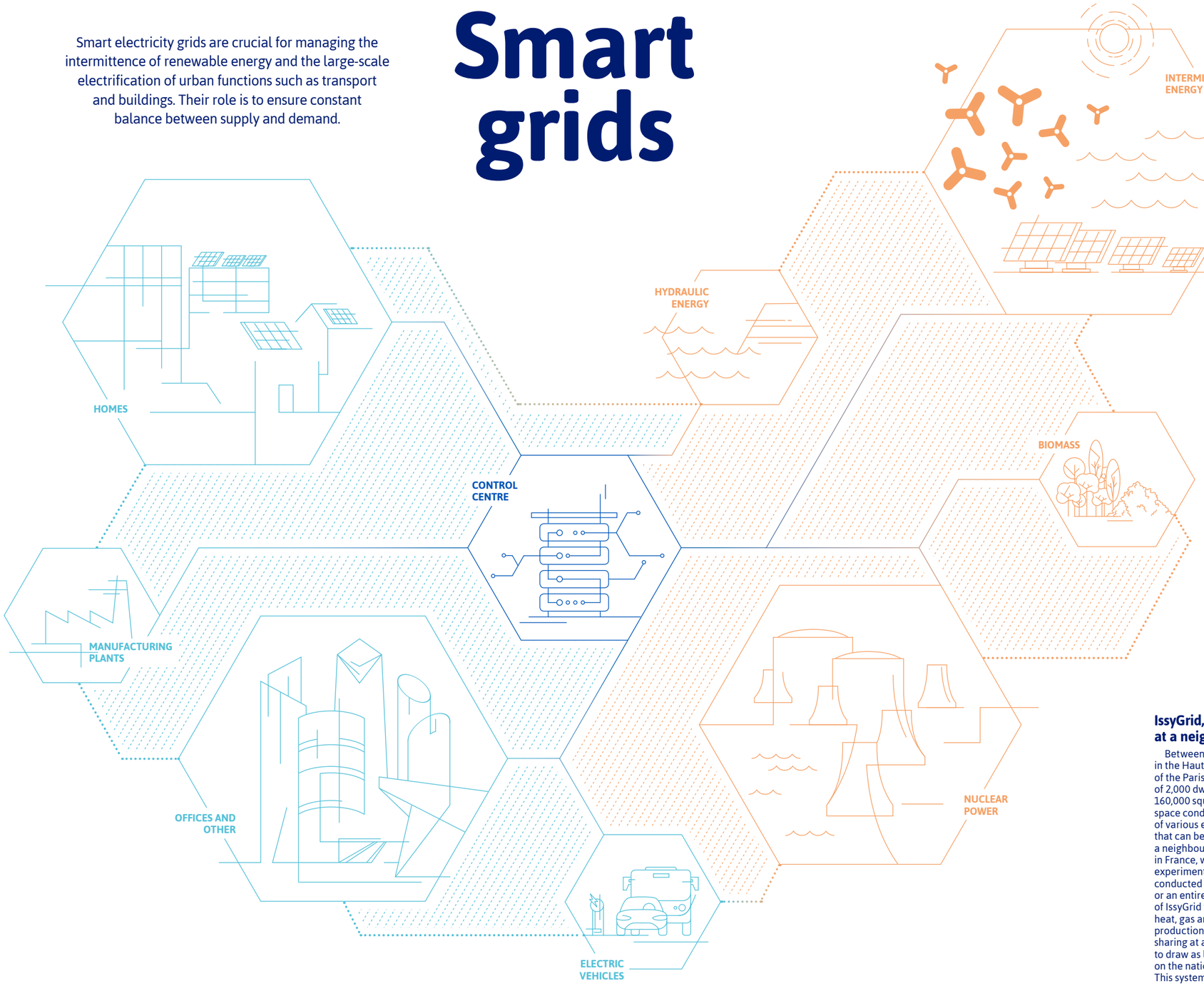
Urban electricity storage: first generation zinc-air battery

If local production of renewable electricity is to be accelerated, stationary storage solutions must be invented that are tailored to the constraints of the urban environment. This requires compact batteries that are not a hazard for human activity and are designed for slow charging to store excess electricity produced during the day – for example from solar panels – and consume it in the evening or during the night. Developed by EDF's R&D, zinc-air technology ticks all these boxes and is affordable due to the abundance of these materials. It also has a low-carbon footprint as the zinc is sourced from recycling plants. In partnership with the ZnR Batteries startup, incubated by EDF Pulse Croissance, a first generation of the zinc-air battery, called "Zinium", will be released in 2020 for single dwellings and apartment buildings. Two demonstration units are already in service: a single dwelling of the future, in France's Orne department, to boost the self-consumption rate of electricity produced by a photovoltaic installation; and the MASERA microgrid, an EDF group pilot project in Singapore to develop a cost-effective and efficient product offering as a solution for energy problems in isolated regions of South-East Asia.

(1) https://www.lafabriquedelacite.com/publications/la-cite-ideale-existe-t-elle/. (2) World Bank, "What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050", September 2018. (3) United Nations, "Sustainable Development Goals – 17 goals to transform our world", 2015.

Smart grids

Smart electricity grids are crucial for managing the intermittence of renewable energy and the large-scale electrification of urban functions such as transport and buildings. Their role is to ensure constant balance between supply and demand.



HOMES AND OFFICES
Through self-consumption, load shedding and electric-vehicle smart charging, consumers help balance the electricity network.

CONTROL CENTRE
centralises all production and consumption data, supervises in real time the optimum use of electricity produced and manages remote maintenance and targeted-field service operations.

NUCLEAR, FOSSIL-FIRED AND HYDRO POWER PLANTS
Their generation capacity is modulated against renewable energy generation. They offset the lack of wind or sun to ensure continuous supply.

INTERMITTENT ENERGY
Centralised or local renewable energy supply is prioritised for the green electricity grid.

MANUFACTURING PLANTS
Their considerable capacity for load shedding or consumption deferral is used in real time to balance the grid.

DATA
The volume of data produced by a smart grid is used to continuously improve network management (planning, operation, etc.).

ELECTRIC VEHICLES
Charging them at the right moment flattens consumption peaks. Electric-vehicles batteries provide storage capacity available for use at any moment.

STORAGE
During renewable energy production peaks, batteries and pumping stations store electricity ready for its later release back into the grid.

IssyGrid, pioneer at a neighbourhood scale

Between 2012 and 2018, in the Hauts-de-Seine department of the Paris region, the occupants of 2,000 dwellings and 160,000 square metres of office space conducted real-scale tests of various energy-saving systems that can be rolled out across a neighbourhood. This was a first in France, where smart-grid experiments had until then been conducted on a single building or an entire city. The purpose of IssyGrid was to encourage heat, gas and electric energy production, consumption and sharing at a local level in order to draw as little as possible on the national electricity grid. This system, in which EDF was a partner, required the installation of a central IT system, photovoltaic panels and various systems to store electricity and cold. At any given moment, the 15,000 residents involved could consult a detailed dashboard of their own consumption. By tapping into this data, the IssyGrid manager was able to automate equipment charging – boilers for example – at the best time to maintain the supply and demand balance and identify any malfunctions.

As French regulations do not yet allow the transfer of energy between public buildings, IssyGrid was not able to test this major smart-grid function. Still, the results of the trial were very satisfactory. The newer buildings were able to cover 50% of their electricity use from local production, and the energy saved across the neighbourhood was used to light three streets. The experiment is over, but IssyGrid is still operational and is gradually being rolled out to other neighbourhoods in the suburb of Issy-les-Moulineaux.

Interview

“Cities must be ready to learn from one another and to exchange solutions and best practices.”

Saskia Sassen
Sociology professor
at Columbia University

Saskia Sassen is a sociologist and economist specialising in globalisation who has been working for more than 30 years on cities and globalisation. She has a clear-sighted view of urban development issues that is far removed from over-simplifications and clichés. In her view, the future of cities will require better incorporation of expertise in order to deliver local solutions. We interviewed her.

— In 1991, you devised the concept of the "global city" to home in on urban issues and the real power of cities. What did that mean exactly? And, today, 30 years later, what in your opinion has changed in this approach?
Saskia Sassen: At the time, the notion of "globality" was used for states and governments but never for entities such as cities. Through my research in the early 1990s, I repeatedly found that the main actors in the life of large cities, such as major corporations, non-profit organisations and stock markets, were able to shape the world. So, cities concentrated this power and capacity to act, and their populations were growing exponentially. In order to become a planetary phenomenon, globalisation needed to anchor itself at the local level, in cities. Thirty years later, this trend has become even more apparent. As I see it, the major change is the growing number of global cities. They are no longer limited to London, Paris and New York, but have formed a much bigger network. It is clear that this movement is reflected in a similar development of the economy where smaller structures, grouped together in connected networks, have become decisive in the growth dynamic. And, as these companies are, by and large, located in urban areas, they reinforce the influence of cities.

— Today, we hear a lot about "smart cities". What is your opinion of this semantic shift?
S.S.: I find it very seductive and interesting, but somewhat misleading for the moment. We are no doubt moving towards smart cities – connected cities that make astute use of the mass of data generated – but we are far from there yet. Just look at the difficulties that wealthy cities, with all their highly advanced technology, have in presenting effective housing policies and combating the exclusion of their weakest and oldest citizens. The first reason is the lack of money needed to seriously tackle these problems and, then, there's a sort of fascination today for...

— Fascination?
S.S.: Yes, we are often seduced, hypnotised even, by technological solutions which, while innovative, do not have a profound impact on the situation. We often fall under the charm of advanced techniques that are astounding, distracting and even impressive, but which do not provide any fundamental solutions to the essential challenges we face. Although important, technology can't solve everything. We need to keep our critical faculties on alert to select those ideas that really do bring change.

— Cities are growing and gaining in economic power and influence. As a result, they sometimes create a wide gap between themselves and their immediate environment, such as rural areas. Do you think we should be worried about this situation?
S.S.: It's a defining chapter in the growth of urban areas. If we think about it, cities seem very powerful but they are also very fragile, because they are dependent. They all need to call on external resources for their vital needs. I'm one of those who think that cities should be self-contained in terms of knowledge and be able to generate the solutions they need rather than to bring food and items in by the truckload. This will be a long and difficult learning curve, but obviously beneficial in the long run. Furthermore, it would create the conditions to form solid and equitable ties with rural areas by leveraging their expertise rather than emptying them of their resources. I believe that this spirit of cooperation is totally central to inventing the city of the future.

