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OCTOBER 2019

rETHINKING Energy

Number 44

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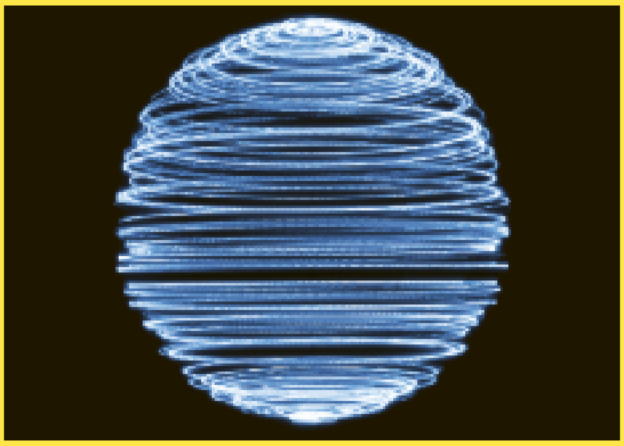

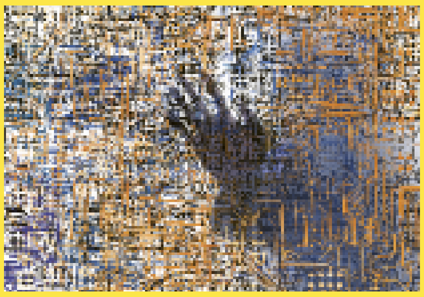

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Editorial/Decarbonization, categorical but not ideological

With Feet on the Ground

“Rethinking energy” happens cyclically, but it is vital to go beyond the emotions and approach the theme rationally, seeking confrontation, grasping the positive aspects and rejecting utopian plans that end up achieving the opposite of expectations

The time frequently comes when the whole world finds itself repeating that we need to “rethink energy.” While the choir goes looking for the right note—it almost never finds it, because everyone says something different on this topic—companies in the sector (re)think energy every day. The refrain can apply to the many who have never thought of it before, but it sounds paradoxical for those who do it naturally as their commitment, their career, their profession. Clean energy means a better life. Nobody wants a worse one. Emotions are always (un)predictable, the growth of “green” movements (with a varying scale and impact on public opinion) all over the world has provoked a revival of political attention (often instrumental), and in the end, the term →

"green deal" has been taken on as a mantra, a formula repeated many times as a meditative practice.
That is why this emotional tsunami needs rationality, it must be explained. It is vital to seek comparison, grasp the positive aspects and of course reject utopian plans, those that are unattainable and end up achieving the opposite of expectations. *World Energy* does this exacting and profound work of (re)viewing positions, extracting the truth and reproducing it in the form of analysis, visual design (excellent examples of which are in this issue), journalism—and not just isms. We think there is a great need for this. Let's move on. Decarbonizing is good and proper, indeed a categorical imperative (Kantian, if you wish to look at it in terms of philosophy). How and with whom is a much more complicated operation than the environmental statement. It is a matter that must be removed from ideology and contemporary isms, and put into the urgent inbox of Homo Faber.

We need to talk about policies

Where does the daily challenge of "rethinking energy" come in? In the pace of modern life, in the matter that permeates every environment: in politics. This issue cannot therefore be discussed without mentioning policies, i.e., the system of principles—and the consequent actions—that make up the environmental policy of public and private institutions. NB: I use the term "environmental policy," which should not be confused with politics in general, a much broader matter. In the Bobbio *Dictionary of Politics*, Matteucci and Pasquino (a seminal work) the "Politics and ecology" entry reads: "It was in the midst of the Industrial Revolution, and in its cradle, in Britain, that the link between ecology and the economy, thus politics, was first theorized. Malthus drew attention to the fact that soil fertility is not homogeneous, and the fact that the human species has a reproductive potential greater than the chance of survival (which depends on the availability of environmental resources). The combination of these two facts pushes humanity to cultivate first the most fertile soils and then, little by little, less and less fertile soils. This results in a steady decrease in the average productivity of the cultivated soil." We are faced with the fundamental topic of nature and human presence on Earth. And of course biology and evolution. So much so that Darwin considered Malthus's studies as a solid pillar for his theory of evolution because "the engine of evolution lies precisely in the imbalance between the birth rate and the availability of resources." What is all this? Malthus theorized the exuberance of man's reproductive potential and—via Darwin—of all living species. Some might say that these are out-of-date theories, that academic debate is different, and yes, of course, we are aware of developments in economic science, biology and physics. But that's what Malthus is talking about out there. Don't you believe us? Let's move on. We have a lot of hooks to hang the picture on. Before writing the editorial in this issue of *World Energy*, I read an article by Janan Ganesh in the *Financial Times*, touching on a delicate point of contemporary life: the (re-)emerging alliance between the populists and the Greens. The unexpected (but logical) link between realists (right) and utopians (left), the phenomenon of opposites marrying in the name of the environment, the natural creation of a political agreement with a single objective. We are completely upside down, but this shows the importance of the issue, the risks that industry runs in underestimating it and the excesses the legislature may incur in overestimating it. To underestimate it means not to grasp the positive effort of seeking harmony with "Creation" (notes from the Vatican and Pope Francis are very interesting and dense with culture); to overestimate it means to follow as automatons the watchwords of movements, but protecting the Earth means standing with your feet on the ground, keeping in mind the necessary and inexorable presence and action of humans on the planet, its mere existence. It cannot be erased, nor can it be imagined to engineer demography, deaths and births, migrations, exoduses, war and peace, abundance and famine. In this context, populism and environmentalism have become two opposing movements, coming to the fore due to the convergence of interests. History helps us understand: the *FT* article recalls that in America it was President Richard Nixon who passed laws to protect the oceans and endangered species. Nixon, a Republican, a right-winger, implemented these reforms despite the clear liberalism of their connotations. Not only is it possible, but it has already gone down in history. Which, as you know, everyone loves to repeat ad nauseam. Ganesh deftly outlines the divergent and seemingly irreconcilable traits of the two strands of contemporary politics: populism attracts the older classes, while environmentalism is for the young and the very young. Both are united and attracted to a common theme: a harsh criticism (more than justified on many aspects, but spoiled by moral prejudice on others) to the mechanisms of capitalism on positions "recognizable as Malthusian." Here we are again, with Malthus. And here

is the theme of demographics, the availability of resources, inefficiency and reproductive exuberance and therefore the exponential increase in consumption in a society whose model is the capitalism of will, which satisfies not the biological needs but the projections of a soul that is never satiated. A 24h takeaway for the unsatiated and connected soul.

Building a new imagination

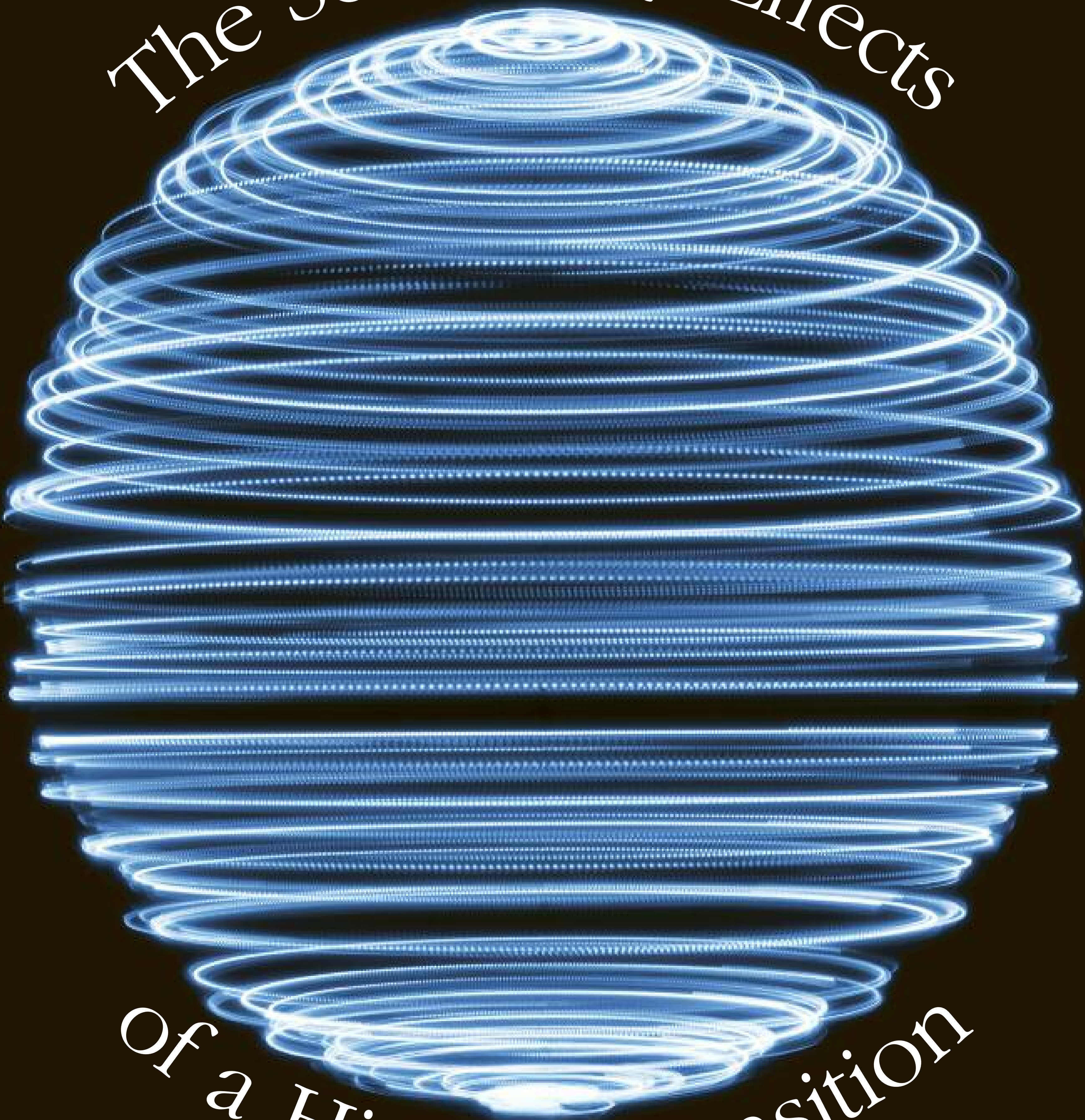
Another point for consideration: for populists, migration is a problem for the prosperity of nations, while for the environmental movements it is population growth (and a lack of resources) that threatens the future of the planet. The yellow vests in France thus marched along with the green movements. Another interesting note on the *FT*: populists and environmentalists have a much wider extension than the parties trying to represent them, they have "an extra-parliamentary wing" that pushes them forward, they are expanding, not shrinking. And they polarize the at-

Giacomo Balla,
"Science against obscurantism",
oil on canvas, 1920
Galleria Nazionale
d'Arte Moderna, Rome.

tention of the public, as demonstrated by the long-distance confrontation between Donald Trump and Greta Thunberg in New York at the Headquarters of the United Nations. If this is the framework on an ideal level, it is clear that we are faced with something powerful, the construction of a new imagination that relies on a few watchwords and the proposal of simple (and simplistic) solutions to complex issues. I would like to draw just one example from Francesco Gattei's article in *WE*: "Until the 1970s, the world used only about 20 metals. With the boom in electronics, and then renewables, we began to use almost the entire Periodic Table of Elements and its eighty metals. These are metals that have magnetic properties, as catalysts, accumulators and conductors." How many of the protesters for radical change in environmental policy have given up using their smartphones? None of them, of course, because technology is an extension of our lives and what Kevin Kelly in "What Technology Wants" calls "individual personal reinvention" and that we must sometimes "choose the inevitable." Not only that, Kelly also shows in his book how technology is (im)mutable and in turn loves to reiterate itself in other forms and distribution models. To demonstrate this, the Montgomery Ward catalog of 1894-1895 offers tools for agriculture to be purchased by postal order that have the same characteristics and purposes of use as those offered on e-commerce web pages in 2005. Today's wave of ecology also has its own aspect of immutability, one profoundly depicted by Christopher Lasch in *The Revolt of the Elites*: "Social classes speak to themselves in their own jargon, inaccessible to outsiders; they mingle with each other only on a few ceremonial occasions and at official festivities." Twenty-five years after the publication of this seminal work, the situation has worsened and become even more paradoxical because the explosion and multiplication of connections corresponds to a dizzying increase in loneliness. But it is in this being together and alone (*Alone Together* is the title of an excellent book by Sherry Turkle on this key theme of our present times) that the most incandescent ideas develop. It is in the post-20th century bewilderment, with the dematerialization of work, that restless consciences develop an imaginary imminent environmental catastrophe, now resulting in mass public demonstrations. And it is no coincidence that the demonstrators are very young people with a thousand fragmented digital lives, the outcome of the clangor of the "Fractured Times" described in a book by the Marxist historian Eric Hobsbawm. The irrational wave—but finally a wave with its own logic, lying precisely in the matters we have tried to unpack here—stands before us. And it takes forms that move from the demonstrations to legal decisions, to court cases built on *isms*, to the economic policy of a nation or an entire geopolitical space (think of the importance of European rules on energy and the environment). These elements—which have suddenly entered the mainstream—are de facto accepted as positive *per se*, without an informed discussion. They are rarely subjected to an impact assessment, but still end up becoming jurisprudence and legislation. We are no longer dealing with imagination. This is real life.

Scenario/What will the energy revolution bring?

The Secondary Effects of a Hi-tech Transition



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The intensive use of technology is fundamental for the decarbonization of the energy system. However, blockchain, artificial intelligence, robotics and big data also have consequences that will entail risks and political headwinds for governments

He returned in 2018 to leading the firm's Global Energy and Natural Resources (GENR) group after serving as Eurasia Group's chief executive officer for five years and steering it through a period of strong growth and global expansion.

The energy revolution is disrupting both markets and countries. The drive toward decarbonization of the energy sector in line with the Paris Agreement or even more aggressive pathways will not happen without technological transformation on a global scale. Yet "global" assumes governments will be willing partners to fund and enable deep decarbonization, both through direct support and incentives, as well as increasing penalties for business-as-usual fossil fuel production and consumption. Government action in these areas is inadequate and uneven at best. Traditional concerns about energy security and economic growth, as well as affordability and access to reliable energy, have more recently been further exacerbated by the global trend toward populism. Populist leaders find it easy to position climate as a global problem whose costs and responsibilities should be borne by others.

The next layer in the challenge is to look deeper at how growing reliance on tools such as blockchain, artificial intelligence, robotics and Big Data affect the global challenges to climate action. It is argued here that these technologies represent potential breakthroughs on decarbonization but also bear secondary effects that will drive political risk and headwinds for governments to move on climate action.

Examples of the incredible transformative potential of these technologies include the prospective development of autonomous vehicle fleets and advanced grid management systems to accommodate the integration of distributed renewable energy generation at massive scale. We also see significant promise in the use of digital ledgers to enable cross-border carbon markets such as those envisioned in Article 6 of the Paris Agreement. On the other hand, the shift to autonomous vehicles and cloud-based grid management is clouded by cybersecurity questions as new modes of critical infrastructure are being created. Greater use of AI-enabled autonomous vehicles will also disrupt traditional labor markets in driving and vehicle maintenance. Employment impact is also the downside of the growing use of artificial intelligence and robotics in oil and gas production—usage that is driving lower costs and higher profitability also translates to fewer workers per rig.

Jobs, automation, and the energy sector

Technology is central to any deep decarbonization pathway. This statement is true both for new zero-emissions technologies and for traditional oil and gas producers adjusting their business model to a world of more uncertain demand and rising competitive pressures. Yet one of the downsides of these technologies is their effect on traditional employment patterns in the energy and transportation sectors. This in turn could have the unintended consequence of weakening the traditional political support and influence the industries have been able to mobilize through their erstwhile vital role in creating high wage blue collar jobs.