— Why is that?
S.S.: No single urban area can find the answers to issues as diverse as eco-efficiency, housing, transport, social inclusion, and so on. The topics are too varied and extensive. Cities must therefore be ready to learn from one another and to exchange solutions and best practices. This movement is already well under way. A growing number of cities are working together and swapping expertise. This is creating a solid foundation for collective intelligence that is also informed by each citizen's engagement and personal action.

— What will be the main challenge for cities in the years ahead?
S.S.: The ability to leverage their full potential, to incorporate as much expertise as possible and to limit their dependence on the outside world. The many responses to this point are environmental, social and economic.

"Cities need to reduce their dependency."

Saskia Sassen

AT THE HEART OF SMART REGIONS

What can be done so that urban space, buildings, offices and dwellings consume less and better? Frugality is a key part of the challenge, and EDF's contribution is its bouquet of complementary energy services.

EDF and its subsidiaries (Dalkia, Citelum, Izivia, EDF Renewables, etc.) muster their expertise to develop solutions for the challenges that energy transition presents for regions: studies, renewable energy production, heating networks, collective self-consumption, energy performance contracts, electromobility, smart charging, smart buildings(1), smart lighting, digital platforms for urban management, and so on. By assembling all these technological bricks, the Group provides innovative, comprehensive and tailored solutions to the challenges each region faces.

(1) The main definition of a "smart building" is that digital technology is used to optimise its energy consumption and interact with its ecosystem.

SMART REGION

SUD PACA REGION

43 smart energy grid projects.

€340 million investment (state, region, municipalities, companies and electricity grid managers).

115,000 inhabitants.

Become Europe's first smart region

and a global showcase for innovation in energy transition: that is the goal of the Sud Provence-Alpes-Côte d'Azur (Sud PACA) region of southern France through its Flexgrid programme to conduct full-scale tests of the potential of smart energy systems applied to some 20 applications. Flexgrid turns each regional component into a smart system, whether for urban districts, coastal or rural towns, ski stations, the Lérins Islands, conservation areas or economic activities (Marseille-Provence Airport, Aix-en-Provence high-speed rail (TGV) station, agricultural greenhouses, etc.) and electricity grids. Since 2017, around 40 projects have been started or are under way, and the aim is to eventually industrialise them. As a partner in this programme, EDF is managing two trials in particular:

- **So FLEX'hy !:** by combining the Durance Valley hydropower plants with the regions' photovoltaic farms, this project aims to demonstrate how hydroelectricity can act as a backup for solar power and smooth intermittence. In this way, fully renewable energy can be guaranteed at all times;
- **Villette ECS:** a 7-hectare eco-district will be created in Cagnes-sur-Mer as part of a urban renovation project. Here, geothermal and solar energy production and electricity consumption will be centralised and digitalised. Dalkia Smart Building, an EDF subsidiary, will be implementing innovative contract and tariff models for energy exchange between apartment block management companies, energy operators and residents.

Flexgrid will facilitate the development of renewable energy in the Sud PACA region. EDF hopes to multiply sixfold the regional production of solar power within the coming 15 years.

GREENING ELECTRICITY PRODUCTION

The Sud PACA region produces only **50%** of the electricity it consumes. And, of the energy it produces, around **55%** is from renewables.

Installation of a smart lighting system can produce annual energy savings of up to 80%.

URBAN FUNCTIONS

CITELUM WORLDWIDE

3 million lighting points managed.

Lighting for **30** million people.

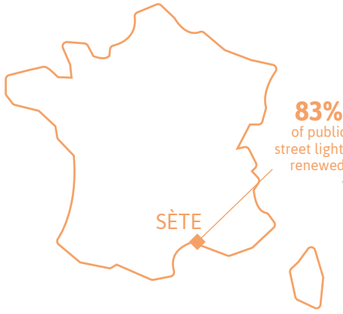
Active in over **1,000** cities.

Public lighting accounts for 37%(1) of French municipalities' electricity bills

Since 2013, Sète has been one of the many cities to contract Sogetralec, in a consortium with EDF subsidiary Citelum, to renovate and optimise the energy performance of their facilities. For Sète, this means around 8,000 lighting points, 530 sports ground lights, 30 traffic-light controlled intersections and 604 illuminations. This twenty-year public-private partnership also includes maintenance. Citelum has committed to energy savings of 63% by the end of the contract in 2033.

LED bulbs have been installed, and motion sensors modulate the lighting level. These connected systems provide real-time data to the Muse® digital operations platform used to provide preventive maintenance and continuous optimisation. As Muse® is compatible with all connected urban systems, Citelum subsequently added functions to improve traffic flow on urban roads and facilitate parking. Sensors installed in the road surface and on light poles feed data into an app that residents can use to check traffic density and find free parking spaces. Over the past 7 years, Citelum has considerably improved the quality of life for the residents of Sète and reduced the municipality's electricity consumption for lighting by 40%.

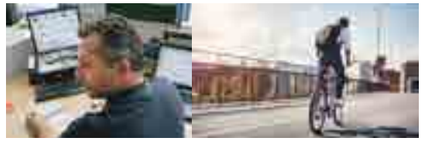
(1) Ademe.



83% of public street lighting renewed.

40% energy savings after four years.

Target of **63%** savings by the end of the contract in 2033.



New services connected to lighting

As lights are found throughout the public space, they can be used as a support for other connected equipment and provide new services to municipalities and residents without causing any significant additional cost for the municipality. In Greater Dijon, France, for example, the Muse® platform provides centralised management for CCTV, road maintenance services and city centre access terminals. In Calais, also in France, Citelum is trialling an electric-vehicle charging system installed directly on light poles, in partnership with the Ubitricity startup.

Citelum's latest innovations include sensors to measure noise in urban areas. Muse® collects the data in real time, calculates averages and automatically sends alerts to municipal departments in the event of excessive noise. On certain busy squares in Sant Cugat del Vallès, Spain, public lighting starts flashing to remind pedestrians to respect the neighbourhood's peace and quiet.

PLANS

PLANNING

A city's design determines its level of energy frugality

In Moscow, the developer of the future Rublyovo-Arkhangelskoye neighbourhood has called on EDF to optimise planning of the physical networks (energy, water, transport, etc.). EDF's City Platform 3D tool can describe the city spatially down to individual buildings. Then, for each hour of the day across an entire year, it can simulate the neighbourhood's different energy uses (air conditioning, heating, hot water, etc.) and incorporate this data into the operation of other urban systems, in particular transport and air quality.

Already used in Singapore, EDF's City Platform energy and urban planning tool will help this future neighbourhood in Moscow become a benchmark for smart cities in Russia.

2019
• The Sberbank City Platform planning tool is commissioned.
• For this neighbourhood, EDF is preparing a commercial offering that includes various smart services.

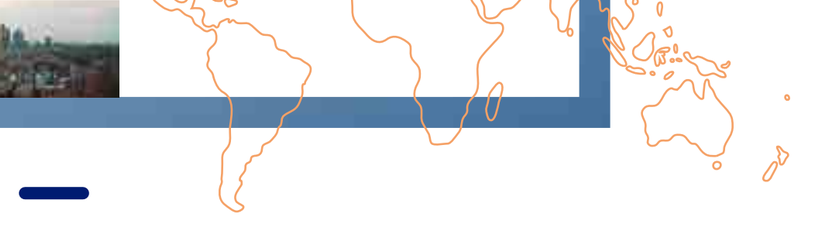
2029
end date for the smart city's construction.

The future Rublyovo-Arkhangelskoye neighbourhood

460 hectares of housing and offices.

66,000 residents, **76,000** workers.

Local renewable energy generation, storage and electromobility solutions.



ECO-CITIZENSHIP

Preventing energy waste and raising awareness of eco-habits and energy transition solutions are all significant drivers for reducing a region's carbon emissions. It is also an opportunity for everybody to play their part, which is why EDF constantly innovates with new tools.

• **Actee, for municipalities:** this website was designed in partnership with FNCCR, the French federation for concession-granting local authorities and municipal departments that manage public services. The website helps such organisations in each step of their energy renovation projects for public buildings. A simulator can estimate the energy savings and carbon footprint reduction.
www.programme-cee-actee.fr

• **CUBE.S(1), for schools:** EDF is a partner in this competition in which 261 primary, junior and senior high schools have already taken part. The aim is to encourage students and teachers to adopt good habits and find creative ways in reducing their energy consumption.
www.cube-s.org

• **Moby at school, pupils aged 6 to 11:** EDF is a partner in this programme, which is a fun way to raise the awareness of infant and primary-school children about clean mobility and the need to travel differently. Schools also use this programme to draw up their School Travel Plan over a year.
www.moby-a-lecole.fr

• **For everybody, participatory platforms to finance decarbonising their region:** to enable residents who are willing to help finance municipal heating and cooling network projects, EDF subsidiary Dalkia is working with two energy transition sector crowdfunding websites: Lendosphere and Enerfip. Calls for donations and investment have already raised enough to complete the funding for several projects.
https://enerfip.fr/
www.lendosphere.com

(1) CUBE.S : challenge Climat, Usages, Bâtiments, Enseignement scolaire.

MOBILITY

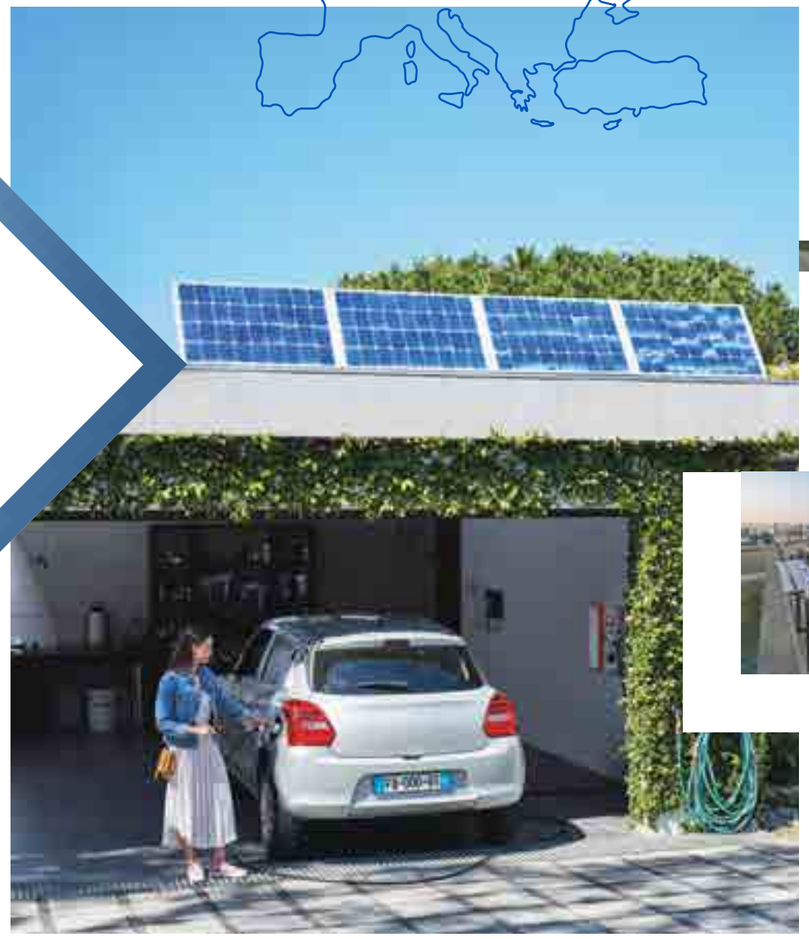
EDF wants to be the leading electromobility energy company in Europe by 2022

In October 2018, the Group introduced its Electric Mobility Plan to shift into a higher gear in its four main European markets. The plan includes concrete targets to become the:

no. 1 electricity supplier for 600,000 electric vehicles by 2022 (a 30% market share).

the European leader in smart charging, with 4,000 smart charging stations under operation by 2020.

no. 1 operator of charging station networks by rolling out 75,000 stations by 2022 and providing its customers with access to 250,000 interoperable stations in Europe.



30%
Contribution of transport to CO_2 emissions in France.

70%
less CO_2 by 2050.

This target has been set for the transport sector in the French Government's low-carbon strategy, and in particular involves making a modal switch to electromobility and halting sale of internal combustion engine light vehicles by 2040.

Electromobility will revolutionise the way we use vehicles

And first of all with private cars, which are parked 95% of the time. Batteries will turn personal and public transport vehicles into a source of stored electricity that is usable at any time. This will help balance the electricity system during peak-consumption periods and provide power to a building, block of apartments, company or even a neighbourhood. Energy companies are currently working on this highly realistic scenario for the medium term, focusing on smart charging by automating its management in conjunction with the needs of the electricity system. This will bring down the cost of charging for customers.

Even more innovative, various stakeholders are developing bidirectional charging technology that can draw down electricity but also send it back into the grid (vehicle-to-grid), into the home (vehicle-to-home), and eventually between vehicles or to any piece of electrical equipment (vehicle-to-everything). This is, in particular, one of the aspects of the cooperation agreement signed in September 2019 between EDF and Nissan, a pioneer in vehicle-to-grid technology. For the moment provided by charging stations, this smart technology could also be directly installed on vehicles within the coming 2 to 3 years.

2020

50%[1]
of new public transport buses and coaches must have low-CO_2 and atmospheric-pollution emissions.

95 g[2]
of CO_2/km (down from 130 g/km in 2015): Europe's new emissions threshold for new vehicle manufacturers.

2023

1.2 million[3]
electric passenger cars and 2.4 million hybrid passenger cars in France.

2025

The new emissions standard[1] will apply to all vehicles in public transport bus and coach fleets.

2028

4.8 million[3]
electric passenger cars in France, of which 3 million fully electric and 1.8 million plug-in hybrids, as well as 500,000 electric light utility vehicles.

2030

59.3 g[2]
of CO_2/km (37.5% lower than in 2021): Europe's new emissions threshold for new vehicle manufacturers.

(1) France's energy transition for green growth law (LTECV), decree no. 2017-23. (2) New CO_2 emission standards set by the European Union for the member states in April 2019. This threshold is calculated on the average of any given manufacturer's complete range of new vehicles. (3) Targets set in France's Multi-Year Energy Programme, published in January 2019 by the government.

“The acceleration of electromobility is now a certainty and, for our customers, a competitive driver for carbon reduction.”

Marc Benayoun,
Group Senior Executive Vice President,
Customers, Services and Regions

Smart charging will allow electromobility to accelerate local production of renewable energy

The combination of smart and bidirectional charging will be one of the solutions for using solar energy at night. For municipalities, companies and individuals, the growing fleet of electrical vehicles will create an unprecedented way of optimising the use of local low-carbon electricity.

The virtuous circle beginning to take shape between the electrification of transport and the development of renewable energy is good news. However, electromobility can only reach its full potential to reduce carbon emissions if it uses low-carbon electricity. For example, in France, the carbon footprint of an electric vehicle throughout its entire life cycle is two to four times below[1] that of an internal combustion vehicle.

*(1) RTE-Avere France study “*Les enjeux du développement de l’électromobilité pour le système électrique*” (Effect of electromobility on the electricity system), May 2019.*

Smart charging

To flatten peak electricity demand, vehicles are charged during off-peak hours (night-time, for example).

During peak-consumption periods or when the electricity system needs it, the vehicle sends its electricity back into the grid while still maintaining sufficient power for the vehicle owner’s use. Vehicle owners are paid for this service enabling them to reduce the cost of their electric mobility.

V2G

V2H

When photovoltaic panels are operating at full capacity, your electric vehicle automatically stores the excess power produced.

When your vehicle is parked, its battery feeds power to your home. For example, a Nissan Leaf can power your home for four days.

Until V2G and V2H technologies are fully mature, simple smart charging solutions are already supporting the transition to electromobility. Yannick Duport, EDF group Electric Mobility Director, explains.

What smart charging services are already available?

Yannick Duport: Smart management of electric vehicle off-peak charging, for example late in the evening, is a first level of smart charging that already works extremely well. EDF has been using this for quite some time to optimise the power consumed by 10 million hot-water heaters. With this service, electromobility customers have better control over their electricity bill. This basic management technique easily flattens consumption peaks and is suitable for handling a massive rollout of electric vehicles without compromising the robustness of the electricity system or the balance between supply and demand. There is a more sophisticated level of smart technology to manage fleets of company vehicles. The charging process is optimised in such a way as to ensure that not all vehicles draw on the grid at the same time, rate and power, without interfering with the company’s processes and ensuring the best possible price for the customer.

When will V2G be available?

Y. D.: This bidirectional charging technology exists. Several companies have already opted for this solution and have taken out a subscription with DREEV, a joint company created by EDF and NUVVE. Now what is needed is to industrialise its operation so that customers can sell back the energy in their batteries when their vehicles are not in use. The rate of uptake of this advanced management solution will also depend on the capacity of automakers to equip their vehicles with V2G technology. We believe that it may be standard within 3 years.

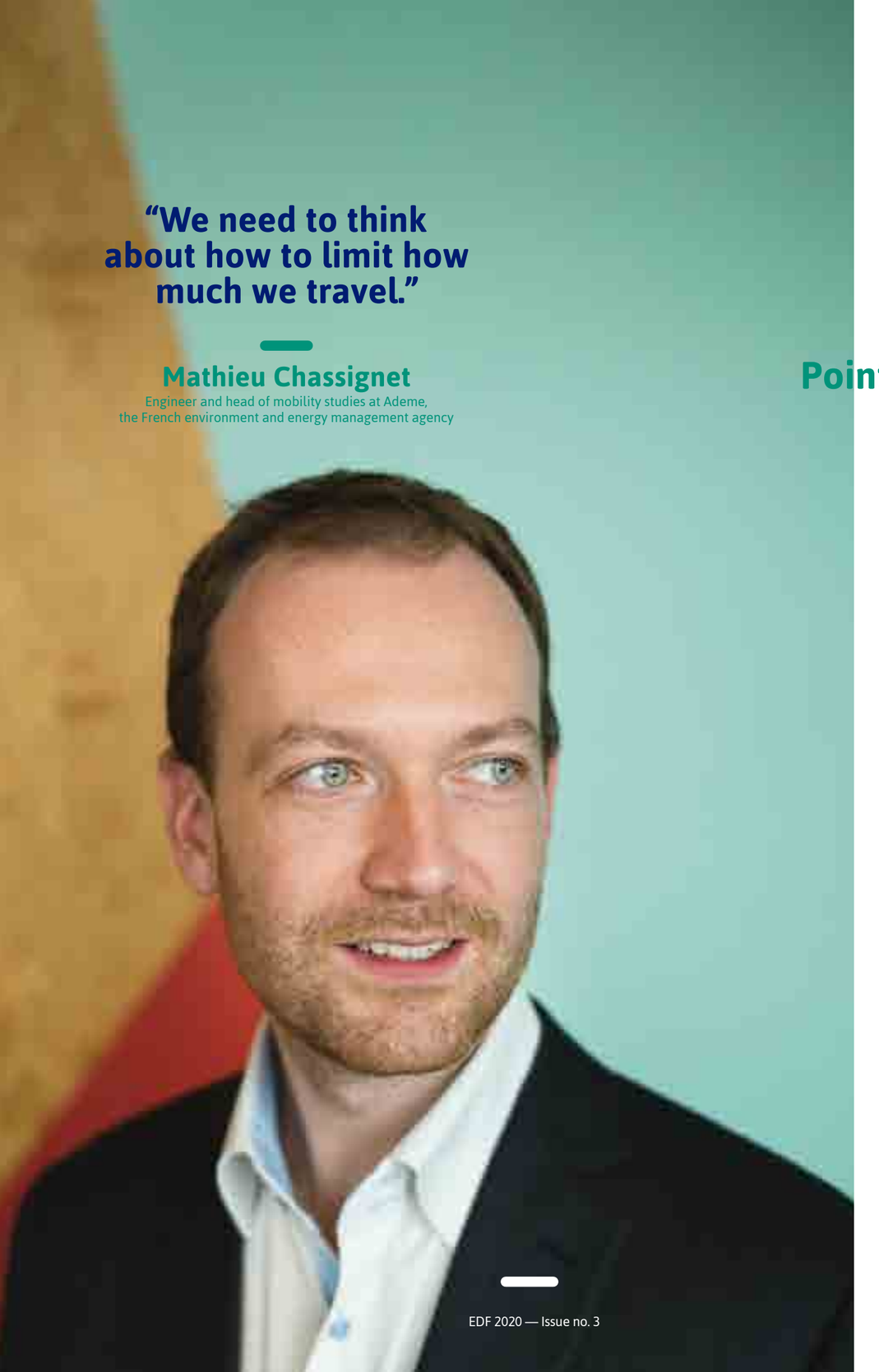
What is EDF doing to speed up this shift?