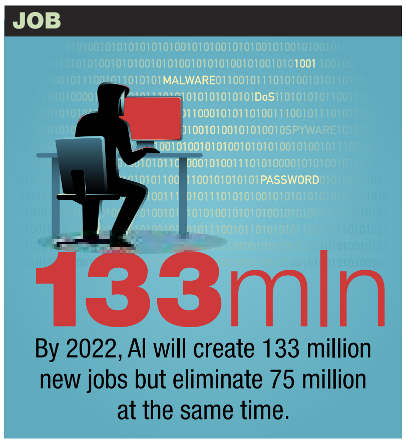
Electric and clean energy vehicles (CEVs) provide an interesting case study. With the transportation sector accounting for 24 percent of global GHG emissions in 2017, the need for breakthrough technology is critical. The IEA Sustainable Development Scenario illustrates the vital role that CEVs will play in achieving decarbonization in line with the "EV30@30" scenario, in which electric vehicles grow to 250 million units by 2030. This scenario would displace 4.3 million barrels per day (bpd) of oil demand versus the business-as-usual case.

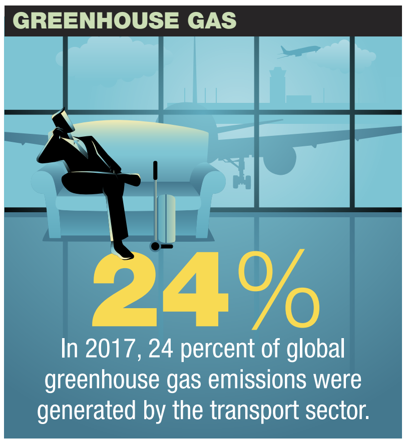
While experts debate the technological and political barriers to achiev- →

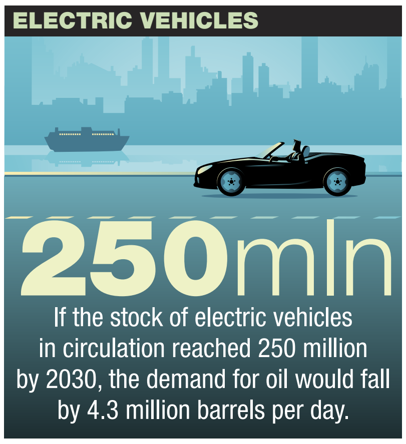
ing this scenario, a couple of facts seem clear. First, China will be the dominant manufacturer of EVs. Both in terms of annual sales and control of supply chains for batteries, China has strong energy security, industrial policy, and environmental policy incentives to lead this emerging sector. Chinese firms constitute seven of the ten largest global battery manufacturers and China has the most secure position in critical mineral supply chain as well. Second, overall employment in the EV sector is likely to be lower than with internal combustion engines. This is already shaking up labor markets in the US auto sector.

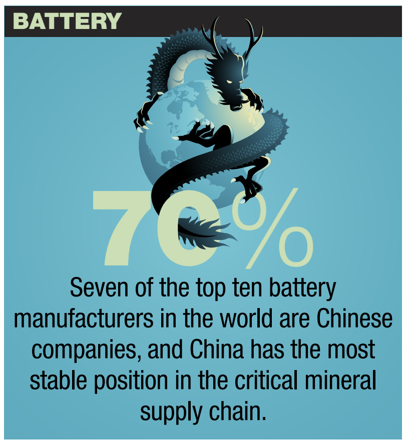
Together, these trends create a new political dynamic for the auto sector. What will their political influence and ability to affect and shape public policy be in a world where they are employing fewer workers per manufactured vehicle? And what will the implications of China's dominant position in electric vehicles and batteries be for their energy security and geopolitical strategy? As US and European automakers pursue JVs in China, we have already seen a backlash from the Trump administration with its intense focus on the fairness of China trade and its strong appetite for "reshoring" of US manufacturing.

The dynamics around technology and automation in the upstream sector have some similarities to what is taking place in the automobile industry, but also some key differences. Decarbonization is a key factor of course—in terms of managing the life cycle emissions of production but also in terms of longer-term demand for oil and gas along various decarbonization pathways. Recent technological innovation in the upstream has primarily been driven by an imbalanced market and weak industry returns, particularly in the 2015-2017 time frame. Both in US shale and in deepwater, weak market conditions created a focus on cost reduction through replacing manual labor processes with digital and automation-based strategies, including artificial intelligence and robotics. In the more rapid decarbonization scenarios there would be continued pressure on the oil sector to reduce cost and avoid risk wherever possible, with technology being a key survival mechanism. As in the auto sector, employment effects would be significant. Like the auto sector, the shift toward fewer and more high-skilled jobs will impact the political standing of the oil and gas sector. In particular, the trade-offs between GHG-intensive oil and gas production and the economic benefits of large numbers of jobs will be reassessed.









Cybersecurity: new challenge for autonomous vehicles and smart grids

One of the most promising decarbonization pathways is the application of big data and artificial intelligence to breakthrough energy technologies like autonomous vehicles and smart grids. In the case of autonomous vehicles, there are significant gains to economic productivity and (potentially) safety, but the potential benefits in terms of decarbonization of the transport sector are more uncertain. The potential benefits would be linked to a sharp reduction in vehicle ownership and a greater reliance on various forms of ride sharing and fleets. But it is also possible that total vehicle miles traveled and fuel consumption could remain the same or even increase. Another significant uncertainty for self-driving vehicles is security, a critical barrier for consumer trust and safety. Media reports document a range of vulnerabilities from hackers targeting wireless key locks to ignition and braking systems. In one high profile case, "white hat" hackers working for Chrysler manage to hack into a Jeep operating on a test track and shut off its ignition, leading the company to recall 1.4 million vehicles. These problems have mostly manifested with "connected" vehicles but will become even more serious as "fully autonomous" vehicles capture a larger share of the fleet.

Security issues are also material for the smart grid sector. Smart grids help enable the deployment and integration of distributed generation technologies such as small-scale solar or fuel cells. Such networks are characterized by two-way flow of electric power, a vastly larger number of nodes in the system than traditional grids built around large central power stations, and greater complexity in managing grid stability. The GHG reduction benefits are considerable, both through enabling greater utilization of renewable resources and greater efficiency through fewer line losses and better customer data on usage. But as with autonomous vehicles, the "connected" nature of the smart grid will create opportunities for hackers and vulnerabilities in the reliability and security of electric power critical infrastructure.

As autonomous fleets of clean energy vehicles grow and smart grid deployment expands, the pathway to "deeper decarbonization" becomes more viable. At the same time, the very definition of energy security will change from securing fossil fuel reserves in unstable countries and transit routes to protecting complex digital system managing staggeringly complex data-driven transportation

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and electricity systems. The August 9th blackout in the UK was in part attributed to an underestimation of how much reserve electricity is needed to back up growing amounts of local distributed solar and other small-scale generation. The changing nature of the electricity system will require new forms of resilience.

Blockchain and the "digital ledger" for International Transferrable Mitigation Outcomes

Technology also holds the potential to enable a critical element of developing global carbon markets. Past efforts around the Clean Development Mechanism, in which developed countries receive carbon credits for funding "offset" projects in developing markets, have been plagued by inefficiency and corruption. These issues are again surfacing in the context of proposals

to finalize Article 6 of the Paris Agreement and efforts to establish International Transferrable Mitigation Outcomes (ITMO) built around fuel-switching of LNG for coal.

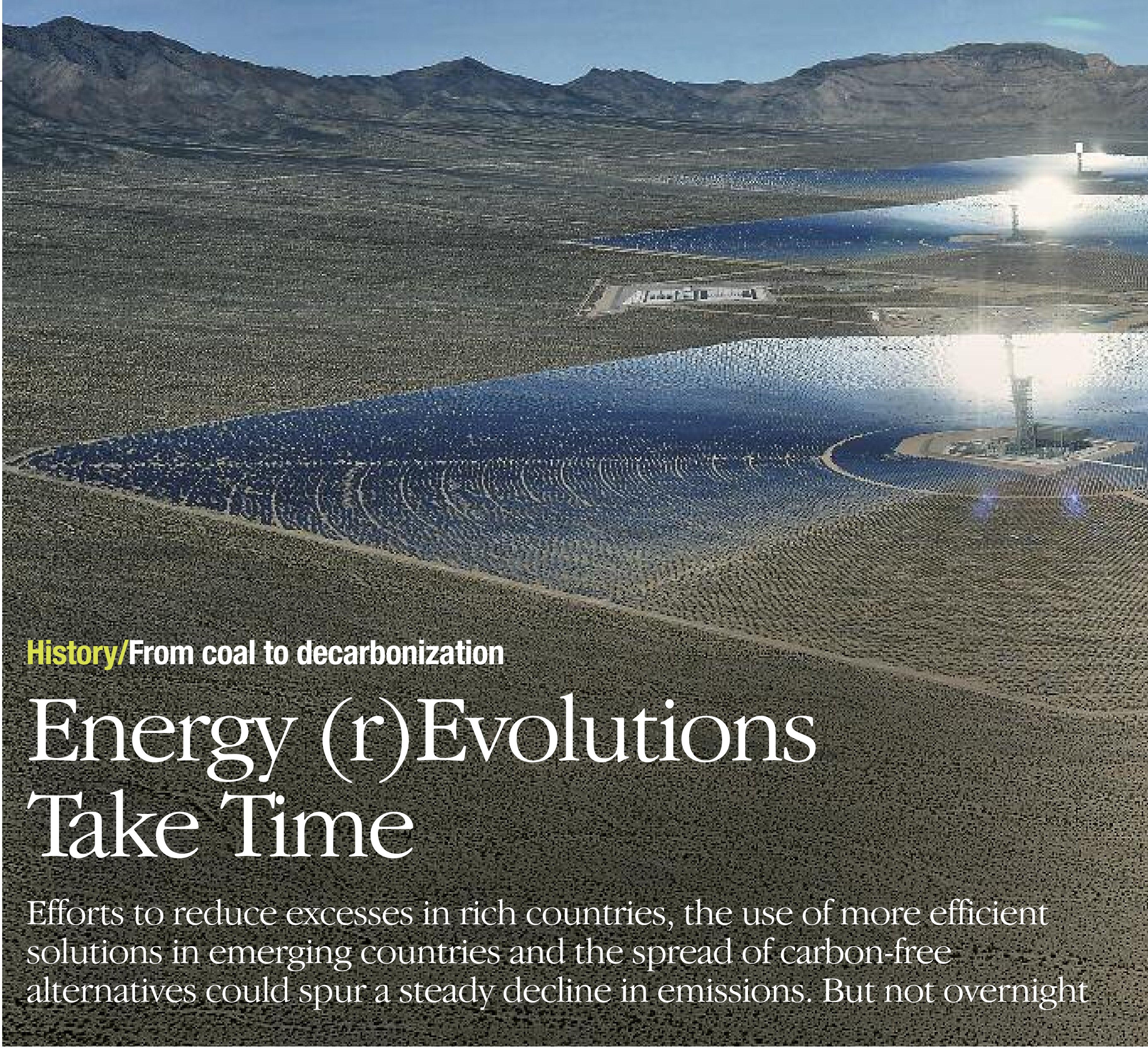
The logic of ITMOs is that it would support the development of LNG in countries with strong environmental and GHG regulatory frameworks, particularly for projects with the lowest GHG life cycle emissions. The ITMO would allow LNG developers to acquire or share a carbon credit that is generated when a consumer substitutes LNG for coal or even potentially for higher-GHG LNG. Environmentalists argue that for ITMOs to work, there must be an efficient and credible system to verify the lower GHG properties of the fuel and that an actual emissions reduction is taking place when the fuel is used to substitute for a higher GHG fuel.

The government of British Columbia is working with the LNG sector "to bring together the previously separate domains of Clean Growth and Digital Trust." BC LNG is subject to a carbon tax and developers are committed to using zero-emissions hydroelectricity to power their plants, resulting in a low GHG life cycle impact. In doing so, the province would be a leader in the creation of "Digital ITMOs." Using emerging standards, protocols and technologies from organizations such as the World Wide Web Consortium and the Linux Foundation's Hyperledger Project, the Digital ITMO process would aim to enable parties to issue digitally verifiable certifications regarding the GHG characteristics sources and sinks within their jurisdiction.

In the case of LNG, the BC gas would be assigned a digital identity verifying its origin, its GHG characteristics, and potentially other financial, legal and technical information. By creating government-regulated digital certification, a buyer could be certain that the LNG purchased has the lower GHG and origin characteristics that they require. For the seller, the Digital ITMO would facilitate the verification of the GHG reduction that takes place when the buyer uses the LNG to displace coal or higher-GHG gas from another source. Such verification confirms that an emissions reduction is taking place and the economic value from that reduction can be divided between buyer and seller in a number of ways. Without the innovative and low cost technology enabler of the "digital ledger," the political and market barriers to implementing ITMOs are unlikely to succeed.

DO SELF-DRIVING CARS OFFER TRUE DECARBONIZATION?

The benefits of autonomous vehicles in terms of decarbonization of the transport sector are uncertain.
The potential benefits would be linked to a sharp reduction in vehicle ownership and a greater reliance on various forms of ride sharing and fleets.



History/From coal to decarbonization

Energy (r)Evolutions Take Time

Efforts to reduce excesses in rich countries, the use of more efficient solutions in emerging countries and the spread of carbon-free alternatives could spur a steady decline in emissions. But not overnight

VÁCLAV SMIL

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At the beginning of the 19th century the UK was the only country with significant coal extraction: coal provided 95 percent of Britain's primary energy, and British coal accounted for more than 90 percent of the fuel's global production. Elsewhere the world was, as it had been for millennia, fueled by wood and charcoal, straw and dried dung. Economies of these traditional low-energy societies were stagnant or growing at a fraction of one percent a year. In 1800, wood supplied more than 90 percent of France's energy. Charles Dupin's 1818 inventory of energy (wood, charcoal and a small amount of coal) in Paris added up to only about 20 gigajoules (GJ) per capita, no more than was available in Rome at the time of Marcus Aurelius and no more than today's per capita averages in Tanzania or Togo.

The first energy revolution

Transition from wood to coal was the modern world's first energy revolution. During the 1830s, high-pressure steam engines began to power the first railroads and oceangoing ships while increasingly efficient stationary steam engines began to provide energy for industrial uses. By the mid-1870s, coal supplied more than half of all primary energy in France. The US had its tipping point between biomass and fossil fuels in 1884, Japan in 1901, and at that time, coal and crude oil also began to provide more than half of the world's final energy consumption. The second modern energy revolution began in 1882 with Edison's pioneering electricity generating plants. During the following 50 years, electricity lit the cities, electric motors transformed industries, transportation, construction (high-rises made possible by electric elevators) and kitchens (refrigerators, electric stoves, small appliances). Concurrently, fossil-fuel-based mechanization of agriculture (steel implements, tractors, combines, fertilizers) released the labor force required by rapid indus-

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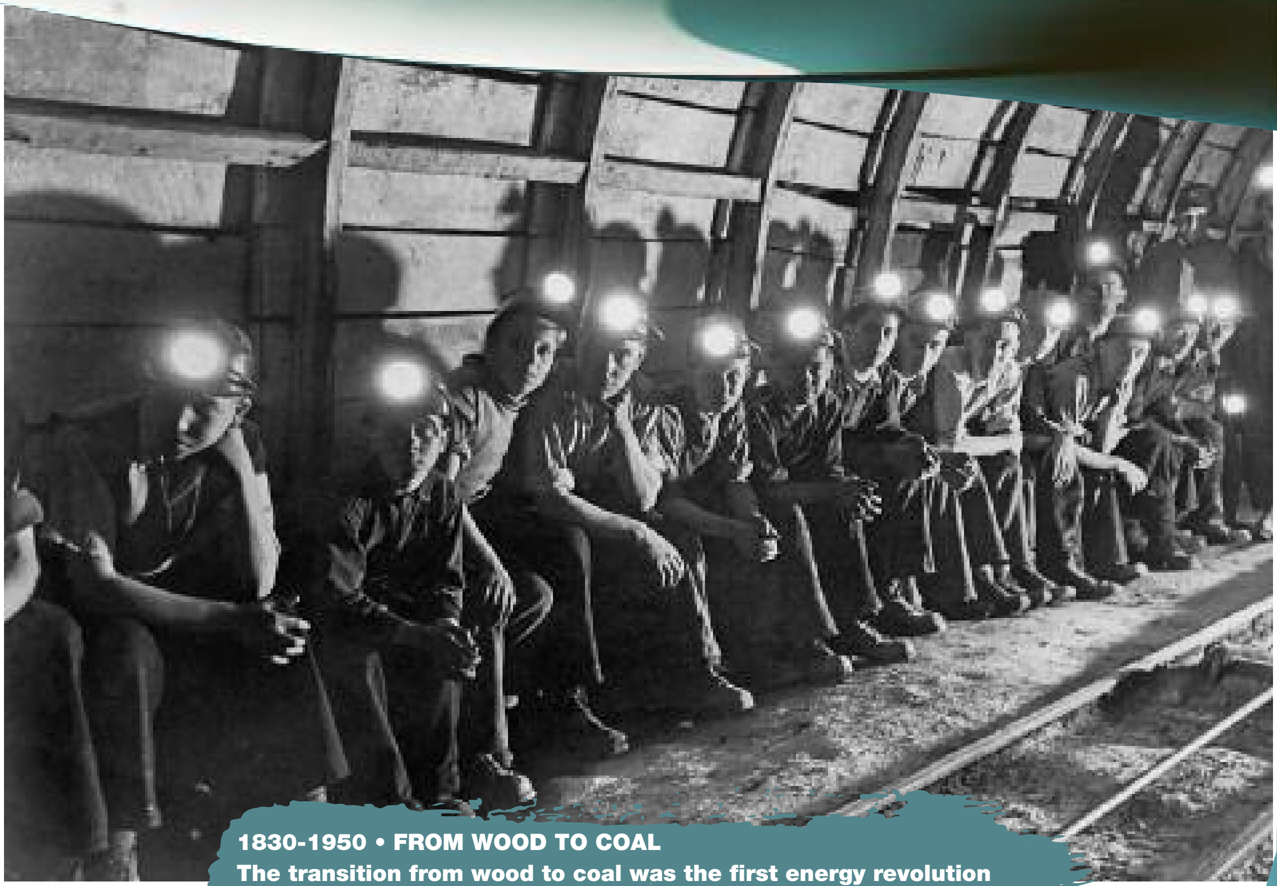
A RECORD SOLAR SYSTEM
Aerial view of the Ivanpah solar heating system in California's Mojave Desert. Owned by NRG Energy, Google and BrightSource Energy, it is the largest solar tower system in the world. 347 thousand mirrors are controlled by sophisticated computers that calculate the sun's presence on the reflective surfaces and concentrate that energy in boilers at the top of three towers. There water is heated to produce the steam that provides energy for turbines that supply energy for over 140,000 California homes.

trialization, and urbanization began to create a new world of rising life expectancies, higher incomes, better housing, and increased education and affluence.
Shortly after 1900, annual per capita energy supply surpassed 150 GJ in the UK, and it reached approximately 100 GJ in the US and 90 GJ in Germany. Many economies, including those of Germany and Japan, grew by 2 percent a year; the US economy grew by 4 percent. The third modern energy revolution was the rise of refined oil products. With the notable exception of the US, where large-scale oil production was driven by pre-WW II discoveries in California and Texas and by early and rapid automobilization, this revolution had to wait until after 1950. Then the exploitation of giant oilfields in the Middle East and the need for higher-quality fuel for post-war reconstruction in Europe and Japan combined with the availability of large oil tankers, rising ownership of automobiles and extensive construction of new pipelines and refineries to make crude oil the world's most important fossil fuel.

The rise of natural gas

By 1965 its global consumption had surpassed coal and by 1973 crude oil, with 42 percent, provided the highest share of the world's primary energy. OPEC's two rounds of oil price rises cut that share, and eventually the fourth modern energy revolution got underway with the rising reliance on natural gas. Its widespread use became possible with the construction of transcontinental pipelines that spanned North America and connected Siberia with Europe and China, with the exploitation of abundant offshore resources in the Gulf of Mexico, North Sea and Persian Gulf and with the reliance on large liquefied natural gas tankers whose deployment turned gas into a fungible commodity delivered from Qatar to Tokyo and from Texas to Latvia. The post-WWII decades also saw major expansion of the generation of hydro and nuclear electricity but fossil fuels have remained dominant. In 1950—leaving aside traditional biomass fuels and with 1kWh of non-thermal primary electricity equal to 3.6 MJ—fossil fuels supplied about 98 percent of the world's primary energy, and by the year 2000 that dependence declined only slightly to about 90 percent. This retreat was slowed by China's economic modernization, as the country became the world's largest producer of coal and the world's largest importer of hydrocarbons. Annual per capita averages of primary energy supply rose close to 300 GJ in North America, above 150 GJ in the richest EU countries as well as in Japan, and the Chinese mean is now approaching 90 GJ. This increase of usage was accompanied by a 16-fold increase in the production of global energy during the 20th century.
Because the century saw major gains in energy conversion efficiencies, average global per capita availability of useful energy had gone up more than 40 times between 1900 and 2000, and this surge created the modern world of affluence, longevity and connectivity, but it has also caused significant environmental degradation. Eventually, most societies managed those challenges reasonably well thanks to technical fixes ranging from water treatment, double-hulled tankers and monitored pipelines to electrostatic precipitators for capturing fly ash, desulfurization of flue gases which during the 1980s were seen as the greatest environmental threat in Europe and North America and car exhaust controls by three-way catalytic converters. In many ways the fossil fueled world has become not only richer but also cleaner.
But, due to a rapid oxidation of carbon, burning of fossil fuels generates CO_2 and global emissions of this gas have soared from just 29 million →



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1830-1950 • FROM WOOD TO COAL
The transition from wood to coal was the first energy revolution in the modern world. The birth of the first power plants, in the early 1900s, transformed industries, transport and construction. Photo: British miners wait for a train to take them to the Markham coal mine in Derbyshire, c. 1950.

© JAN KOPRIVA/UNSPLASH

tons in 1800 to nearly 2 billion tons by 1900, to almost 26 billion tons in 2000 and another record in 2018 with about 37 billion tons. Although a large share of these emissions has been absorbed by the ocean and by the biosphere, atmospheric concentrations of CO_2 rose from about 280 parts per million (ppm) in 1800 to 410 ppm by the beginning of 2019. This is a historically unprecedented rise because during the past millennium the concentrations remained remarkably stable, just between 275-280 ppm.
In 1896, Svanté Arrhenius calculated that doubling of atmospheric CO_2 might increase average temperatures by 5-6 °C the result being, remarkably, of the same order of magnitude as indicated by today's complex climate models containing more than 200,000 lines of code. And in 1957, Suess and Revelle wrote about humanity "carrying out a large-scale geophysical experiment that could not have happened in the past nor be reproduced in the future." While scientists have been aware of the phenomenon of global anthropogenic warming for more than a century, the problem only began to attract wider attention during the late 1980s and now it has become a leading public and political concern.

Waiting for the fifth energy revolution

The solution appears to be simple enough: replace fossil fuels by non-carbon energy sources. After all, the planet receives enough solar radiation that capturing a mere 0.1 percent of it could satisfy a global demand ten times higher than that for today's energy use. But like its predecessors, global decarbonization, the fifth energy revolution that will do away with fossil fuels and replace them by an uncertain combination of renewably generated electricity, hydrogen and nuclear power, will take a long time to accomplish.
Even if we had all the requisite non-carbon alternatives available for immediate commercial deployment, the scale of the challenge would dictate a long period of transition. The world now extracts about 15 billion tons of fossil fuels containing about 10 billion tons of carbon. Energy released by their combustion accounts for nearly 90 percent of all modern energy supply, a supply that generates about two-thirds of the world's electricity, heats homes for about one billion people, powers more than 95 percent of land-borne, water-borne and air transportation and provides indispensable heat and raw materials

1970-2019 • THE RISE OF GAS
OPEC's oil price rises in the 1970s kick-started the fourth modern energy revolution in natural gas. Photo: a worker prays toward Mecca. In the background, a butane gas tank in Scotland.

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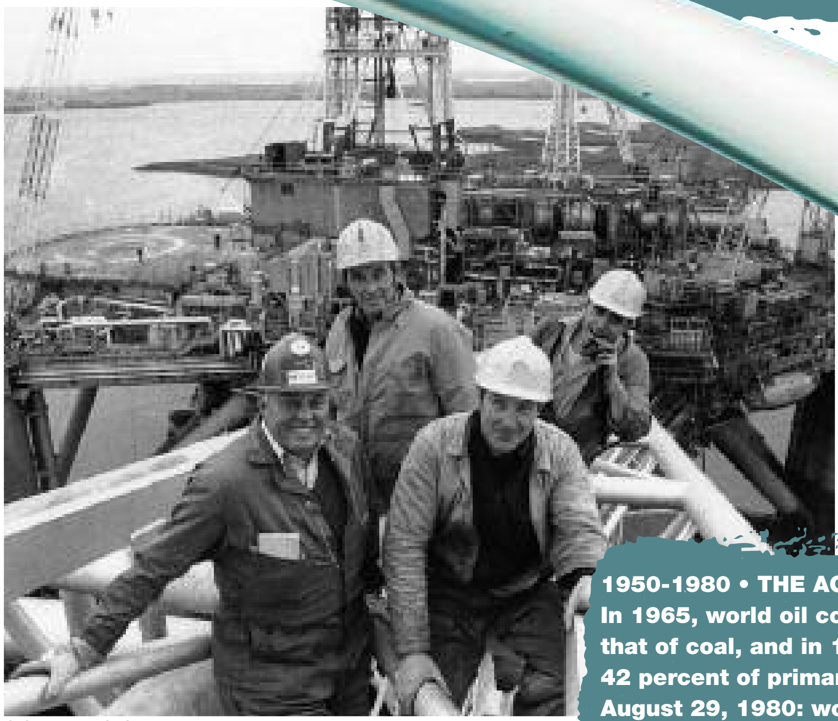

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1950-1980 • THE AGE OF OIL
In 1965, world oil consumption exceeded that of coal, and in 1973 crude oil provided 42 percent of primary global energy. Photo: August 29, 1980: workers at the "Drill Master" oil rig in Stornoway, Outer Hebrides, Scotland.

for the production of the four material pillars of modern civilization, iron, cement, plastics and ammonia. Structures and infrastructures of this immense global fossil fuel system range from more than 1.25 billion road vehicles, hundreds of millions of furnaces, nearly four million km of pipelines and hundreds of thousands of turbines to tens of thousands of large airplanes and steam turbines and thousands of large oilfields, tankers and electricity generating stations. Replacement cost of this global mega system would be, most likely, in excess of USD 30 trillion.

But we do not have any immediately deployable alternatives for long-distance, mass-scale flying dependent on kerosene to power gas turbines, for long-distance trucking and containerized and bulk ocean shipping dependent on large diesel engines or for the production of basic materials. Steel production from primary iron now requires about a billion tons of coke made from coal annually; cement is produced in large kilns heated by low-quality fossil fuels; hydrocarbons serve as feedstocks and fuel for syntheses of plastics and ammonia, and without ammonia applications we could not maintain the crop yields necessary to feed nearly 8 billion people. Alternatives, including smelting iron with hydrogen, using CO_2 in cement or deriving hydrogen for ammonia synthesis from electrolysis of water, are under early development, but the scale of the global demand—1 billion tons of primary iron, more than 4 billion tons of cement, nearly 200 million tons of ammonia and more than 300 million tons of plastics—means that any new non-carbon techniques will take considerable time to displace large shares of today's highly optimized processes.

Moreover, we do not just need to decarbonize the existing supply, we need a large expansion of energy use in most Asian countries and, above all, in Africa. The world of energy affluence, North America, EU, Russia, Japan and Australia, is oversupplied, and despite its long history of improving efficiency, remains inexcusably wasteful. We may have doubled the efficiency of internal combustion engines so that gasoline-fueled machines are now almost as good as diesels but even in Europe the average car mass has more than doubled. A Citroen 2 CV or Fiat Toppolino weighed less than 600 kg; now the bestselling VW Golf weighs about 1,400 kg. We had more than doubled the efficiency of household heating and natural gas furnaces are now more than 95 percent efficient, but the average size of American houses has grown 2.5 times since 1950, and in summer air conditioning keeps the indoor temperature at levels that would trigger heating in winter. Our best jetliners now consume 70 percent less kerosene per passenger-kilometer than did the pioneering designs of the late 1950s, but during the same time total passenger kilometers flown have increased about ten-fold. Simply, in many instances we are using and wasting more because of rising masses, sizes and frequencies of use than we have gained thanks to better designs.

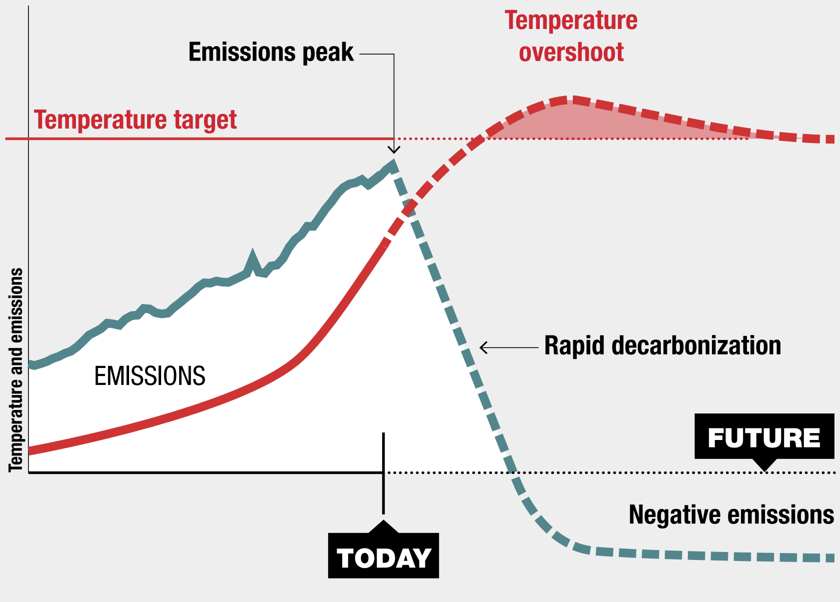
In this affluent world it should be easier to cut the excessive consumption: good quality of life does not hinge on flying for a weekend for €40 from Amsterdam to Cyprus or eating fresh green beans airlifted from Kenya to London in January. But the second world, the countries striving to reach the affluence level shown by China still wants more: Chinese per capita energy supply rose from about 40 GJ in 1980 to nearly 90 GJ in 2018 but the country does not want to stop at this level, one similar to Spain in the late 1980s. And the third world, the countries still stuck in underdeveloped misery, has to multiply its energy use: India's mean is only about a quarter of the Chinese level, and the African ladder descends from Nigeria's inadequate 30 GJ/capita to a dismal 15 GJ in Ethiopia and to barely registering 2 GJ in South Sudan. Yet it will be in sub-Saharan Africa where more than half of the world's population increase will be added during the next 30 years. Obviously, that fast-growing population will tap every available energy source in order to improve their lives and Africa will be opening new oilfields and new coal-fired power plants.

Vanishing promises

What all of this means for the likely pace of global decarbonization? The recent record is indisputable. Between 1992, the year of the first UN climate convention, and 2017 all major indicators associated with the demand for fossil carbon increased substantially. As a result, during those 25 years the global consumption of fossil fuels rose by 54 percent, CO_2 emis- →

Emissions and temperature overshoot

Limiting global warming to 1.5 °C requires emissions to start falling immediately at a rapid rate in order to be reduced to zero (or become negative with sequestration) by 2050. The graph is based on IPCC special report on global warming of 1.5 °C published in October 2018.