Y. D.: With the introduction of its Electric Mobility Plan at the end of 2018, EDF is able to structure solutions for its customers, including the supply of low-carbon electricity, charging at home or on the move, and smart charging services for which we hope to become the European leader in our four main markets (France, United Kingdom, Italy and Belgium). One of the first steps in this direction was the creation, in February 2019, of our subsidiary DREEV with the Californian startup NUVVE, which is developing and marketing innovative V2G solutions.

Points of view

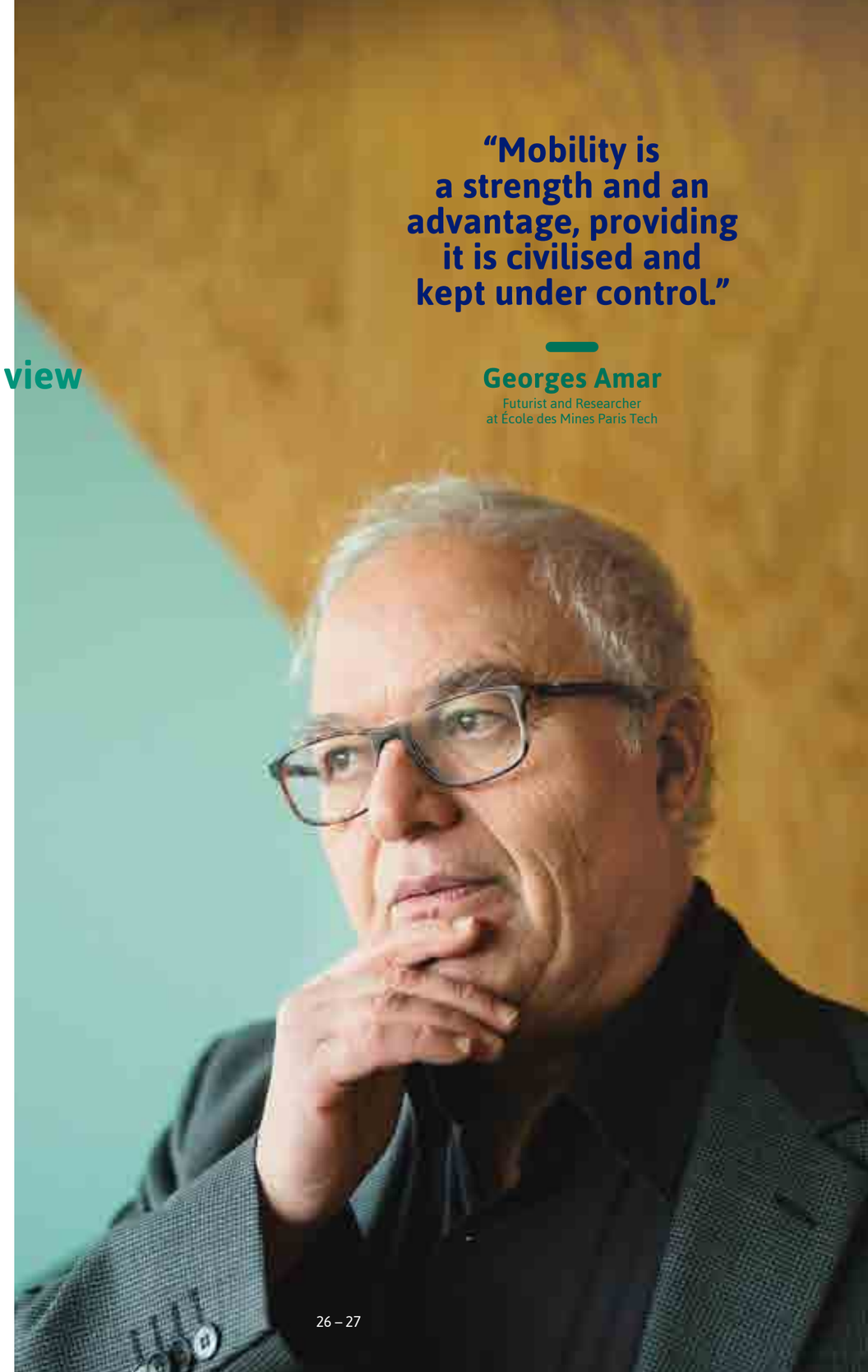
“We need to think about how to limit how much we travel.”

Mathieu Chassignet
Engineer and head of mobility studies at Ademe,
the French environment and energy management agency



“Mobility is a strength and an advantage, providing it is civilised and kept under control.”

Georges Amar
Futurist and Researcher
at École des Mines Paris Tech

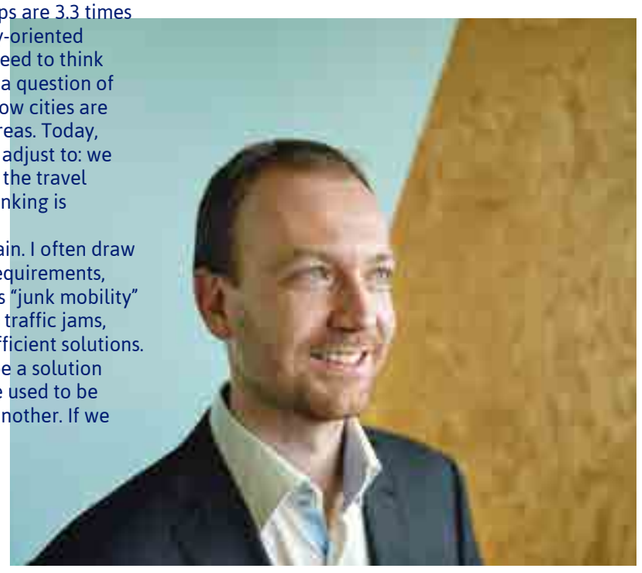


What type of mobility do we want? What will be the consequences on our lifestyle? These two important questions – like all crucial issues – need to be discussed openly. Georges Amar, futurist and researcher at École des Mines Paris Tech, and Mathieu Chassignet, engineer and head of mobility studies at Ademe, the French environment and energy management agency, engage in a discussion to clarify the notion of mobility and its associated issues.

— It is always telling when an expression enters into everyday language. In the previous issue of our magazine, Étienne Klein discussed the fact that the word "innovation" has come to replace "progress". What does "mobility" inspire in you as it is replacing "transport" and "travel"?
Georges Amar: The word "mobility" signals a far-reaching change in the way we live. We are entering into a civilisation of mobility, or "mobile life", which signifies a rupture with what I would call "stationary life". The latter is based on the spatial organisation of social life in which activity is conducted in a specific location: you work in an office, you study at school, you see a film in a cinema, and so on. This pairing of activity with place is no longer self-evident. It is a massive change.
Mathieu Chassignet: The notion of mobility is actually paradoxical. It is often presented as a personal issue: what solutions are provided to allow me to travel? Whereas in fact, it above all concerns the common good and living in society. It cannot be restricted to just the personal dimension, to the simple notion of "mobility consumption". Moreover, I feel that this word also implies an order to be mobile: you have to keep on the move, accept travelling and see it as necessary and as something positive. Even fiscality encourages us to be more mobile – personal car expenses for business trips are reimbursed and take into account your vehicle's engine power.

— Behind this order to move, isn't there a form of addiction? In other words, do we move too much? Mightn't the concept of "sufficiency" apply to mobility?
M. C.: Absolutely. The demand for mobility is growing exponentially. On average, we still make four trips a day, but those trips are 3.3 times longer than in 1960. Hence the idea of more sufficiency-oriented mobility, a notion which I believe is crucial today. We need to think about how to limit how much we travel. This is not just a question of transport solutions but also an in-depth reflection on how cities are organised, and the locations of business and housing areas. Today, mobility is often experienced as something we need to adjust to: we choose where we want to live and then we think about the travel required. The question of how to change this way of thinking is fundamental today.
G. A.: Yes, mobility needs to become a cultural issue again. I often draw a parallel with food. Food is a culture, with its habits, requirements, rituals and excesses. Just as there is "junk food", there is "junk mobility" in which we travel about indiscriminately. This leads to traffic jams, crammed public transport and poorly adapted and inefficient solutions. However, let me be clear, I think that mobile life may be a solution to this "junk mobility" phenomenon. The ultimate value used to be speed, to get as quickly as possible from one place to another. If we

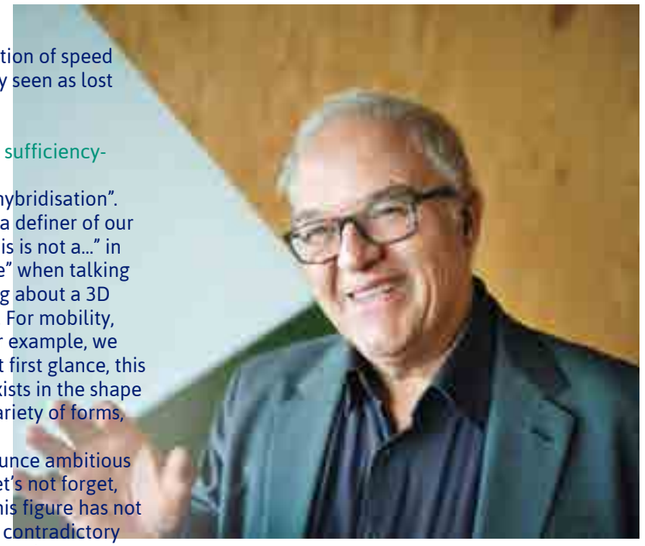
"More sufficiency-oriented mobility will require rules and obligations, and therefore commitment."
Mathieu Chassignet



disassociate an activity from a specific location, the notion of speed is no longer crucial. Travel time is no longer necessarily seen as lost time but can instead be used differently.