Source: IPCC

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LONDON, UNITED KINGDOM
Beddington Zero Energy Development (BedZED) is a small eco-friendly neighborhood in the south London suburb of Wallington, built between 2000 and 2002. This is the first carbon-neutral residential area. Almost every apartment in BedZED has a small garden.

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AMSTERDAM, NETHERLANDS
The Edge Amsterdam, the 40,000-square foot skyscraper home of consulting firm Deloitte, has been named the smartest and most environmentally friendly office in the world. The building is extremely efficient in terms of use of resources, but also in terms of the organization of employee spaces.

sions from fossil fuel combustion rose by 57 percent, and, using the UN's conversions, the share of fossil fuels in the global primary energy consumption remained unchanged at about 90 percent. Further, the share of all forms of non-carbon energy (hydro, nuclear, wind, solar, biofuels) in the global primary supply rose by just three percent over the last 25 years, from 12.3 percent in 1992 to 15.3 percent in 2018 (even when using higher conversions for all primary electricity).

The promise of assorted "solutions" is now wearing thin. Work on controlled fusion began three generations ago, small, inexpensive and inherently safe nuclear reactors have been promoted since the early 1980s, and the miracle of cold fusion (LENR) has been around for nearly as long, yet none of these promises have resulted in actual commercial conversions. Mass production of biofuels is inherently limited by the low power density of photosynthesis and by the necessity of material inputs such as water and fertilizer for high-yielding production. New renewables like solar and wind have been making important dents in some national energy balances but without practical non-pumped hydro electricity storage or without unprecedented high voltage direct current (HVDC) interconnections they are not available on demand to supply rising megacities, nor can they energize long-distance transportation. The hydrogen economy is another constantly retreating mirage. And carbon sequestration will not get us to zero anytime soon, as today's large-scale facilities capture less than 50 million tons of CO_2, slightly more than 0.1 percent of current emissions.

What would then justify the belief that in the next 25 years we could have non-carbon energies supplying 100 percent or, assuming massive carbon capture, at least 80 percent of the growing global energy demand? The Paris agreement actually confirms a further substantial increase of emissions as it "notes with concern that the estimated aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the intended nationally determined contributions do not fall within least-cost 2 °C scenarios but rather lead to a projected level of 55 gigatons in 2030." This comes as no surprise as recent long-range forecasts indicate strong growth of activities dependent on fossil fuels. The International Civil Aviation Organization expects total air traffic to more than triple by 2040. McKinsey forecasts a 2.5-fold growth in container shipments by 2066. The Food and Agriculture Organization foresees global meat consumption doubling by 2050, and the Organization for Economic Co-operation and Development has steel demand growing by a third by 2025.

Determined efforts to reduce excesses in affluent countries, to adopt the most efficient energy solutions in nations rising from energy poverty, and to accelerate the diffusion of non-carbon alternatives could end the further rise of emissions and enable their steady subsequent decline. But it is highly unlikely that we could engineer an immediate plunge in CO_2 emissions and eliminate them by 2050 in order to replicate the trend shown in the IPCC's 1.5 °C report. Global energy (r)evolutions take time and to break that historic pattern would require either a collapse of modern civilization or a supremely coordinated and resolutely executed transformation on the global scale, beginning instantly and proceeding rapidly and at a cost, a major share of the global economic product, that has no precedent in history.

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Governance/How energy changes are transforming national interest

The Diplomacy of Decarbonization

The transformation of the energy paradigm on a global scale reveals the inadequacy of international institutions, triggering a redefinition of the balance of power between producer and consumer countries

GIULIO SAPELLI

Full professor of Economic History at the University of Milan and editor of the *Il Messaggero*, Sapelli is one of the most original and contrarian voices of Italian economists.

Historically the energy sector, both as an industry and as individual companies, follows and often imposes gradual shifts in the weighing of the importance of global confrontations and conflicts over power. Today we are facing a world characterized by new areas of production and consumption, especially in Asia with its rapid demographic and technological expansion. Asia is joining the historically established center that includes the democracies of the West, the OECD and the relatively small group of OPEC producers and Russia. Transnational energy relations are now fragmented to an unprecedented extent, and inevitably governance models are subject to major transformation. Moreover, countries are now taking on an identity without a "national interest" and are increasingly hybridized by those who evade the rules of liberal democracy. For example, the international agreements on decarbonization should replace both the market and the state, a singular contradiction that opens up significant economic and philosophical issues.
Humanity is being called upon to act according to models of behavioral biopolitics that take on complex interstate dimensions, taking shape as ideological landscapes in a way that has never been seen before. The conditioning of consciences goes hand in hand with countries' constant denial of a "national interest," until now the essence of their raison d'être. Mainly as a result of political transformations in the US, this has conversely gradually affirmed, with both difficulty and force, an opposed movement resistant to the financialization of politics and the economy and opposed to its denationalizing effects.

A new world order

The intercountry agreements of multilateral cooperation regarding "national interest" and freedom of enterprise are increasing as demonstrated by representatives of the various international technocracies on energy transition, primarily on decarbonization, but at the same time the rejection of models of multilateral cooperation is becoming increasingly manifest. It is thus difficult to enforce any model and implementation process through guidelines, rules and behaviors. The root lies in the chaotic world that is emerging in international relations. After the collapse of the USSR, a vacuum in the regulation of relations of power has remained unfilled because no general agreement has replaced the power architecture of the Cold War. This happened due to the lack of a treaty that could rebuild the system of world international relations. The treaty was not signed because of the insanity of the unilateral power of the US. The whole world is now paying the price.

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The needed hegemony is becoming less and less possible, despite it being exactly what is essential to stabilize the world, to regulate its relational mechanisms with a new "entente cordiale." This hegemonic will reappeared with unexpected vigor with the election of Donald Trump, a testament to the aforementioned cultural transformation. Thus came about the cultural, political and diplomatic dislocation of North American power that is ongoing, but is already decisive and advocated by the segment of the powerful elite who are now in charge, if insecurely and unstably, in the US. In the meantime, China continues to increase its newfound maritime, demographic and technological power in the world arena, upsetting relations between countries that have never settled since the collapse of the USSR. The same was true of the Balkan and Mesopotamian wars, with the Mediterranean once again the object of contention for the return of Russia to more temperate climes. This is the fractal, the fundamental fault, for our energy issues, too. World history has witnessed many such a process of re-establishment: the Peloponnesian War between Sparta and Athens, the Thirty Years' War, the Napoleonic Wars and World Wars I and II were all the result of the rise of revisionist maritime powers, from Persia then from Athens, to Germany and Japan, and now to China. It is very clear that we are now witnessing the emergence of China, accompanied by the highly dangerous division between the US on one side and France and Germany on the other.

Access to new resources

As we can see, the problem of decarbonization is immersed in a major confrontation of world powers and is a web of themes and problems that, as it unfurls, requires us to look at the world and its power from a point of view other than that artificially constructed by the narrative, by the now dominant ideological landscape. However, to affirm itself as a worldwide method of creating stability, diplomacy requires countries with a "national interest." This is what is missing today and continues to feed into increasing risk. Heteroregulation is replacing self-regulation, just when "corporate social responsibility" has become a buzzword and companies' and pressure groups' self-regulated behaviors are being invoked. In Shakespearian terms, folly rules the world.

It is in this scenario that the international technocratic processes proposed by multilateral agreements regarding the world energy sector are considered. The industry consists of organizational populations of companies and relations between these companies and countries, until, as in the case of the National Oil Companies (NOCs), they become state-owned enterprises and thus clusters of "national interest" embodied in the form of a state-owned enterprise. The processes of energy transition and decarbonization have been driven, primarily but not exclusively, by the global fight against climate change. The transformation of the energy paradigm on a global scale requires a redefinition of the balance of power between producer countries and consumer countries and the emergence of new areas of geopolitical and strategic interest. New natural resources such as lithium, cobalt and rare earths will need to be accessed, causing confrontation between global players and local elites to secure control by redefining the rules of the security of supply. Although the heart of the world's fossil fuels will remain in Arabia and Mesopotamia for centuries (US shale oil and shale gas is nothing but a transient illusion), the sources required to build the vectors of so-called renewable energies will go to parts of the world not considered today and will require forces to contain the power of opponents different from those we now see.

The gradual obsolescence of fossil fuels will never result in their disappearance. In fact, the need for them will increase exponentially in order to construct the infrastructure required for the so-called renewable energies that cannot become our main sources. They are instead vectors, requiring an increasing volume of fossil fuels, no matter what the dominant narrative is saying. However, the political and social pressures of collective movements, led by the lobbyists for state subsidies to fund economically non-self-sustainable renewable vectors and the resulting in-

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dustries and services, will undoubtedly have consequences on political stability besides affecting the economies of the major producing countries (see the fundamental work by Massimo Nicolazzi, a manager in the oil and gas sector).

How much coal still matters

Many fossil fuel-producing countries, heavily dependent on oil revenues, will feel threatened in terms of their system of national and international alliances under the authoritarian polyarchy of which they form the majority. On the other hand, the inexorable development of state-of-the-art technologies will create new interests and geopolitical power conflicts related to the retrieval of raw materials and competition on and for networks with consequences that we can already see in the current confrontation over these issues between the US and China. The situation in sub-Saharan Africa will be decisive. Millions have no access to essential energy services; factors such as technological primacy together with the expansion of trade will therefore become key elements in the energy policy of the medium-size and major powers, provided that the assumptions of the dominant world policies of limited neoliberal rationality fall, with consequent shrinkage in domestic markets. In this context, to reiterate, the current governance mechanisms of the energy sector are essentially based on the duality between a compact group of consumer countries gathered under the aegis of the IEA, and the OPEC-producing countries and some of its extensions, for example ROPEC and, if with a more limited impact, the GECF (Gas Exporting Countries Forum). And these mechanisms are proving inadequate to address the changes necessary to meet the challenges of the energy transition.

We are faced with clear evidence of the inadequacy of current international institutional infrastructure in the energy sector. It is vital to challenge a narrative construction incorrectly based on the assumption that decarbonization is the main route by which the CO_2 emitted into the Earth's atmosphere can be reduced, an analysis that fails to take into account that all energy sources allow for the reproduction of the world's economic and social systems. Coal is an essential element that also guarantees that thermodynamic balance by which energy allows for the social reproduction of the capitalist system and the monopolistic capitalist systems of Asian countries (China, North Korea and Vietnam). These countries coexist with varying degrees of interconnection with the world capitalist system operating in other regions of the world, including the demographic giant that is India. Decreasing the percentage of coal and CO_2 produced worldwide is not only a complex effort but is more of a Herculean task than ever. Incessant and continuous disturbing simplifications must be put aside; for example, the notion that global percentage quotas resulting in non-entropic energy circularity will automatically lead to CO_2 reductions or that the energy generation processes required for the manufacture of renewable infrastructure will not themselves require carbon fuels. The world must be led to overcome the belief that conventional industry, based on both fossil fuels and mining, cannot result in even greater CO_2 savings than those achievable through the advent of non-fossil fuel-based energy sources. Progress will therefore require a profound transformation of the entire methodology of production on a multifactorial worldwide scale.

Beyond capitalism

Entrusting this process to international hetero-regulation is unthinkable. It can only be implemented via enterprise self-regulation to avoid divestment in sources that are increasingly indispensable to changes in world demographics, none other than long-standing and unavoidable fossil fuels. Profound change is required in the production processes that use and produce these fuels for any form of energy, manufacturing or services: nothing else. Having said that, the issue of regulation must still be put to debate. For the first time in world history, in fact, such a huge transformation has been achieved through a series of international agreements. This implies a transformation in practices and even in the very concept of "national interest." In this regard, Anne Marie Slaughter brought attention to this point in her seminal works on the transformation of international relations and the constitutional profiles resulting from these transformations, increasingly removing broad spaces of compulsivity from the democratic process. These processes have already taken place with unexpected force, especially since the collapse of the Soviet Union and the emergence of an increasingly centralized and self-regulated neo-financial capitalism. Moreover, there is no doubt that an imaginary and symbolic landscape— built in years of soft power by the power groups consisting of the industries and movements favorable to so-called renewable sources—today determines a large part of the economic policy decisions in the rapidly changing capitalist system. This landscape frees elites to make priority choices over how the system governs economic and social policy that are different from the choices made in the past. As Ulrick Beck put it, even if politics disappears from the technocratic self-referential process of the oligarchs described clearly by Professor Slaughter, politics reappears when least expected, for example in the international hetero-regulatory decisions of the climate accords, none other than forms of governance brought about by economic policy processes. The distinctive root of these political forms lies in their constantly crossing the border between state and market, preforming both technical procedure and ideology, one or another of the elements of state-market relations, this based on the mighty weight exercised by international relations, which have settled into this symbolic and social interweaving of the new transnational power. How can we define this new landscape? How can we classify it in the context of the great transformations of the relationship between companies, state and society, which has always had too much effect on market positions and the will of the ruling classes? A diffuse system of beliefs and symbolic reflections has been created and now must be both ideologically disseminated and realized in forms of fixed capital stock, an approach rarely used to date. This is how movement of capital and the production of goods by means of goods operates and is typical of the dominant economic system across the world, except in China, Vietnam and North Korea. These countries now have the bureaucratic and military dictatorship regimes of state monopolistic capitalism, along with an increase in the now widespread but politically impotent capitalist middle classes. Since China's accession to the WTO, they are closely related with the globalized financial capitalism that now dominates. This belief system constitutes a new international secularization and is being diffused by the very diverse beliefs that stem from the absence of the sacred in personal relationships. This is a massively significant anthropological and axial transformation but also relates to issues raised by decarbonization.

Analysis/The new world of energy technology

An Opportunity to Make a Difference

While not as sexy as in other fields, the revolution in energy technology is going on all around us. As with all revolutions, it will require a flexibility and readiness to adopt new ideas

EUGENIO CAU

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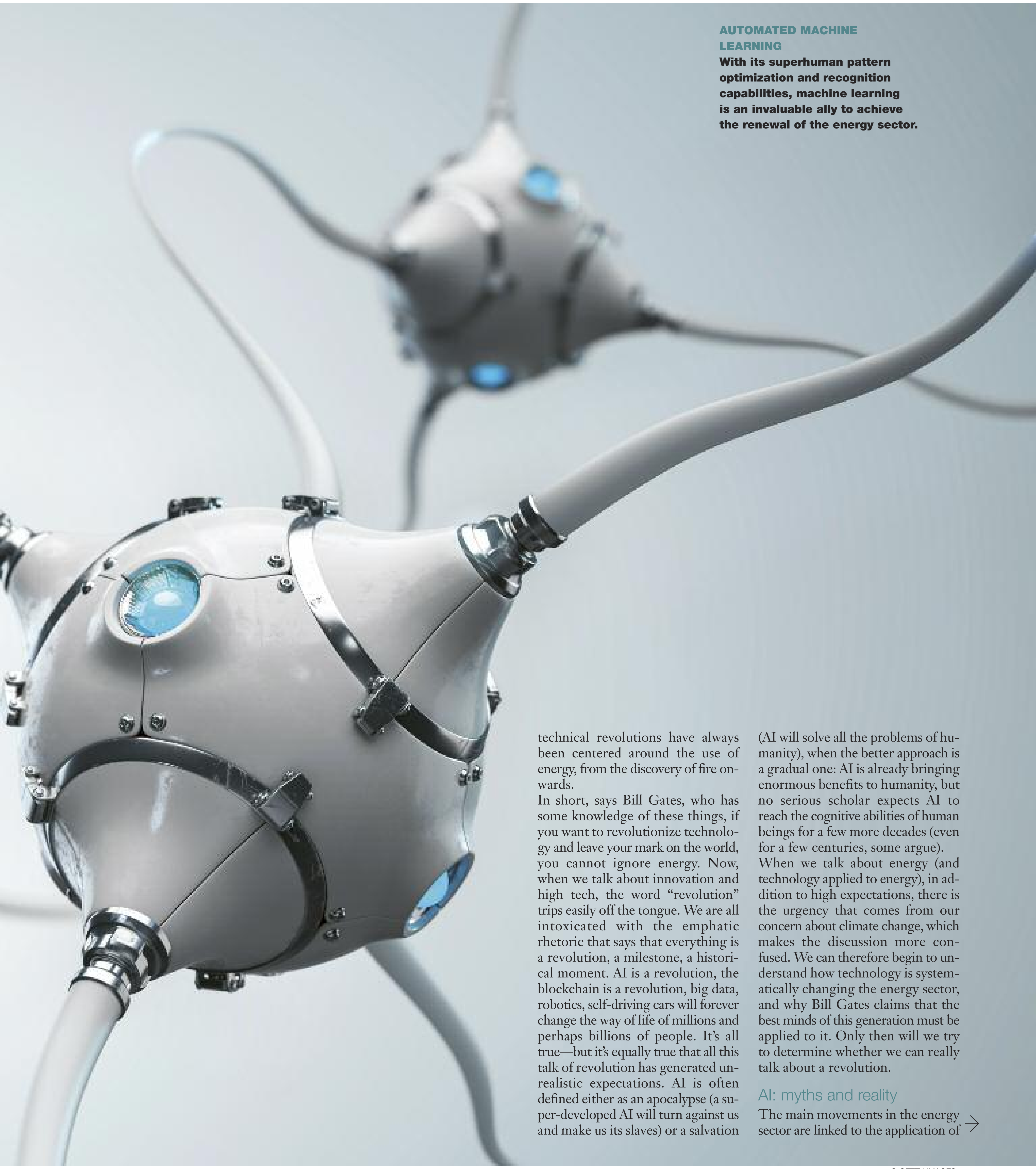
In the spring of 2017, Bill Gates, the co-founder of Microsoft and one of the wealthiest men on the planet, sent an open letter via his personal website to all the young people who were due to graduate at the time—this from a man who never graduated himself. He congratulated them, encouraged them to become a force for change, then said that many young people ask for career advice. Gates responds that if he were twenty years old again and looking for "an opportunity to make a difference in the world," he would consider three areas: "One is artificial intelligence. We have only just begun to discover ways to make people's lives more productive and creative. The second sector is energy, because making it clean, economical and reliable will be essential to combat poverty and climate change. The third is life sciences, which are rich in opportunities to help people live longer and healthier lives."