— In your opinion, what must we do to achieve more sufficiency-oriented mobility and put an end to "junk mobility"?
G. A.: If I were to sum this up in one word, it would be "hybridisation". Already a significant trend, it is increasingly becoming a definer of our times. Today, to paraphrase Magritte, we could say "This is not a..." in reference to numerous objects. "This is not a telephone" when talking about a smartphone. "This is not a printer" when talking about a 3D printer. Today's tools far exceed their original purpose. For mobility, hybridisation opens up a vast field of potentialities. For example, we will increasingly see personal public transport (PPT). At first glance, this would seem to be an oxymoron. However, it already exists in the shape of bike sharing services, for example, and can take a variety of forms, including self-driving cars.
M. C.: For me, the key word is "consistency". Don't announce ambitious targets – such as carbon neutrality by 2050, because, let's not forget, 80% of the distance travelled in France is by car, and this figure has not changed in 20 years – and then implement completely contradictory policies. For example, many municipalities build hypermarkets on the outskirts of urban areas, which increases the need for travel and undermines the economic life of town centres. Why not give greater thought to what the commercial activity should be in town centres in order to encourage local shopping? The same applies to the correlation between employment and residential areas. In short, we could say that in the past the company housed employees whereas today it reimburses kilometres travelled. Now that's a problem given the climate emergency. Surely there's a middle way between the two. The fundamental issue remains one of political will. More sufficiency-oriented mobility will require rules and obligations, and therefore commitment: Seville in Spain has introduced an ambitious plan based on the bicycle. Again in Spain, Pontevedra, which has 83,000 inhabitants, has entirely pedestrianised its town centre. Initially, there was some opposition, but the mayor has been re-elected three times. Sometimes, it pays to stick to your guns.

— Any pitfalls to avoid?
M. C.: The rebound effect. Often, solutions are promoted without thinking about their full consequences. Working from home is all very well, but studies have shown that, if you spend two days a week at home, you tend to move even further away from your office, thereby increasing the distance you have to commute.
G. A.: The main pitfall would be to ignore the current deep paradigm shift. Mobility is a strength and an advantage, providing it is civilised and kept under control.



"Mobility needs to become a cultural issue again."
Georges Amar

87%
of French people[1] use their car for at least one of their daily trips.

LOW-CARBON MOBILITY THE CHALLENGES

All stakeholders – energy companies, automakers, OEMs, regions, etc. – are working together to develop large-scale electromobility. As well as technological and cultural challenges, there is the economic challenge of making electric mobility accessible to all.

The mobility sector is undergoing structural change driven by significant shifts.

The myth of the car, so admirably described in 1957 by Roland Barthes in his *Mythologies*, continues to permeate our collective mind. As the transport historian Mathieu Flonneau notes, French people are still very attached to an "automobile culture" which, far from simply coming down to individualism, is a factor of emancipation, social inclusion and national cohesion. "Cars still reflect a happy place in the French collective subconscious,[2]" he says.

In this time of climate challenge and exponential growth in mobility needs – total daily trips in the Paris region rose 4.9% from 41 million to 43 million between 2010 and 2019 – what future is there for private car? How can we reinvent mobility?

One answer is to revolutionise usage and ring in the era of sharing. These new forms of collaborative mobility, enabled by the digital transformation and platformisation of the transport sector, have moved into a higher gear with the emergence of MaaS (Mobility as a Service). MaaS provides smooth and seamless trips for users and marks the end of single-occupant car use.

Another response is to develop low-carbon electric mobility, which is a significant change accelerator. Smart charging and vehicle-to-grid technologies are already a reality; when such infrastructure is in place, electric-vehicle charging can occur at the best moment or electricity can be sent back to the grid. This creates a virtuous circle and precision management of consumption. The whole point is to lock in mobility that consumes less energy, is more efficient and better connected.

(1) Survey on daily mobility in French regions, September 2019, by Régions de France, Transdev and Ipsos.
(2) Source: Le Monde website – August 9, 2019.

Infrastructure

Average time to fully charge (40 kWh) an electric vehicle

30 minutes
to 2 hours fast charge (from 22 kW).

7.5 hours
with a standard charging station (7 kW).

21.5 hours
from a standard domestic power socket.

Automakers have set a target of 12 minutes fast charge by 2030.

275,565
Electric vehicle fleet in France in December 2019, of which 79% are fully electric(1).

In addition to radical change in usage and technologies, we also need a conceptual revolution with the emergence of Carlos Moreno's or Francis Pisani's "quarter-hour city", meaning a city where residents find everything they need within fifteen minutes from home by walking, cycling or riding an e-scooter. Some go even further and ask if mobility is now a social injunction. Ultimately, will the 21st century's ultra-mobility, which has become an end in itself, be a source of liberation or constraint?

The ease of access to a charging station will be the key to the faster uptake of electric mobility. As it is expected that there will be 4.8 million private electric vehicles by 2028 in France, the government, under its Multi-Year Energy Programme, recommends installing 300,000 public charging stations by this same date.

A local "electric" solution for all

Drivers charge their cars at home or at work 80% of the time. This desire for ease and practicality points to the need to provide as many people as possible with a local charging station, even if it is shared. At home, users can choose a specific electricity supply contract that includes lower off-peak rates – 50% cheaper at night with EDF's Vert Électrique Auto offer, for example. Eventually, with smart and bidirectional charging (*see p. 23*), they will be able to contribute to offloading and vehicle-to-grid solutions against payment. RTE estimates that, for drivers who charge their vehicle at home, the annual "fuel" cost is three times cheaper(2). Savings can be as high as 80% when using off-peak charging, and even almost 90% with vehicle-to-grid technology.

Provide alternatives for people who do not have their own parking space

In France, 11 million households do not have their own garage or parking space. Charging in office carparks is an alternative that will become increasingly commonplace for employees. But other solutions close to home need to be developed in the public space. "On-demand" stations installed in the street by municipalities at residents' request are proving very popular in several European countries. In Amsterdam and Oslo, for example, where they are shared by several users in the same street or neighbourhood. Developed by the startup Ubitricity, in which EDF is a shareholder, light-pole charging is

(1) Source: Avere-France.
(2) RTE – Avere-France study "Les enjeux du développement de l'électromobilité pour le système électrique" (Electromobility growth challenges for the electricity system), May 2019.

another solution. Using a cable supplied by the company, customers plug into a light pole close to their home, and the data transmission system takes charge of remote invoicing for each user. Eventually, shared and connecting carparks, such as those provided by Zenpark – in which EDF acquired a stake in January 2019 – will continue to improve how existing infrastructure is used. One example would be to allow residents to charge their vehicles at night in empty company carparks.

High-power infrastructure for long-distance trips

Electromobility on the motorway and when travelling require fast charging, which is on the increase thanks to innovation (*see p. 36*). Growth in electromobility will also see an increase in the need for high-power top-up infrastructure in commercial and outer urban areas for visitors far from home. In the United Kingdom, Pod Point, a company bought by EDF in February 2020, has developed a network of almost 3,000 charging stations for public use, mainly in Tesco and Lidl carparks, in addition to its home and workplace charging stations.

At some time in the future, changes to road infrastructure may allow electric vehicles, especially those weighing over 3.5 tonnes, to charge while on the move. Several innovations are currently being tested, including charging from an electric rail embedded in the road surface, or by induction or catenaries.

In Lyon, Izivia increases charging station network density

Izivia is helping Greater Lyon (France) accelerate the uptake of electromobility across its area. By the end of 2020, this EDF subsidiary will have installed 641 new charging stations across the city of Lyon and its greater metropolitan area. Universal charging stations will cater to the needs of all electric and plug-in hybrid vehicles with a range of power ratings: 600 standard charging stations (22 kW or less) and 41 rapid charging stations (50-150 kW).

They can be used with or without a subscription and reserved using a mobile app.

For this project, which includes design, installation and the technical and commercial operation of the network, Izivia has joined forces with FMET, a fund for the ecological modernisation of transport, and its company Demeter, which is financing the investment. This is an innovative economic and financial model for electromobility.

As a signatory to the EV100 global initiative, EDF group has committed to switching its entire fleet of 32,000 light vehicles to electric vehicles by **2030**.

28,666
public charging stations at the end of 2019 (up 15% in a year) in metropolitan France, representing one for every 7.4 light electric vehicles in circulation(1), of which:

- **49%** on the roadside and in public place.
- **30%** in carpark.
- **21%** in companies and retail outlets.

Turnkey solutions for B2B clients

EDF is developing an entire range of products to assist its clients in making the shift to electric mobility:

- assistance with the installation of charging infrastructure including supply, operation and maintenance
- smart charging solutions provided by DREEV
- company-fleet management tools
- supply of green electricity
- assistance with transitioning a fleet of internal combustion engine vehicles to electric vehicles

(1) Source: Avere-France-Gireve survey, December 2019.

Recharge

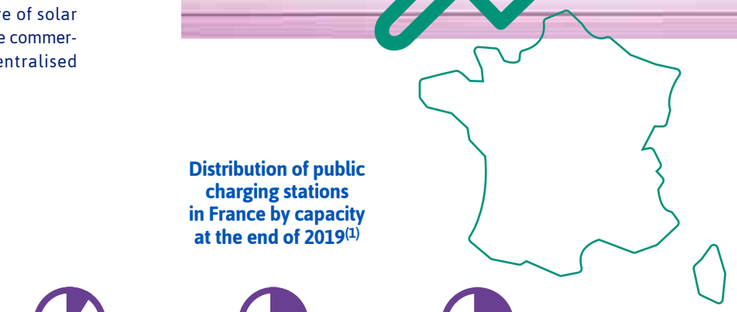
Rapid charge 50 kW stations on motorways can charge an electric vehicle to 80% in under 30 minutes. However, with the upcoming arrival of vehicles with a driving range of up to 600 km, charging will have to be even more powerful.

Two major issues: smart and fast

The size of electric-vehicle batteries has increased from 50 kVA to 100 kVA, and even up to 350 kVA for the latest models. This means that the power delivered by the charging station has to be continuously raised to maintain a short charge time of around 15 to 20 minutes. EDF R&D is preparing for this in its new "Very High Power Charge" laboratory, where the Group is testing charging terminals with a capacity of up to 500 kW now being released onto the market. They are designed for use by private cars as well as buses, coaches and trucks. EDF R&D is also using this platform to test combining these charging stations with electricity storage and local production.

In the future, electromobility should contribute to balancing electricity supply and demand in real time. Improving smart charging is therefore the other major challenge for the years to come. EDF recently acquired US company PowerFlex Systems, a pioneer in the field of electric vehicle charging technology. Incorporating its expertise into the Group's range of solar energy production and storage solutions will provide commercial and industrial buildings with a single, decentralised energy ecosystem.

Distribution of public charging stations in France by capacity at the end of 2019(1)



9%
Rapid (>24 kW).

65%
Fast (11-24 kW).

26%
Standard (<11 kW).

(1) Source: Avere-France-Gireve survey, December 2019.

DREEV installs its first V2G station

You can earn money by switching your company fleet to electric vehicles. For the customers of EDF's new subsidiary, DREEV, this is one of the benefits of its smart-charging management. Hotravail, a company in south-western France with 560 employees, is a case in point. Its head office has had three V2G (vehicle-to-grid) bidirectional charging terminals since April 2019. By controlling the time and speed of charging, this technology lets client companies sell back the electricity stored in their electric vehicles' batteries. The company maintains control over the scheduling of its needs using a mobile app. So far, Hotravail's terminals store and release electricity in ten of its vans, resulting in savings of around €20 a month per vehicle thanks to the remuneration received from DREEV in exchange for the electricity sent to the electricity grid.

DREEV's V2G technology can also use the electricity stored in electric vehicles to power a building or a neighbourhood.

Battery

Cutting-edge R&D

EDF group is engaged in an ambitious electricity storage development plan and, at the end of 2019, it doubled the testing capacity of its R&D laboratory studying the performance of stationary batteries and electromobility. The lab's work focuses on all stages in battery development, from the electrochemical cell to the prototype, and on to the battery at the industrial stage.

Lifespan, modelling of ageing, power of energy delivered, recyclability, etc.: all the parameters fundamental to the intended uses of the batteries are tested and evaluated. Even their level of safety is verified under extreme conditions: fire, immersion and overcharging.

Numerous future applications

Last year, at the CES trade show in Las Vegas, the Lancey start-up from Grenoble, France, announced that it was going to recycle electric bike batteries in smart radiators that store energy during off-peak hours. The 2020 CES show also unveiled a new bouquet of innovations for mobile batteries. Dutch start-up Skoon presented its battery sharing platform designed to match supply and demand more easily, in particular for construction sites, events and outdoor filming locations. Otonohm, a company based in Lille, France, wowed the audience with its lithium-battery technology with integrated charging and converting functions that does away with the need for chargers, converters and inverters, and has higher capacity and power. The first instance of this mobile battery's use is a greener alternative to gensets. Its universal charge means it can be plugged into the grid or renewable energy production systems.

Providing a second life for electromobility batteries is a promising area of development. In isolated regions relying on self-consumption for example, used electric-vehicle batteries can act as stationary storage for renewable energy. This solution has been used on Porto Santo Island in Madeira where the automaker Renault is conducting an experiment with first-generation batteries from its ZOE electric vehicle.

$150/kWh

The current cost of a battery compared with $1,000/kWh 10 years ago.

The continual and rapid fall in the price of batteries – from around $1,000 per kWh a decade ago to $150 today – is opening the door to electromobility to a growing audience. As the battery accounts for around 30-50% of the vehicle price, there is a proliferation of research on all possible areas of cost savings and, more generally, on all the battery's electrochemical parameters: density, weight and power. These affect the vehicle's performance, including driving range, speed, charge time, carbon footprint, and more.

Improving vehicle performance

As the only technology that can currently be mass produced, the liquid electrolyte lithium-ion battery should continue to dominate the market for the next 10 years or so. After that, "all-solid-state" batteries that combine safety with high performance may become the norm. Meanwhile, developments in the materials used for the two electrodes are already improving battery autonomy, capacity to respond to sudden heavy draw-down and ability to withstand extreme temperatures (from –20 °C to +50 °C). This is excellent news, as the electrochemical alternatives for which research is the most advanced are unlikely to be used in electric vehicles despite their undeniable advantages. Similar in operation to the lithium-ion battery, the sodium-ion battery might be more cost-effective, more powerful and last longer. However, its lower energy density makes it more suitable for stationary storage or for the market for starting up vehicles. For its part, lithium-sulphur technology has a density four times greater than lithium-ion, but the battery space required puts it more within the orbit of aerospace industries.

Towards a technological breakthrough

The most promising avenue for light vehicles will probably come in the shape of a complete change of technology with "all-solid-state" batteries, the first industrial demonstrators of which are expected from 2025 onwards. In this new type of battery, the liquid electrolyte will be replaced by a solid inorganic compound. In addition to being non-flammable, all-solid-state batteries pave the way to using innovative materials, such as polymers and ceramics, which will considerably increase battery safety and storage capacity.

Hydrogen

Project for hydrogen transport on the Seine River

Validate the technical and economic feasibility of using hydrogen for maritime and waterway transport: this is the goal EDF and its many partners have set themselves under the European H2SHIPS project launched in 2018 by EIFER, an R&D centre jointly created by EDF and the Karlsruhe Institute of Technology. Based in Germany, EIFER has been working on hydrogen since its creation in 2001. The French part of the project involves identifying a site for producing low-carbon hydrogen in Paris for freight and passenger waterway transport. This pilot operation has already led to a preliminary design for a hydrogen-powered pusher tug by Europe Technologies on behalf of CEMEX, EDF (EIFER) and Banque des Territoires. The development phase is now under way, and the vessel will be able to sail on the Seine in 2024. The aim of H2SHIPS is also to share best practices with the project's other two port ecosystems: Ostend in Belgium, which will test a hydrogen bunkering system compatible with open-sea operations; and Amsterdam in the Netherlands, charged with developing solutions for transporting freight on waterways. The success of these projects is important for the sector's decarbonisation as north-west Europe accounts for 85% of Europe's waterway transport, with all ships currently using diesel propulsion.

"EDF will focus on low-carbon hydrogen applications where the highest number of tonnes of CO_2 can be saved: heavy transport and industry."

Alexandre Perra
Group Senior Executive Vice President, Innovation, Corporate Responsibility and Strategy

In
2050
hydrogen consumption could account for

18%
of final energy demand worldwide[1].

10%
of low-carbon hydrogen in 2023 and

40%
in 2030: this is the aim of France's Multi-Year Energy Programme.

Hydrogen vehicles produce their own electricity using a fuel cell. Compared with conventional battery electric mobility, they provide considerable driving range for a limited fuelling time. For example, it takes only five minutes for the Toyota Mirai to store enough hydrogen in its tank to cover 500 km. Hydrogen plus fuel cell technology emits no CO_2, fine particles or nitrogen oxides (NOx) while on the move because the combustion of hydrogen produces nothing except water.

Decarbonising heavy and long-distance vehicles is a priority

These performance levels are particularly suited to the high power and driving range required by heavy transport vehicles such as buses, coaches, trucks, household waste collection trucks, light commercial vehicles, trains, boats, and private and public fleets of logistics transport vehicles. This makes hydrogen a promising replacement fuel for heavy oil and diesel. In Germany, hydrogen trains have been running since 2018 on non-electrified regional lines. The French Government has set itself the goal of authorising its first model in 2024. Still, although the motors may have almost reached maturity, the production costs for equipment and the rollout of hydrogen fuelling stations remain high and require subsidies. For this reason, the nascent hydrogen mobility sector is developing hand in hand with the decarbonisation of hydrogen for industrial purposes (refining, chemicals, electronics and metallurgy). Currently, this accounts for the bulk of the world's grey hydrogen consumption and, when possible, the creation of ecosystems that bring together these various actors. The stakes are high: 95% of the world's hydrogen is produced by cracking carbon molecules from hydrocarbons, gas or coal, resulting in a high carbon footprint (10 kg of CO_2 per kilogram of hydrogen produced).

Water electrolysis for clean hydrogen

Among the few processes used to manufacture clean, decarbonised hydrogen, photosynthesis is still at the laboratory stage. Water electrolysis using low-carbon electricity should, on the other hand, rapidly reach the industrialisation stage given the fall in electrolyser prices. That's certainly what EDF wants to see, and it is investing in their development. In 2018, the Group became the first shareholder in McPhy, a French manufacturer of electrolysers. Then, in April 2019, EDF subsidiary Hynamics was created to produce and sell low-carbon hydrogen to public and private heavy mobility stakeholders and industrial concerns. In the future, electrolysis-means hydrogen produced from low-carbon electricity – nuclear and/or renewable – will also be a new way of storing low-carbon electricity. Also, it will be possible to transport hydrogen produced in gaseous form over long distances in pipelines or in liquid form in tanker ships to regions lacking in renewable energy resources. Hydrogen could also be recombined with CO_2 from large industrial facilities – refineries, steel mills and cement works – to produce ethanol, methanol and even decarbonised synthetic fuels.

(1) "Développons l'hydrogène pour l'économie française" *(Developing hydrogen for the French economy), Afhypac 2018 report produced with McKinsey.*

Interview

“The sustainable city will mean the inclusion of everyone.”

Rachel Kyte

Dean of The Fletcher School – Tufts University, the oldest graduate school in the United States dedicated to international affairs

Rachel Kyte is the Dean of The Fletcher School – Tufts University (Massachusetts). Her perspective is both realistic and concrete, informed as it is by her experience in the field about the changes taking place in urban areas in response to today's environmental issues. We take a trip into the heart of the sustainable city to explore questions such as priorities for action, budget independence and management of space and mobility.