It is of course fairly obvious that Bill Gates would encourage young graduates to work in the field of artificial intelligence (AI). In a sense, the same goes for life sciences, particularly considering the activities of the charitable foundation set up by Gates and his wife Melinda after giving up his operational role at Microsoft. Of the three sectors mentioned, therefore, the most interesting is undoubtedly energy, too often snubbed by people who call themselves innovators. Come to think of it, energy is not a sector often mentioned by people on the cutting edge of innovation. Better to talk about space travel, which stimulates people's imagination and makes newspaper headlines, as clearly demonstrated by the out of atmosphere adventures of Elon Musk with his SpaceX. Better to talk about robotics, which is a fascinating technology. Energy is considered boring, despite the fact that in the history of humanity,



AUTOMATED MACHINE LEARNING
With its superhuman pattern optimization and recognition capabilities, machine learning is an invaluable ally to achieve the renewal of the energy sector.

technical revolutions have always been centered around the use of energy, from the discovery of fire onwards.
In short, says Bill Gates, who has some knowledge of these things, if you want to revolutionize technology and leave your mark on the world, you cannot ignore energy. Now, when we talk about innovation and high tech, the word "revolution" trips easily off the tongue. We are all intoxicated with the emphatic rhetoric that says that everything is a revolution, a milestone, a historical moment. AI is a revolution, the blockchain is a revolution, big data, robotics, self-driving cars will forever change the way of life of millions and perhaps billions of people. It's all true—but it's equally true that all this talk of revolution has generated unrealistic expectations. AI is often defined either as an apocalypse (a super-developed AI will turn against us and make us its slaves) or a salvation (AI will solve all the problems of humanity), when the better approach is a gradual one: AI is already bringing enormous benefits to humanity, but no serious scholar expects AI to reach the cognitive abilities of human beings for a few more decades (even for a few centuries, some argue).
When we talk about energy (and technology applied to energy), in addition to high expectations, there is the urgency that comes from our concern about climate change, which makes the discussion more confused. We can therefore begin to understand how technology is systematically changing the energy sector, and why Bill Gates claims that the best minds of this generation must be applied to it. Only then will we try to determine whether we can really talk about a revolution.

AI: myths and reality

The main movements in the energy sector are linked to the application of →

THE EFFICIENCY OF THE MACHINE
The entire supply chain of the oil and gas sector could save around USD 50 billion by making better use of data and machine learning technologies. In the photo, a 3D rendering of a drone performing an aerial inspection of a gas pipeline.

the most important emerging technologies. Take for example AI. Machine learning, with its superhuman ability to optimize and recognize patterns, is a precious ally for those who want to achieve renewal in the sector. At the beginning of 2019, DeepMind, a Google company involved in AI, announced that it had increased the value of Google's wind farms in the center of the United States by "about 20 percent" thanks to its own algorithms. The machine learning model had in fact been trained to predict, 36 hours in advance, how the wind would blow, and to plan the supply of electricity to the power grid a full day ahead. Machine learning algorithms capable of learning by themselves are also essential for creating "smart grids" for decentralized and digital electricity.

AI has also been used in the mining sector in combination with big data (side note: machine learning feeds on big data, and does not exist without it). Industry is naturally rich in data, and in recent years this wealth has been put to good use in many ways. Creating predictive models that can learn by themselves through machine learning can reduce infrastructure and operational costs, increase production efficiency and improve safety. During drilling, for example, AI can facilitate operations by performing a continuous and immediate diagnosis of many factors, including seismic vibrations, thermal gradients and the permeability of soil layers. Moreover, machine learning can facilitate data-driven decisions when it comes to evaluating investments in exploration and production. Analysis of geological data by AI can allow a faster and above all more efficient identification of new oil fields. Just as in the field of medicine, machine learning proves more efficient than experienced professionals at interpreting certain data, such as reading x-rays. AI is often more efficient than geologists with decades of field experience.

This does not mean that AI will replace geologists, just as it will not replace radiologists. It does however mean that algorithms will support the work of professionals (often they are already doing it), making their work more effective and safer. McKinsey has estimated that the entire supply chain of the oil and gas sector could save approximately USD 50 billion by making better use of data and machine learning technologies, and investments are moving accordingly. According to a MarketsandMarkets survey, the industry's investments in AI, which were $1.57 billion in 2017, will reach $2.85 billion by 2022.

Potentials and pitfalls of the blockchain

Blockchain is another technology everyone is talking about now. There was a time, two or three years ago, when the movement around the blockchain believed it had found the key to changing Western societies. Thanks to its decentralized system, which allows the safe passage of information without the intervention of a central authority, the blockchain would forever change finance, logistics, even liberal democracy, allowing the creation of horizontal and anarchist systems. Even the energy sector would have been demolished:

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the blockchain would have allowed the widespread management of energy self-production and self-consumption systems, giving rise to energy micro-communities at neighborhood or condominium level, capable of creating their own "grid" separate from the main's. From finance to democracy, these autarchic dreams have turned out to be greatly exaggerated. The same is true for energy, but it does not mean that the blockchain has no significant potential. According to a survey by the German Energy Agency, which interviewed 70 energy decision-makers, from utility managers to network operators, 20 percent of respondents believe the blockchain will be a "game-changer" in the energy sector.

As the main power of the blockchain is to certify any transaction in a secure manner and without the need for an external control body, it is difficult for anyone who wants to create a "smart grid" not to use it. In a smart grid, where electricity comes from many sources and is exchanged between many actors, transactions swirl around, and a flexible and decentralized system like the blockchain is considered ideal by many. Use of the blockchain has obvious implications for supply chain management in all areas of the energy industry, and the guarantee of traceability of all the elements has the potential to boost the oil and gas sector, where reliability is of primary importance.

The huge popularity of the blockchain has not obscured the fact that its application can be insidious. In the worlds of both energy and finance, there are doubts about the actual scalability of the technology, due to both the fact that at the moment there is no standard technological architecture and, more significantly, questions about its sustainability. Keeping a blockchain active requires an enormous amount of energy, which would be ironic for a technology that the energy sector wants to make it more efficient.

Who's afraid of robots?

Robotics is a sector that immediately generates passions. People often have an unpleasant view of robots, but when we consider their use in industrial settings, they become decidedly less showy. Manufacturing in all sectors is experiencing a structural change due to the automation of many processes, and in the energy sector this means increasing efficiency and quality. Silicon wafers that make up photovoltaic panels, for example, are extremely delicate and research has shown that the use of pneumatic robots makes the manufacturing process more precise and efficient. In the oil and gas sector, the use of robots has flourished for years and may help reassure those who, in other industries, fear that the advent of automation will lead to an unbalanced coexistence. From undersea installations to inspections of offshore fields, robots and drones work alongside human operators, and replace them in the most dangerous operations. This has helped make professions that were once considered risky extremely safe.

This list of technological applications is undoubtedly partial, but it can be a first step towards trying to understand how far the technological revolution in the energy sector can go. Assuming it can be defined as a revolution obviously. According to a study by the World Economic Forum, in the oil and gas sector alone, between 2016 and 2025, digitalization will benefit all industry players, as well as consumers, to the tune of USD 1,600 billion. It will also be a factor of change: digital optimization and efficiency processes will lead to a reduction in emissions equal to 1,300 million tons of CO_2, to 3,600 billion liters of water being saved and to the loss of 230 thousand barrels of crude oil being avoided.

If an old fox like Bill Gates is advising the most talented youngsters to dive into the energy sector, it is because he knows that revolutions are not born in a vacuum. A characteristic of revolutions, especially those that do not take place in the street, with people being wounded and killed, is that you do not always notice them while they are happening. Perhaps Gates himself did not feel like a revolutionary when he was programming the first Windows embryos in a garage; the revolution only came later. But all the epochal changes leave certain clues and certain traces. To make a revolution you need financial resources and an aptitude for risk. You need flexibility and a readiness to adopt new ideas. You need realism and recklessness. We need a receptive cultural climate and an urgency for change—the latter is certainly not lacking. The ground to start the digital revolution is fertile.

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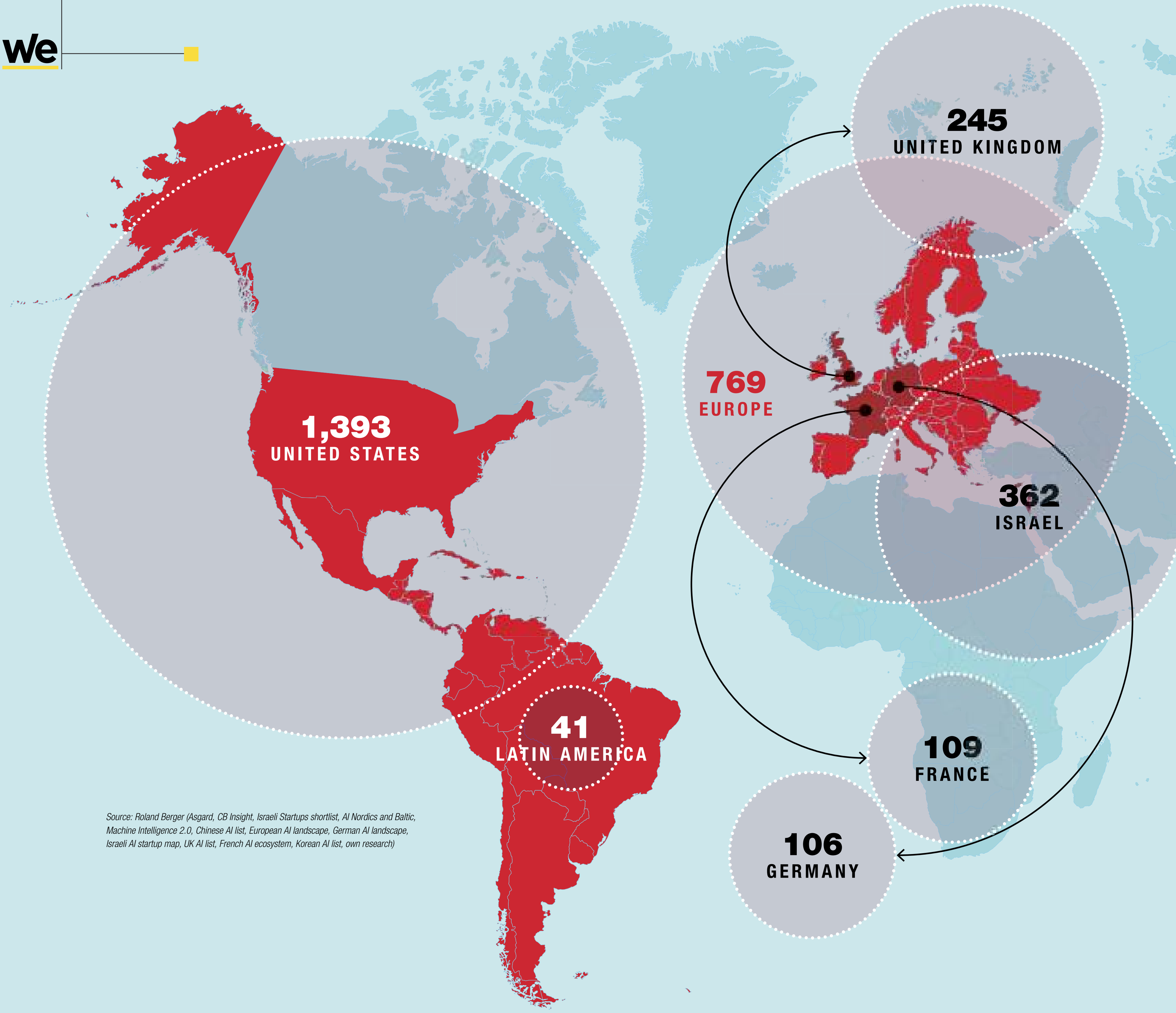
ROBOTICS IS HERE

The design of predictive models that can learn by themselves through machine learning can reduce infrastructure and operational costs, increase production efficiency and improve safety. In the photo, a Launch smart robot equipped with sensors inspecting an electric power plant in China.