— Today's cities must confront crucial issues, especially the fight against climate change and limiting CO_2 emissions. In your view, are cities fully aware of the extent of these problems?
Rachel Kyte: Yes, they are, for a very simple reason: urban centres have to deal with these issues all the time. Migration triggered by climate change, sustainable mobility, eco-efficient housing, to name but a few. Urban centres can no longer ignore these problems as they are their present and future. For this reason alone, they are generally more aware and active than governments.

— When dealing with such vast challenges and issues that are often global in scope, it is sometimes difficult to rank the actions needed. In your opinion, what are the most important challenges cities face today?
R. K.: We need to reach zero emissions in all areas of human activity: moving, eating, staying warm, communicating. It's crucial that we maintain our efforts in this area and even step them up. Clean mobility is therefore a priority, coupled with CO_2 emission capture and storage solutions. We also need to rethink our relationship with space and housing. What do we really need to live? How can we improve the eco-efficiency of buildings and make them comfortable in both summer and winter without emitting any CO_2? These are fundamental questions about housing, one of the nerve centres of all big cities. The younger generations address these topics in a very natural way. Can we share space and apartments? Means of transport? Is this a way forward? Undoubtedly, yes. One last point: I feel that cities should not live in isolation, focusing inward on their problems.

— What do you mean by that?
R. K.: By definition, a urban centre is the opposite of solitude. It is not cut off from the world and, especially, the immediate world around it. I believe it is crucial for cities to think about their relationship with their surrounding rural areas, if only because of the quality of food for their citizens: 90% of the food consumed in cities should be produced in cities in close collaboration with rural areas. This brings us to how space is used: how can we find locations for urban farming and provide healthy and affordable food for all? And I mean real food, not just some promotional campaign around a few strawberries grown on a rooftop. The notion of the smart city covers many aspects that must be moved forward together.

"We must generate electricity as cleanly as possible."

Rachel Kyte

— What role does electricity play in these smart cities?
R. K.: A leading one. We must generate electricity as cleanly as possible to electrify as many services as possible. The aim is to be efficient, not to just feel our way but to arrive quickly at the most complete solutions. This is true of transport but also for things like air conditioning. We know that the current systems are neither efficient or sustainable. The very first question we must ask is that of efficiency, and electricity is the starting point for many solutions.

— For some, the words "energy transition" are synonyms for "degrowth" or "slowing the economy". What is your reaction to that?
R. K.: It is actually counterintuitive because the energy transition represents an opportunity for job creation, and more specifically local job creation. Energy efficiency, the design of systems tailored to each city and each neighbourhood are all areas that will create new jobs. The sustainable city will not shut anyone out. I'm convinced of that. Just the opposite, these two aspects are inseparable, or we are otherwise doomed to fail. This is an opportunity for us to ask a fundamental question: what is the real purpose of economic growth? We must not let it pass.

— In conjunction with smart cities we often hear the words "collective intelligence" and...
R. K.: What does that mean?

— That's precisely my question!
R. K.: Well, I'm asking you! Joking aside, it's essential not to lose sight of the reality implied by these new terms. First and foremost, collective intelligence is an opportunity to collect and share a huge volume of data, using machine learning and artificial intelligence, and to learn valuable lessons from it. For example, when LiFi technology – access to the internet using light – is added to public lighting, it will become a source of geo-contextualised data for citizens and will improve safety in cities. I saw this in a recent extensive study of coastal cities in Bangladesh. The volume of data analysed contributed to creating forward-looking scenarios. The same applies, for example, to satellite systems that can identify sources of emissions. However, these cutting-edge technologies are often owned by major private corporations. In my opinion, this should be the next expression of collective intelligence. Where these crucial issues are concerned, cities should be able to benefit from partnerships with the Big 4 tech companies and others.

— Something strikes me over and over again during this interview: the sustainable, resilient city is also a question of political will, clear choices and decisions.
R. K.: That's right. Political will, coupled with innovation, is the most powerful of drivers. All the same, we should not overlook another aspect: budgets. How can cities get access to the financial resources they need to take action? Could certain government budget lines be transferred to municipalities so that they can implement appropriate local policies? This is a key issue.

In
France,
the consumption of an
air-conditioned dwelling
is estimated on average
at 700 kWh/year for recent units.

New builds to house
2.5 billion
more people in cities
by 2050[1].

According to climatologist
Jean Jouzel, that will generate
470 billion
tonnes of CO_2 if we continue with
today's construction methods.

rise in global warming.

That is the equivalent of a

URBANISATION

REINVENTION CHALLENGE FOR BUILDINGS

In 2050, two out of three people will live in urban centres, compared with 55% today.[1] This means that current highly polluting construction methods and the building sector as a whole will have to change to build these new cities.

Singapore's Housing Development Board leaves nothing to chance

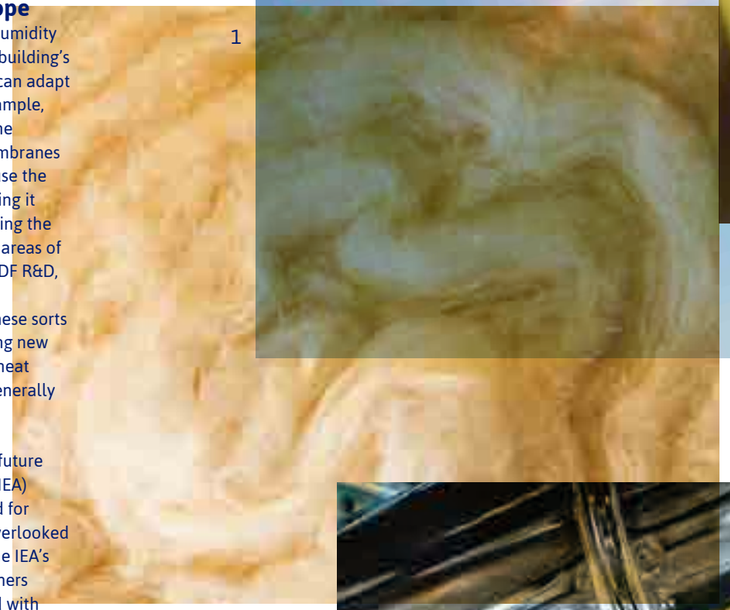
Singapore's Housing Development Board builds 20,000 homes a year. Its main concern is sustainability and the issues associated with an ageing population and increasingly connected young generations. In 2020, the Board celebrated 60 years of existence and now houses 81% of the city-state's inhabitants, 90% of whom are owners. So there is little room for error, except when conducting trials to develop best practice. Since 2014, EDF Lab Singapore has been helping the Board make the right choices thanks to the EDF City Platform urban modelling tool, together with 3D visualisation of the impact of planning decisions – especially in terms of CO_2 emissions – on each building and neighbourhood.

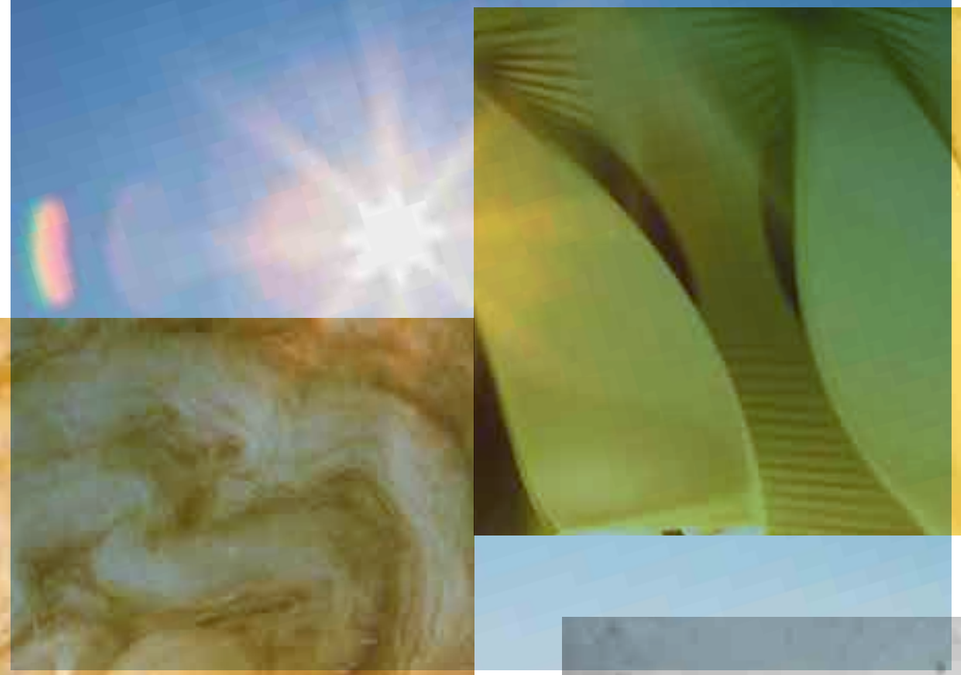
Together, the two partners work on the energy efficiency of buildings, air-conditioning systems and household waste collection, and on how to integrate solar energy into buildings as well as greening roofs and local water recycling. In 2018, EDF Lab Singapore improved its 3D tool by adding the ability to model the impact of the Board's decisions on residents' quality of life, in particular with regard to comfort, noise, air quality, access to transport and social life.

Electric heating gets a boost in France

France's new RE 2020 environmental regulation will replace the RT 2012 regulation on 1 January 2021. In January 2020, the French Government revealed the calculation parameters for limiting CO_2 emissions from heating in new builds: under RE 2020, the carbon footprint of electric heating is lowered from 147 to 79 g/kWh. Also, the primary-to-final energy conversion coefficient for electricity generated in France drops to 2.30 from 2.58, taking into account the country's electricity generation mix for the coming 50 years.

(1) "2018 Revision of World Urbanization Prospects", UN DESA (Department of Economic and Social Affairs).