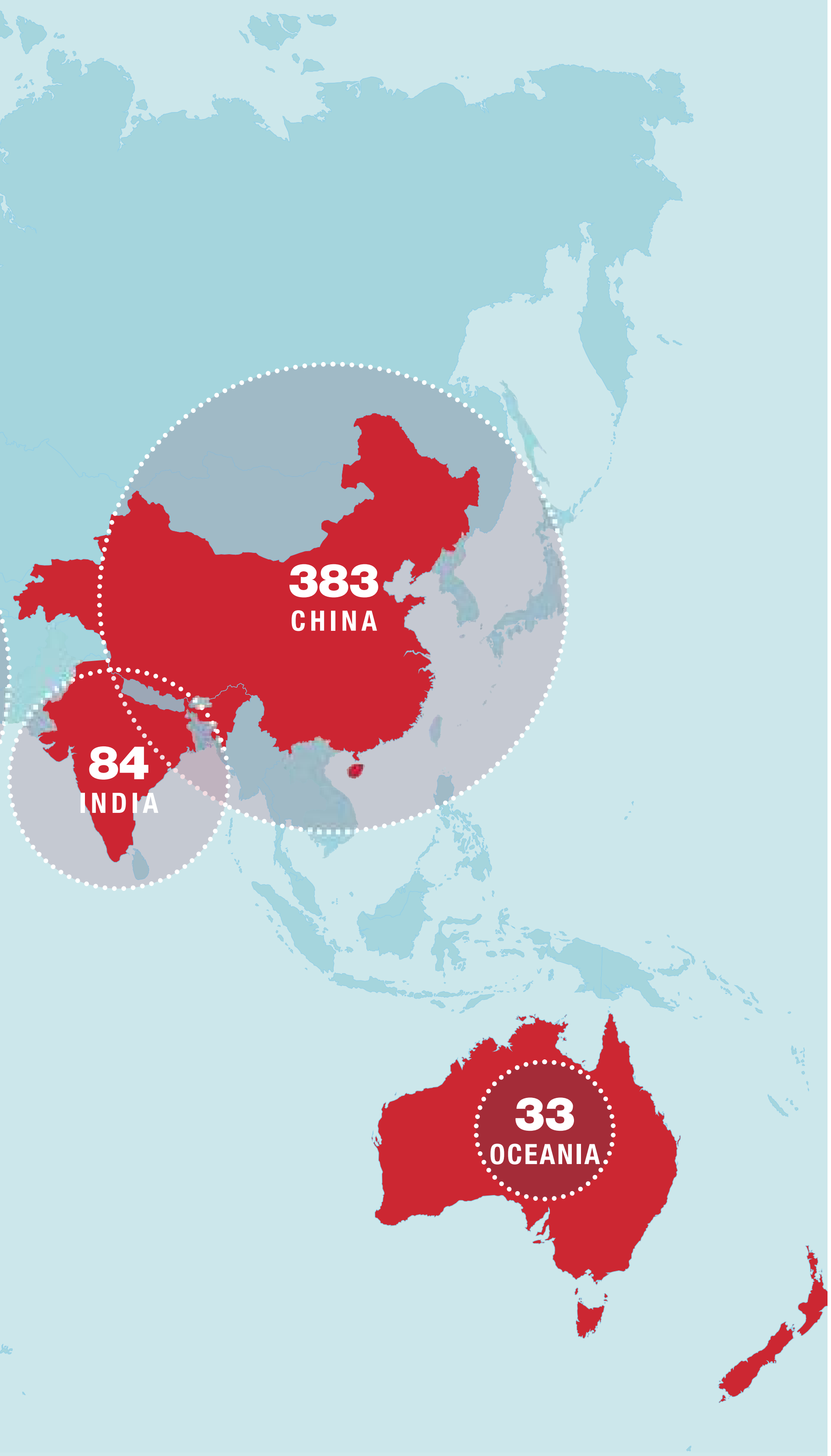


Source: Roland Berger (Asgard, CB Insight, Israeli Startups shortlist, AI Nordics and Baltic, Machine Intelligence 2.0, Chinese AI list, European AI landscape, German AI landscape, Israeli AI startup map, UK AI list, French AI ecosystem, Korean AI list, own research)

Technology/Epochal changes on the horizon

The Geopolitics of Artificial Intelligence

By 2022, AI will have created 133 million new jobs but wiped out another 75 million. Today, more than ever, we need to guarantee that there is a human-centered vision at the heart of this evolution of technology. We need an ethics of AI, and in this area Europe is leading the way



The race for leadership

The United States is an undisputed leader in the AI ecosystem with 1,393 start-ups, 40% of the total. China is in the second place with 383 start-ups (11%) and Israel in the third with 362 start-up (10%). Europe as a whole, surpasses China with 769 start-ups (22%), but no member state holds individually the record. Unique noteworthy the United Kingdom in fourth place, France in the seventh and Germany in the eighth.

PIER LUIGI DAL PINO

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Artificial Intelligence (AI) is profoundly changing all aspects of daily life. Ever since its inception in the 1950s—a period when Alan Turing published an article entitled "Computing Machinery and Intelligence," considered by many to be the manifesto of AI—it has set itself ambitious goals and has achieved significant results, revolutionizing the way we live and work and improving efficiency in all spheres. Thanks to fruitful research carried out in this field in areas including artificial vision, understanding of natural language, decision support systems, and robotics, the potential benefits of AI are now evident. Consider, for example, the support systems that allow more informed decisions to be made in various areas; voice-assisted digital assistants; systems to assist the elderly; self-driving cars; automated drones for parcel delivery; machine learning algorithms used in precision medicine; not to mention cybersecurity and cryptocurrency applications; automatic fraud detection systems; and factory automated production processes. From start-ups to established companies, from public administration to individual consumers, AI and cloud computing are transforming the business fabric at an unprecedented speed, albeit at different rates around the globe. It is hard now to imagine a segment of society that will not be transformed in the coming years by these new technologies.

The world of work will also see important changes globally in terms of reorganization, with tasks rather than roles being gradually assigned to machines and people, balancing the need to automate work with that of enhancing workers' capabilities. A recent report by the World Economic Forum (WEF), for example, predicts that by 2022, AI will have created 133 million new jobs but also wiped out 75 million. The net result is positive, as long as AI is appropriately channeled.

The potential and actual applications of AI have created a stage for true international competition: AI is and will be the quintessence of state domination, for at least three reasons: economic opportunity (think of the quantity and scope of potential applications); "digital" opportunity (AI works on a huge amount of data and information and allows the benefits of the ongoing digital transformation to be fully grasped); social opportunity (the ability to affect people's daily lives from the highest systems). If managed wisely and if pursued for the benefit of society as a whole, these opportunities have the unprecedented potential to improve people's lives and economic productivity. While the United States and China are benefiting from the digital industry— →

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highly developed in these two countries—the European context remains more fragmented and, despite the advances made in terms of AI ethics, it lacks a clear strategy for coordinating and structuring the ecosystem.

The US is not relinquishing its title

The US is currently the main player in the field of artificial intelligence, strong on investments and research led by private operators for several decades: not only is so-called big tech the fundamental driving force in the field, but the whole start-up ecosystem and the world of research are the fabric of AI development. In fact, the US is the undisputed leader of the ecosystem, with 1,393 start-ups—40 percent of the total number. China is in second place with 383 start-ups (11 percent of the world total) and Israel is third with 362 start-ups (10 percent). However, if we take Europe as a whole, with 769 artificial intelligence start-ups (22 percent of the total), China is knocked out of second place. But no Member State of the EU reaches a true critical mass: the most noteworthy is the United Kingdom, which ranks fourth (245 start-ups), followed by France (seventh with 109 start-ups) and Germany (eighth with 106 start-ups). While Italy is present in the ranking, it is second to last with 22 start-ups.
Noting the preponderance of private sector money going to research and development spending in this field, in May 2018, the White House announced its ambition to preserve its leadership in the AI sector, combining market objectives with the need to protect employment and promote research and development with public funds. This statement was echoed more recently by the DARPA (Defense Advanced Research Projects Agency) AI Next program, a two-billion-dollar investment plan aimed at removing the current limitations of AI systems, including, most importantly, their dependence on data, the difficulty of explaining decision-making processes and the inability to understand the context in which decisions are made. In February 2019, Donald Trump launched the American Artificial Intelligence Initiative, focused mainly on strategic sectors such as transport, agriculture and meteorology.

The rapid growth of China

China is well known to have taken a different approach from the US in the field of AI, with a purely state-driven leadership in line with the economic functioning of the country. China has clearly declared its ambition to become the world leader in the field of AI by 2030. China is particularly keen on its Made in China 2025 plan dedicated to the manufacturing sector; the Internet + plan also dedicated to smart manufacturing and innovation; the Robot Industry Development Plan (2016-2020) launched in 2016 to promote the development and dissemination of robotics in industry; and most recently the 2017 New Generation AI Development Plan, with a string of very precise objectives to be achieved by 2025, arriving at market domination by 2030. The plans are very concrete and ambitious and directed at both civil and military applications.

Europe's original sin

According to a recent paper published by McKinsey, AI initiatives remain very fragmented in Europe, as do the strengths and weaknesses it brings to AI. For example, Ireland tops the European ranking in ICT connectivity, Finland in human capital and the United Kingdom in innovation. This suggests that each EU country should consider the best practices of the others in an attempt to create a more favorable environment for artificial intelligence or bring them together into a single unitary system. Moreover, although the EU is among the geographical areas with the greatest number of active AI players—with 25 percent of the total, second only to the United States (28 percent)—compared with the US, European companies are struggling with the adoption of big data architecture and the most advanced machine learning techniques, both of which underpin AI. Furthermore, at the moment Eu-

ropean companies lack pervasiveness of AI and tend to concentrate only on a rather restricted set of technologies and automation, limited to certain business functions. In fact, even in terms of investment in AI, Europe is lagging behind the US and China. The 2.6 bilion euros of investments announced by the European Commission pale in comparison to the investments currently being made by the two world powers in this field. Nevertheless, AI can win Europe pole position in the digital revolution, increasing economic activity by a value of between 2.7 and 3.6 billion euros by 2030, provided that Europe succeeds in improving assets and skills and catches up with the United States. Channeled properly, digital technologies can also act as catalysts for the development of new solutions to the most pressing challenges of our time and the EU's priorities, such as fighting climate change, treating diseases and improving public safety.
In recent decades, the EU has promoted innovation, establishing global standards for the responsible use of technology, including the General Data Protection Regulation. At the height of the fourth Industrial Revolution, the approach to technology focused on the human being adopted by the EU and based on the values of the individual will be one of Europe's main strengths. This intention is demonstrated by the work carried out by the group of experts specifically set up by the European Commission to outline key principles, and in the publication, last April, of "Ethics guidelines for trustworthy AI," a set of principles that constitute the EU's vision on the subject, but also of the concrete guidelines for the development of AI.
Alongside the two superpowers, industrialized countries like Japan (as early as 2015), South Korea, Canada and emerging economies such as India have adopted national AI plans. In Europe, various national initiatives have already been launched, in particular by Belgium, Finland, France, Germany, Portugal, the United Kingdom, Sweden and Italy. This proliferation of national plans has not escaped the attention of the EU institutions, which have decided to strengthen coordination between Member States within the Digitising European Industry program.

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For a technological future centered on the human being

Faced by the rapid development of artificial intelligence globally, we do need to take time to lay the foundations of this disruptive technology and build a set of concrete ethical principles to guide its development. The enunciation of abstract principles needs to be replaced by a strategic vision, an understanding what and how we want artificial intelligence to operate in society. Just as in politics a strategic vision for the country cannot be dependent on successive elections, AI, given its potential and pervasiveness, needs a solid ethical base with a long-term vision to accompany its rapid development. And this vision needs to be outlined and implemented now, today, so that the AI of tomorrow has a positive impact on society. Globally, this is not an easy task for three reasons: first, because of the different approaches that states are pursuing. In line with the approaches mentioned above, in the United States the ethics are mostly driven by big tech companies, some of which have equipped themselves with principles and internal mechanisms for the ethical evaluation of products and services. In the Chinese state-controlled AI, ethics is not emerging as a priority. The EU is making it a fundamental cornerstone, to the detriment perhaps of greater speed in the definition of an industrial strategy, but in harmony with its own values and its own history. The second reason is purely cultural: as a vision and a set of ethical principles, given the different approaches on the subject, it might be complicated to align different visions worldwide. Finding a minimum common denominator, however, is essential, in light of the global and limitless scope with which AI mechanisms can operate. Finally, it is fundamentally important to make sure that the set of ethical principles outlined can be effectively infused into algorithms created in such a way that they operate according to those guidelines, as well as internal evaluation mechanisms.
All the efforts and dialog currently underway are crucial to ensuring that in the future AI can be a tool that benefits the community, one that allows human capabilities to be amplified and through which society as a whole can be improved. Given its scale and impact, digital transformation cannot ignore the need for digital ethics. We cannot miss the opportunity to guarantee the use of technologies that effectively and responsibly improve people's lives. Therefore, it is not about what these technologies can do, but what they should do. It is essential to use algorithms capable of enhancing decision-making and forecasting processes in support of human creativity, increasing the ability to make decisions faster by reducing margins of error. Today, more than ever, we need to guarantee that there is a human-centered vision at the heart of this evolution of technology, society and AI, alongside its rapid growth: a vision in which the human being is at the center of the development of digital innovation, supported and not replaced by technologies. A technological future in which humans and machines will increasingly work together, but where human intelligence will govern development without ever losing control. Beyond the different approaches, the international theater will have to take this into account.

THE FUTURE IS NOW
Thanks to fruitful activity in many application areas such as artificial vision, the understanding of natural language and robotics, AI and cloud computing are transforming the entrepreneurial fabric at unprecedented speed.

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Oil&Gas/AI's potential and early applications

Making a Smart Industry even Smarter

Energy companies are beginning to experiment with AI, and not a moment too soon. The maturing technology has the potential to dramatically improve efficiency of the sector and increase its value by more than a hundred billion dollars. Now is the time to invest

GEOFFREY CANN

He has thirty years of experience advising oil and gas, energy, and technology companies and specializes at the intersection of digital technologies and the oil and gas industry. He teaches regularly at the MBA level on energy issues. He's the author of *Bits, Bytes, and Barrels: The Digital Transformation of Oil and Gas* (MADCann Press,2019).

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The media regularly publishes news and articles about the latest clever developments in artificial intelligence (AI). Whether helping radiologists in healthcare, or indulging consumers need to find entertainment on Netflix, developments in AI always attract attention. The oil and gas industry is also at the early stages of exploring AI's potential impact. Uses are evident, startups are forming to tackle industry problems and early adopters are gaining traction. A Google search for AI in oil and gas brings up some 26 million references, about five percent of all references to AI.

Defining AI

While AI is not a new field—the first exploration of AI dates back to the dawn of the computer era—it is shrouded in confusing terms and definitions. This article characterizes AI as a computerized capability to analyze data using cognitive skills that are normally associated with humans. Beyond mathematics, such cognitive skills include natural language processing, translation of languages, visual perception, auditory interpretation and tool creation.

Something that is artificially intelligent uses sensors to detect the world, historic data to provide reference to prior situations, and computers or analytics to process some rules about the world. In addition, AI is distinguished by its ability to process enormous quantities of data from a large variety of sources at super human speeds and interpret that data in the manner consistent with human intelligence.

An autonomous car is a useful illustration of artificial intelligence in action. The car and its sensors can detect and avoid obstacles, predict the likely path of other moving objects, and change the vehicle's behavior according to driving conditions, e.g., slowing down in the rain or snow. Many robots in the future will feature this kind of other worldly intelligence, learning and adaptability.

AI is at the tipping point for widespread adoption because computer speeds, storage and mathematics can now meet the processing requirements of AI software. Companies like Tesla, Amazon, and Google are investing heavily in AI research, and as Figure A shows (see page 28), searches for terms like AI and deep learning as a percentage of search activity have been growing over time.

Why oil and gas?

Two ingredients that make for the successful use of AI are data and human talent, both of which are abundant in oil and gas. The industry has tremendous quantities of recorded data available for the pur- →

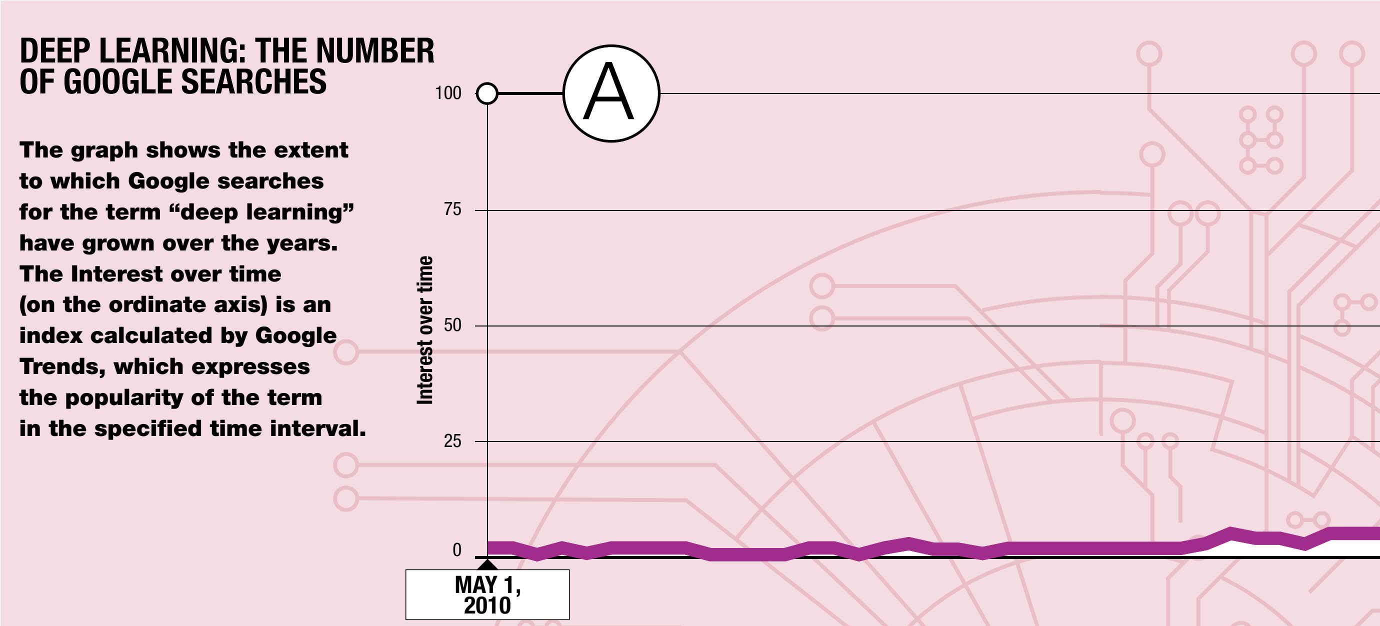
poses of training AI engines or for analysis by AI engines. That data can be dynamic and captured hourly by sensors in the field, as with motor sensors or cameras on the millions of industry field assets, or static, such as legacy seismic data recorded over the decades. The greater the volume of data, and the higher the accuracy of data, the more impact that AI can have.

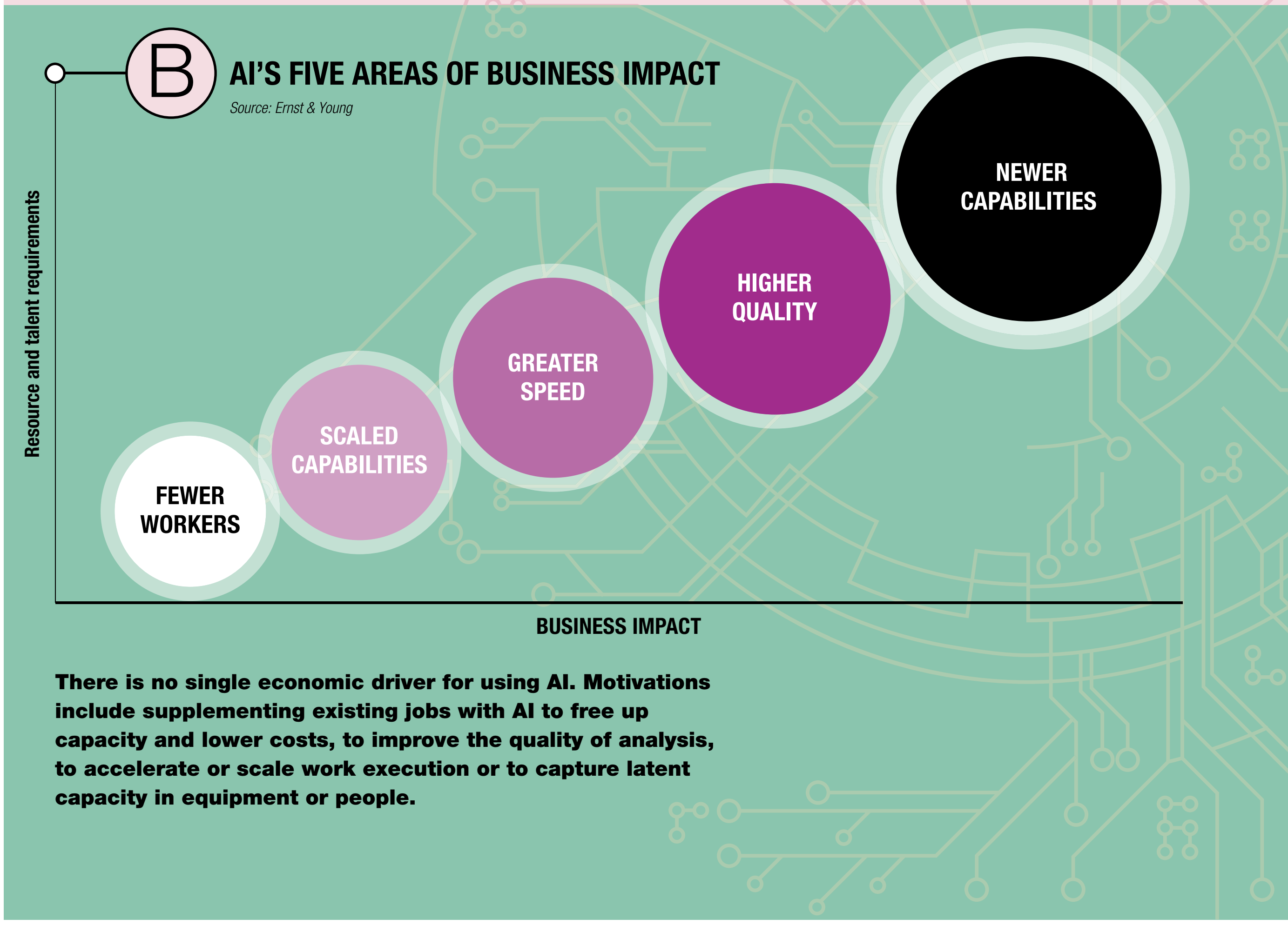
The industry employs ample human talent to interpret that data. Geologists spend considerable high-cost time stitching together disparate data sets and preparing maps from seismic and other subsurface data. Expensive financial professionals laboriously read joint venture and land contracts to develop the royalty payments from production. Control room operators monitor remote gates and tank farms for health and safety compliance. Globally the oil and gas industry frequently ranks among the highest paid industry sectors.

Early indications suggest that there is no single economic driver for using AI. Motivations include supplementing existing jobs with AI to free up capacity and lower costs, improving the quality of analysis to reduce risk or variance, accelerating scale work execution and capturing latent capacity in equipment or people, as illustrated in Figure B by analysis from consulting firm EY.

McKinsey research shows that 45 percent of executives see AI as a powerful competitive differentiator. These are general drivers of performance, and applicable to many facets of the industry, suggesting plenty of scope for applying AI to the industry's challenges. Oil and gas may be able to capture USD150 Billion in value by utilizing AI, as McKinsey illustrates in Figure C.

Use cases are beginning to appear, and, as the barriers to adopting AI solutions are very low, adoption could be very quick.





Early examples

Here are just a handful of use cases that are in operation today in the industry.

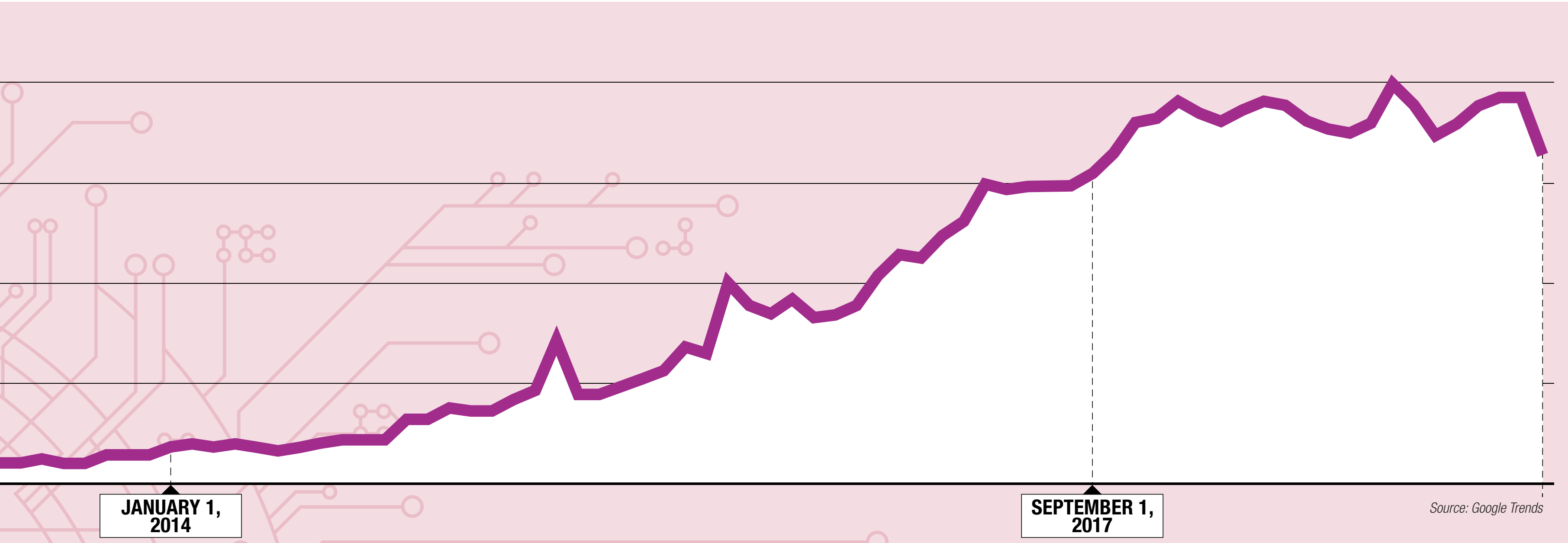
- **RESERVES ANALYSIS.** The upstream is advancing very rapidly in the use of AI, particularly in the subsurface area. Data is abundant, the upstream field is already highly technology literate, and the value at stake dramatically outweighs the costs to conduct trials of new technology to interpret data.

  Upstream companies use AI to improve their reserves understanding. When AI is applied to the interpretation and analysis of available subsurface data, recovery rates from resources improve. McKinsey estimates that AI boosts data analysis performance by 79 percent over humans. AI work is underway in conventional and unconventional resources, both on-shore and off-shore. For example, decline curves for shale resources have progressively improved over the decade but still trail conventional recoveries. The IEA forecasts that digital innovations such as AI applied to better understand porosity, permeability, fluid dynamics, and fracking performance would help to expand reserves by as much as five percent, principally in unconventional resources that are most susceptible to better analytics.

  Geologists are also revisiting mature assets using AI, including resource data set aside decades earlier because the mathematics, the processing power or the compute environment had not been up to the task. Mathematics and processing power have sufficiently advanced that AI techniques are being successfully applied to the archived subsurface data and interpretation of long-discovered conventional basins to enhance the fidelity or precision of resources, enhance production and extend the life of existing wells.

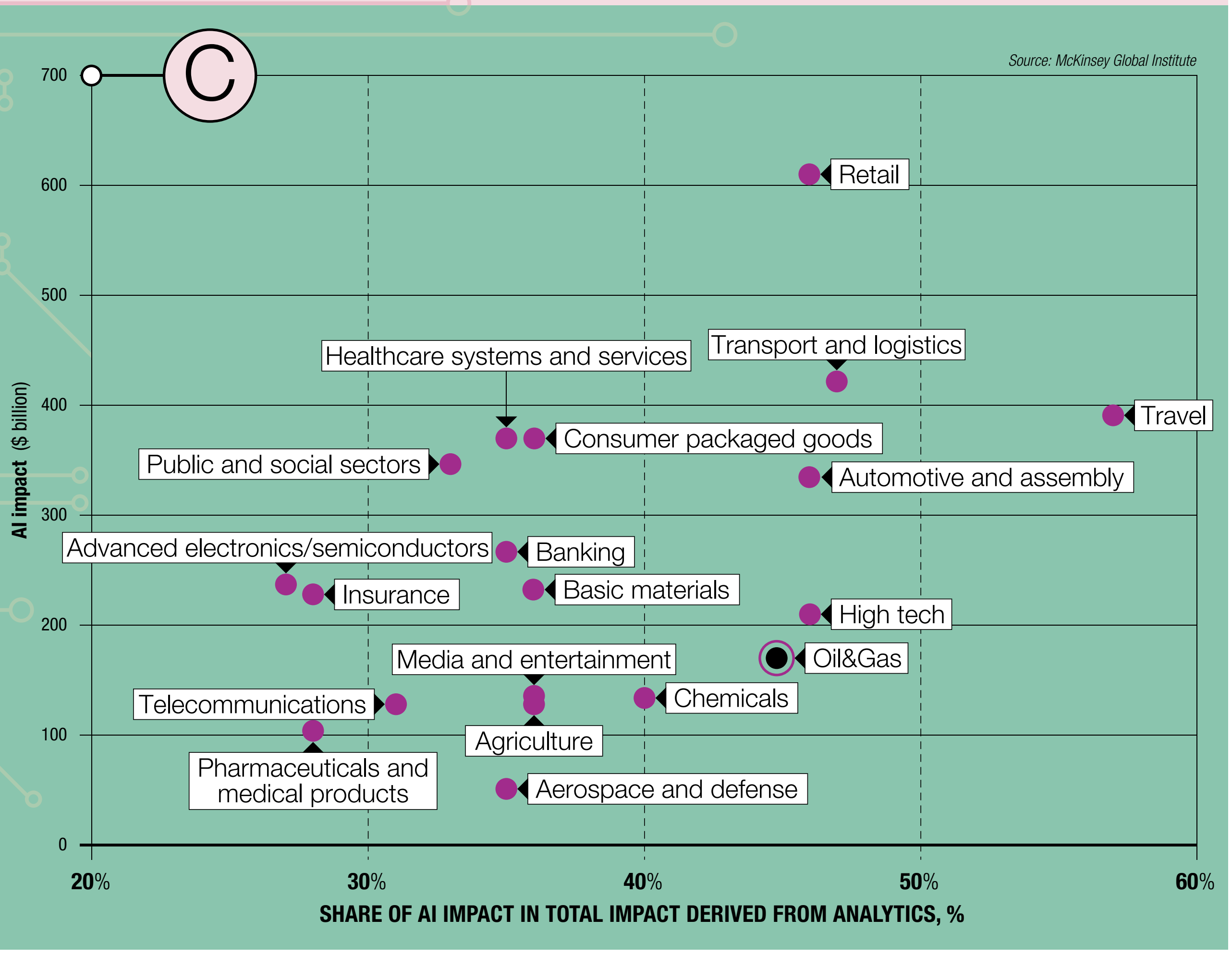
  Data service companies are beginning to offer this as a service. For example, Enersoft's collection of original wellbore data from 200,000 wells in Canada amounted to a quarter of a terabyte (or 250 gigbytes). Meanwhile, Enersoft's robotic cuttings analyzer generates over two terabytes of data per well, producing resolutions that are orders of magnitude more detailed. In effect, AI allows geologists to model reservoirs at the level of a grain of sand.