1. Insulation and the building envelope

As the interface of exchanges of heat, light, air and humidity between the interior and exterior environments, the building's envelope is the focus of many innovations so that it can adapt to the climate, time of day and seasons. Take, for example, smart glazing, which automatically tints to control the amount of heat and light gain, reflective sealant membranes that keep the roof cool naturally and windows that use the sun like a glasshouse to heat the air before transferring it inside the building. Assessing these processes and using the modelling tools needed to design them is one of the areas of research at 4evLab, a laboratory jointly created by EDF R&D, the French scientific research centre (CNRS) and the University of La Rochelle. In the future, harnessing these sorts of complex physical phenomena will lead to including new functions in building envelopes: natural ventilation, heat storage and release, energy production, and more generally the ability to protect against cold and heat.

2. Air conditioning In May 2018, in its "The future of cooling" report, the International Energy Agency (IEA) referred to the exponential growth in global demand for space cooling as one of the most critical yet often overlooked "blind spots" in the energy transition. According to the IEA's estimates, if nothing is done, the world's air conditioners – of which there will be 5.6 billion in 2050, compared with 1.6 billion today – will require an increase in electricity equivalent to the current output of the United States, the European Union and Japan taken together. The solutions recommended by the IEA include government measures to introduce stricter energy-efficiency standards. However, there are other ways of cooling that have less environmental impact, including reversible air-air heat pumps that capture the calories naturally present in the air, and district or city-wide cooling networks. In France, where electricity is largely low carbon, a dwelling with a reversible heat pump emits less than 10 kg CO_2/m^2/year, compared with over 50 kg CO_2/m^2/year for one with a gas boiler. Air conditioners can also be plugged into photovoltaic panels. For non-electrified regions, in particular in Africa, EDF subsidiary Dalkia Froid Solutions has developed Froid Solaire®, a turnkey technological system comprising photovoltaic panels and electric-battery storage that can produce cooling by storing ice to cool milk tanks or cold rooms.
In the future, stationary electricity storage batteries will be the natural pairing for renewable energy to cover air-conditioning requirements as the consumption peak occurs at night in dwellings.

3. Design With climate change, preventing urban heat islands becomes a major issue. This phenomenon is linked to the very nature of cities (lack of greenery, orientation of streets in relation to the sun and wind) and of buildings. The first point is buildings' exposure and use of construction materials that absorb considerable heat during the day and release it back into the atmosphere at night. For this reason, playgrounds in some schools use lawn instead of asphalt. With their frugal technical systems, passive energy buildings can also help consume less while ensuring occupants' comfort. This can be achieved quite simply through insulation, building orientation and shape; solutions can be specific to each region and inspired from the bioclimatic architectural techniques of ancient times.

4. Construction materials With a carbon footprint of 250 kg CO_2-e/m^3 (when used for foundations), concrete has a high environmental impact. Gradually, bio- and geo-sourced materials, such as timber, stone, plant fibre, earth, etc., are making their way back into cities. In Lyon, Angers, Greater Paris and other French cities, offices and housing made of earth are on the drawing board or under construction. Various forms are used: raw earth bricks, rammed earth or earth panels. Dating back millennia, this construction material has a carbon footprint close to zero, together with other advantages: it is biodegradable and recyclable, and its humidity regulation and thermal inertia qualities are outstanding. Earth is very readily available as cities no longer know what to do with their excavated material. A factory to transform the earth from the Grand Paris Express project opened in Sevran, in the Paris region, in 2018. Initially, it will supply materials to build housing in Ivry-sur-Seine. Like all such initiatives today, it will be classed as an experiment until it has passed the regulatory acceptance stage.

Timber, another alternative to concrete, also has undeniable qualities. It is a highly effective thermal and acoustic insulator, and above all is excellent for CO_2 sequestration (1 tonne per m^2) in its standing state, which makes it particularly interesting as a building product. Although not yet at the industrial stage, timber construction is on the increase. In France, in 2018[(1)], it accounted for 6.3% of new dwellings (25,655 apartments and single dwellings) and 16.3% of tertiary sector buildings.

Even so, concrete has not had its final say. Several innovations, in particular in manufacturing processes and components, could reduce its carbon footprint by a third within the next few years.

(1) 2018 survey of the timber construction sector, Observatoire national de la construction bois *(French Timber Construction Observatory), by CODIFAB and France Bois Forêt.*

In the
United States
and Japan, over 90% of households have air conditioning – but only 8% of the 2.8 billion people living in the world's hottest regions have it.

3 questions to Véronique Bédague
Deputy CEO at Nexity

In September 2019, Nexity signed an agreement with EDF. Do you think that collaboration between a property developer and an energy company can lay the foundations for a low-carbon city of the future that is both socially inclusive and environmentally friendly? Which other stakeholders should be included?

Véronique Bédague: Along with EDF, we are totally committed to these issues, and together we have complementary, top-notch expertise. Our partnership is both defining and promising for the two groups. After all, we won the call for tenders to build the athletes village for the Paris Games together. Concretely, the agreement covers all aspects and all phases: construction, operation, recycling and refurbishment. But of course, our belief is that networking with all the city's stakeholders, especially in transport, is the right approach for building the city of tomorrow and contributing to France's goal of being carbon neutral by 2050.

France's future RE 2020 environmental regulation pose a major challenge for new builds to improve the balance between energy performance and a low-carbon footprint. What progress and innovations are we likely to see within the medium term? And in which areas in particular?

V. B: For more than 10 years now, the number of energy-efficient buildings has steadily increased. Progress has been made in many areas. Nexity has implemented numerous tangible measures to reduce the environmental footprint of its buildings: development of new construction processes, bio- and geo-sourced materials, low-carbon concrete, city greening, circular economy, and so on. Another highly promising area is offsite manufacturing, which significantly reduces the carbon footprint. Digital continuity is being used in buildings from design through to recycling and will have very positive effects. Another decisive issue is reducing soil sealing and limiting urban sprawl for a more balanced density that is made healthier and more pleasant by greening buildings. The potential avenues for changing the urban environment are exciting!

Nexity is France's leading builder of timber constructions. What is the outlook for growth in this area?

V. B: Nexity began to make the shift 10 years ago by moving into the construction of timber tertiary buildings. This material has a much better carbon footprint and is also often more aesthetically pleasing. Today, we're the leader in this sector in France. Also, we earned first place in the 2019 property developer awards from the French association for the development of low-carbon buildings for our 12 developments with a BBCA (low-carbon building) label issued or pending. Going forward, we intend to use more timber in housing construction. We're firmly committed to further reducing our carbon footprint and have undertaken to cut CO_2 emissions per dwelling built by 30% by 2030, and by 21% per square metre of floor area for offices delivered

Increase in energy consumption for air conditioners by 2050, compared with 2018 if nothing changes.(1)
(1) Source: The future of cooling, International Energy Agency (IEA), May 2018.

Sustainable city showcase neighbourhood for Paris 2024 Olympic Games

After the excitement of the Olympics, the legacy will be a new neighbourhood. This is the concept behind the athletes and para-athletes village (E Sector), which will be entirely convertible after the Games that will be held from 26 July to 8 September 2024.

Design and construction have been contracted to a consortium comprised of Nexity, Eiffage, CDC Habitat, EDF and Groupama. To be built in Saint-Ouen-sur-Seine (Greater Paris), the neighbourhood will have a surface area of 56,498 m^2 and has been designed to function as a low-carbon site.

The construction method will combine all-French timber and low-carbon concrete for a carbon footprint 75% below that of the London Games. The buildings' energy consumption will be managed by a smart system and the dwellings will be in part supplied from rooftop, solar power combined with zinc-air battery storage (*see p. 9*) developed by EDF group.

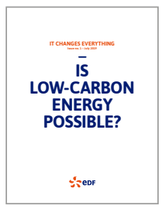
One-quarter of the land area will be planted to take into account climate change and with a view to obtaining the BiodiverCity label. The buildings will also include highly original community spaces, such as shared kitchens and rooftop basketball courts.

After the Olympic Games, the athletes village will be converted into 525 family and student dwellings, together with offices and retail space. By 2025, it may be home to 6,000 people and a workplace for 6,000 more.

In
India
By 2050, air conditioning could account for 45% of peak electricity demand.

IT CHANGES EVERYTHING

A magazine that addresses the major issues of the energy transition.



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Issue no. 3 – July 2020

ÇA CHANGE TOUT

Radio shows exploring and challenging the shift currently taking place in the digital era, with two guests: Mathieu Chassignet, engineer and head of mobility studies at Ademe, and Patrick Pélata, engineer and an expert consultant in the automobile industry.

Interviews with well-known figures and experts that “change everything”.

Find low-carbon solutions on **edf.fr**

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Smart cities: utopia or an unprecedented opportunity to work together to reinvent everything?

For Saskia Sassen, sociology professor at Columbia University, the future of cities will require better incorporation of expertise in order to deliver local solutions. Faced with growing urbanisation and the demographic, energy and environmental challenges of the 21st century, frugality is a key issue. The expertise of EDF and its subsidiaries responds to the problems of energy transition for regions: renewable energy generation, collective self-consumption, electric mobility, smart charging, smart buildings, digital platforms for urban management. We have innovative, comprehensive and tailored solutions.

P. 04

What are the challenges for low-carbon mobility accessible to all?

The notion of mobility is often presented as a personal issue, whereas it above all concerns the common good and living in society. According to Mathieu Chassignet, engineer and head of mobility studies at Ademe, the French environment and energy management agency, and Georges Amar, futurist and researcher at École des Mines Paris Tech, mobility is a strength as long as it is kept under control; more sufficiency-oriented mobility also requires an in-depth reflection on how cities are organised. Developing large-scale electromobility involves technological and cultural challenges as well as the economic challenge. To address the issues, all stakeholders – energy companies, automakers, OEMs, regions, etc. – are working together.

P. 26

Urbanisation: reinvented buildings to reduce their carbon footprint

In 2050, two out of three people will live in urban centres, compared with 55% today. All construction methods and the building sector as a whole – currently highly polluting – must change to build the new cities that will accommodate the new arrivals. According to Rachel Kyte, Dean of The Fletcher School – Tufts University, the oldest graduate school in the United States dedicated to international affairs, the sustainable city will mean the inclusion of everyone. It is crucial to maintain our efforts and even step them up to reach zero emissions in all areas of human activity.

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