  The amount of data now available for analysis and interpretation drives the need for new AI tools. A recent innovation from Bluware applies streaming technology for data handling in the same way that Netflix or Spotify stream video and music data. Large subsurface data sets are compressed and "streamed" to an AI engine for interpretation without the recipient having to purchase the data or ob-



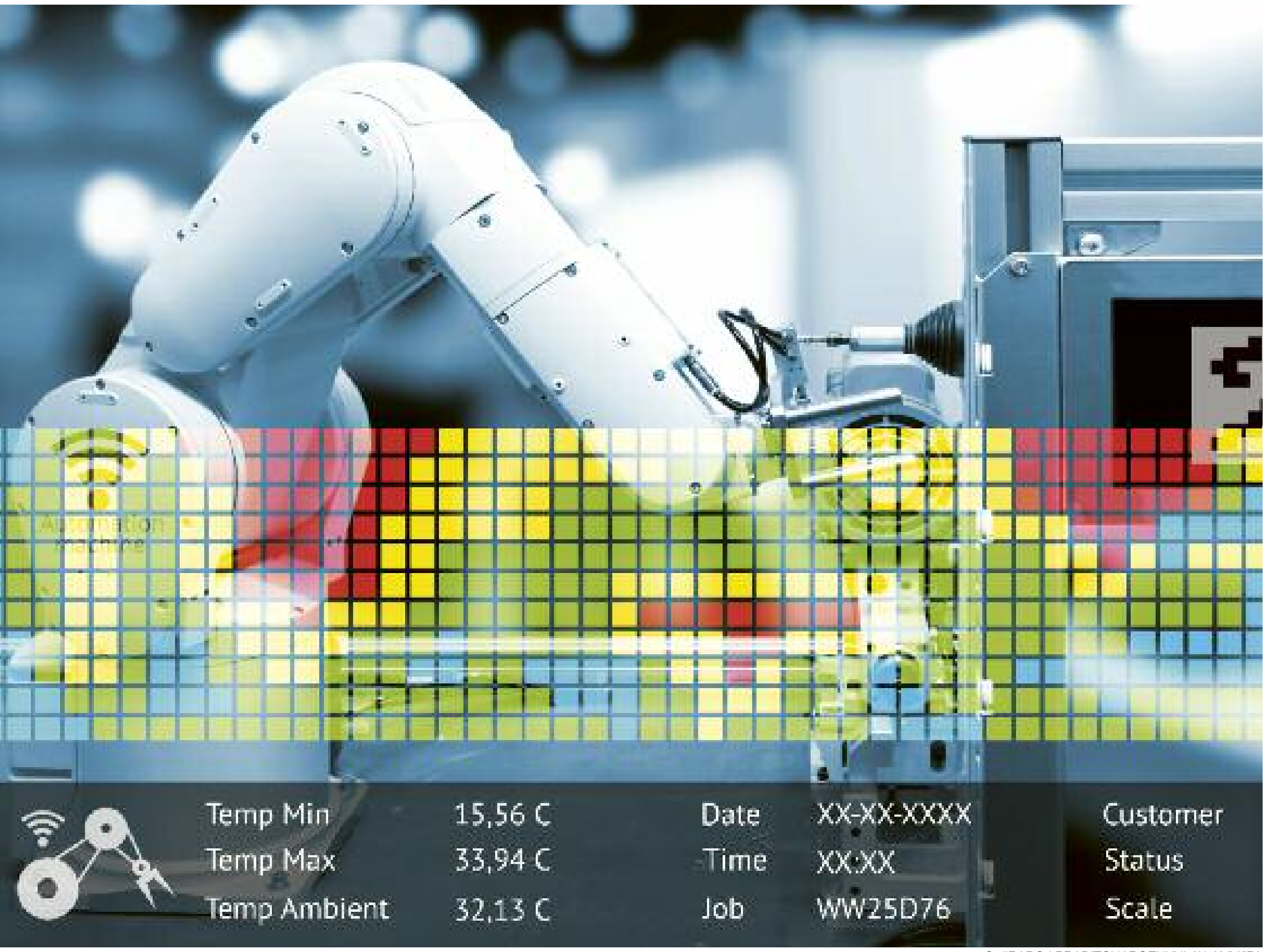
THE VALUE CREATED BY AI

The potential of artificial intelligence in terms of value creation cuts across all industrial sectors. In Oil&Gas, the economic impact of AI amounts to over 150 billion dollars.



tain a copy of the data. This development alters the concept of a restrictive data room used for mergers and acquisitions and allows many smaller players to pool their data to enhance the interpretation of their resources.

- **OPERATIONS.** Visual data interpretation improves safety outcomes, compliance to regulation and site operations. An AI service from Osprey Informatics interprets visual sensor data feeds and detects worker safety issues (not fitted out in safety gear, or smoking or in the wrong place) and sends alerts to supervisors. Its AI engine monitors plumes and detects the presence of harmful hydrocarbon vapors. The system raises site monitoring to 100 percent and is fully auditable, thereby raising compliance rates.
- **PRODUCTION.** Customers of Ambyint, who supply an AI solution for artificial lift applications, report as much as a five percent gain in production and a 10 percent reduction in cost. Ambyint's AI solution attaches to a pump jack, and optimizes the pump to eliminate over and under pumping activity. Finally, AI makes small work of tasks that humans can do but simply take time. For example, Woodside Petroleum uses IBM Watson to catalogue all the previous engineering studies and documents about Woodside's gas projects off the coast of Western Australia. The engineers pose engineering questions to Watson in natural language, Watson interprets the question and then presents the studies, rank ordered by best fit. Woodside estimates that prior to Watson, their engineers spent as much as 40 percent of their time searching for previous studies and analysis. This captured time is now available for more productive engineering work by reducing search times by 75 percent.
- **MIDSTREAM.** Midstream activities also lend themselves to new intelligent solutions. For example, tank farm operators and pipelines build digital twins of their complex network assets and apply artificial in- →



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INDUSTRY 4.0
Artificial intelligence is now so highly developed as to have a profound effect on some of the most complex challenges of industry. The oil and gas sector in particular could exploit the potential of AI to increase its value by 150 billion dollars. In the picture, temperature measuring instruments in a smart factory.

telligence engines to optimize the network, using solutions from companies such as Stream Systems.

A fully functioning digital twin of a business includes many layers of data that work together to provide a rich, fully integrated and analytically deep software version of the business. These layers include engineering content (diagrams, specifications, configurations), physical constraints (operating capacities, throughputs and pressures), operating parameters of the assets (input energies, consumables, byproducts and emissions), financial features (fixed build cost, operating cost per unit), and uncertain elements (customer demand, weather events, supply disruption). Applying AI technology to this digital model of the network lets owners optimize the assets in ways not previously possible or simulate an asset's lifetime. For example, Microsoft used pipeline data in a hackathon to see if an AI tool could be used to find corrosion. It was successful: the winner was able to find corrosion with 99 percent accuracy.

Asset maintenance is reconfiguring to take advantage of AI by introducing a new way for technicians to conduct work. Instead of capturing work details on paper and clipboards or typing on small keyboards to record asset and repair information, workers use cameras and microphones enabled with AI to record work in the moment. Data-driven research, enabled by AI, slices maintenance costs in half, according to Kimberlite research. The AI engine interprets the visual data and spoken words to both assist the worker and to create structured data for maintenance systems.

Beyond petroleum

Carbon concerns, consumer preferences and regulatory compliance are motivating many industries to add greater intelligence to their equipment. Chief among these is the automotive industry, whose internal combustion engine technology consumes 25 percent of all petroleum. The top six automobile companies, who account for 50 percent of all industry sales, are racing to deploy AI in their products. Today's vehicles are already rich in software. The Ford F-150, a market leading pickup truck, has more lines of code in its various components than the Large Hadron Collider, the Space Shuttle, the F-35 Fighter Jet, or Facebook.

Next generation vehicles, which are progressively coming to the market, will incorporate greater levels of connectivity, sharing support and autonomy, elements which are dependent on artificial intelligence to operate. Early results from the use of autonomous heavy haulers in mining applications shows improved fuel usage as a key benefit, as the vehicles automatically adjust engine performance to match load and road grade features. Connected vehicles that can communicate with each other can form platoons or convoys of more closely packed vehicles. The aerodynamic effects reduce drag and increase fuel efficiency.

Moving to deployment

To successfully deploy artificial intelligence solutions, companies in oil and gas need to do three things.

1 | **ROBUST SPONSORSHIP AND SUPPORT.** Leadership must demonstrate unyielding support for AI, including such tactics as tuning performance metrics to reward behavior. Front line employees need to know that they have management support before they will invest much time in a new technology that is perceived to eliminate jobs. The success of AI in the field is not going to be based on how good the algorithms are but on how good management is at promoting change in the workplace.

2 | **EDUCATION.** Oil and gas companies must invest in raising the understanding of AI in their organizations. Similarly, AI providers must include training and education on how algorithms actually work, their self-learning abilities, and their limitations, to help overcome engineering suspicions about the technology.

3 | **COLLABORATION.** Proponents must work more collaboratively to overcome skills shortages. The demand for AI know-how has accelerated in many industries, triggering high demand for skilled talent in data science, machine learning, deep learning, neural networks, analytics and artificial intelligence. Working closely with labs, start-ups, incubators and accelerators is a necessity.

AI is now sufficiently advanced that some of the industry's most difficult challenges are now impacted by this technology. There is no longer any reason to delay investments in this promising and mature technology.

Energy/The profound reconstruction underway in the industry

Electric Surprises

New business models, financial instruments and technologies, radical changes in consumer behavior and stricter regulations aimed at curbing global warming are just some of the factors changing the face of the sector

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MOISÉS NAÍM

He is a distinguished Fellow at the Carnegie Endowment for International Peace, in Washington, D.C. and a founding member of *WE*'s editorial board. His most recent book is *The End of Power*.

n recent years, the attention of energy companies, governments, investors and the media has focused on the enormous upheaval caused by new technologies which have made the exploitation of shale gas and shale oil technically and economically feasible, and these innovations have upended energy markets and traditional geopolitical structures. In particular, the United States has become not only self-sufficient in energy terms but also one of the main hydrocarbon exporters. It is not exaggeration to call the changes in the oil and gas industry revolutionary. However, this change has diverted attention from another revolution changing the world, the electrical revolution.

A constantly changing world

The way electricity is generated, transmitted, stored, distributed and priced is undergoing a complete transformation. New business models, financial instruments and technologies, radical changes in consumer behavior and stricter regulations aimed at curbing global warming are just some of the factors changing the face of the industry. But how exactly? Here are some examples that illustrate the profound reconfiguration taking place in the electricity industry: electric cars and large-scale storage systems, consumers who can also be producers, wind and solar farms, whose renewable energy will account for 35 percent of the total electricity generated by 2035 alongside a boom in electricity demand that will double by 2050. It is worth noting that this boom is asymmetric: electricity demand is falling in developed markets and growing rapidly in emerg- →

ing markets. Even the most seasoned experts describe this transformation with a sense of wonder. "The electricity industry has changed more in the last ten years than it did in the previous one hundred years. Technological innovations have brought and will continue to bring significant changes that benefit everyone: people, businesses and society," says Leonardo Moreno, Head of Strategy at AES Corporation, one of the largest electricity companies in the world. Five forces stand out among the myriad of forces fueling this transformation:

- **ELECTRIC VEHICLES.** The global market for electric vehicles has not yet reached a significant size, but it is poised to grow very quickly, which will boost electricity consumption. Vehicle range has increased to 300 miles per charge, while battery costs have dropped from USD 1000 dollars to less than USD 300 dollars per kilowatt hour. By January 2019, there were seven million electric vehicles in circulation. While this is a significant number, it pales in comparison to the numbers projected by most analysts. A recent Bloomberg report, for example, estimates that the stock of electric cars will grow to 548 million units by 2040, representing about 32 percent of the world's passenger vehicles. While there are still important hurdles that the EV industry must overcome (regulations, safety, infrastructure, etc.), it seems safe to assume that in the long run renewable energy stored in batteries will dislodge fossil fuels as the transport sector's primary source of energy.
- **AN EXPLOSIVE GROWTH IN ELECTRICITY STORAGE.** The International Renewable Energy Agency (IRENA), estimates that battery storage will grow globally from a current 2 Gigawatts to around 175 Gigawatts by 2030, thanks to a reduction of some 60 percent in the cost of batteries, and this substantial increase will make battery energy storage more significant than hydro storage. Such growth now makes possible around the clock off-grid use of electricity in the residential and industrial markets and provides stand-alone power systems to thousands of previously isolated customers.
- **AN INCREASING CIVIC AND CORPORATE COMMITMENT TO A LOW CARBON ENERGY ENVIRONMENT.** According to the American magazine Forbes, over 100 cities around the world now use at least 70 percent renewable energy, while more than 40 cities are powered by 100 percent renewable electricity. But this push for cleaner energy also extends to corporations. Through the We Mean Business coalition, nearly 900 global companies across all sectors, headquartered in over 45 countries and with combined market capitalization equal to 20 percent of global GDP, have decided to take bold climate action. In addition, RE100 is a global association bringing together business entities committed to 100 percent renewable electricity and including almost 200 global corporations that have pledged to reach this goal by 2050. This is a significant initiative since companies in the commercial and industrial sectors represent close to 70 percent of the world's electricity consumers. Investors are also playing a defining and unprecedented role. Some giant institutional investors like California's CalPERS and Norway's Norges (the world's largest sovereign wealth fund) have decided to curtail investments in companies whose business depends on burning fossil fuels.
- **THE DECREASING COST OF RENEWABLE SOURCES.** Over the past 5 years, the costs of solar and wind energy have dropped by 80 percent and now tend to be equivalent to those of electricity generated from fossil fuels, if not lower in some markets. In Chile, Brazil, and several countries in the Middle East, energy from renewable sources is now cheaper than fossil-fueled energy and these low prices do not depend on government subsidies, as was the case just a few years ago. Furthermore, the falling costs are accompanied by a rapid improvement in storage technology, which allows electricity to be supplied at reasonable prices even in areas where solar and wind energy availability is low or volatile. Therefore, a clear trend is emerging: the gradual replacement of large centralized electrical systems with modular systems located closer to consumers. Microgrids, for example, are local energy grids that can operate either autonomously or while connected to a larger traditional grid. They provide energy independence, efficiency and protection during emergencies.
- **DIGITAL ELECTRICITY.** Digital technologies (predictive analytics, digital twins, smart grid, and artificial intelligence) are transforming every aspect of electricity generation, transmission and distribution. Combining the machine learning capabilities of Artificial Intelligence (AI) with other digital technologies is leading to unprecedented operational improvement. The combination of blockchain technology and connected devices and sensors is also expected to transform electric energy systems.

The driving forces behind this transition are the three D's: Decarbonization, the lowering of carbon in electricity generation through the increasing use of renewables; Decentralization by reducing the number of large, central power stations; Digitalization, made possible by the explosive growth in digital technology. Data from IRENA illustrate the strides being made in decarbonization thanks to the electricity revolution. By 2050, electricity will become the main energy carrier, growing from a current share of 20 percent of final consumption to a 50 percent share, and 85 percent of this demand would be met by cleaner, renewable sources of energy. Such a development would allow carbon dioxide emissions to be reduced by around 60 percent of the amount needed to achieve the climate targets set by the Paris Agreement. Decentralization refers to electricity being generated closer to the consumer (rather than in large and remote centralized plants) thanks to wind turbines and solar panels. The resulting lower transmission and distribution costs reduce the cost of energy. Furthermore, thanks to batteries that can smooth out demand peaks and valleys and lower transmission losses, the penetration of renewable sources, which are by their nature intermittent, is destined to increase significantly. At the same time, the increasing use of digital technologies, such as smart meters, new IoT sensors, networks of remote-control systems and digital platforms, are providing faster and better data both for customers and for grid management and operation.

The fight for the planet

The explosion of technological innovation in the electricity sector has become an important ally in the efforts to combat climate change. However, these efforts are not supported by the substantial political commitment needed to accelerate the necessary transition. Energy policies in some of the major countries continue to slow down the efforts to protect the environment. China, for instance, continues to depend excessively on coal to generate electricity and on exporting this highly polluting technology while, in the United States, shortsighted, politically driven agendas are having a negative impact on environmental policies. In its Fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change, IPCC, set a "carbon budget," which is the quantity of carbon that can be emitted worldwide

before the 2 degrees ceiling agreed in Paris is exceeded. According to the report, this budget will be spent by 2045 unless radical steps are taken to minimize the current rate of emissions. It goes without saying that the electricity industry has been and continues to be a significant driver of the

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The five aspects guiding transformation

ELECTRIC VEHICLES

The global electric vehicle market is set to grow very rapidly, which will lead to increased electricity use. Bloomberg estimates that the electric car stock will reach 548 million units by 2040, representing approximately 32 percent of passenger vehicles globally.

AN EXPLOSIVE GROWTH IN ELECTRICITY STORAGE

The International Renewable Energy Agency, IRENA, estimates that stationary storage will grow worldwide, from the current 2 gigawatts to around 175 gigawatts by 2030, thanks to a reduction in battery costs of around 60 percent by that year.

DIGITAL ELECTRICITY

Digital technologies (predictive analysis, digital twins, smart grids, artificial intelligence, etc.) are transforming all aspects of electricity generation, transmission and distribution. The application of the automatic learning capabilities of Artificial Intelligence (AI) to other digital technologies is leading to unprecedented operational improvements.

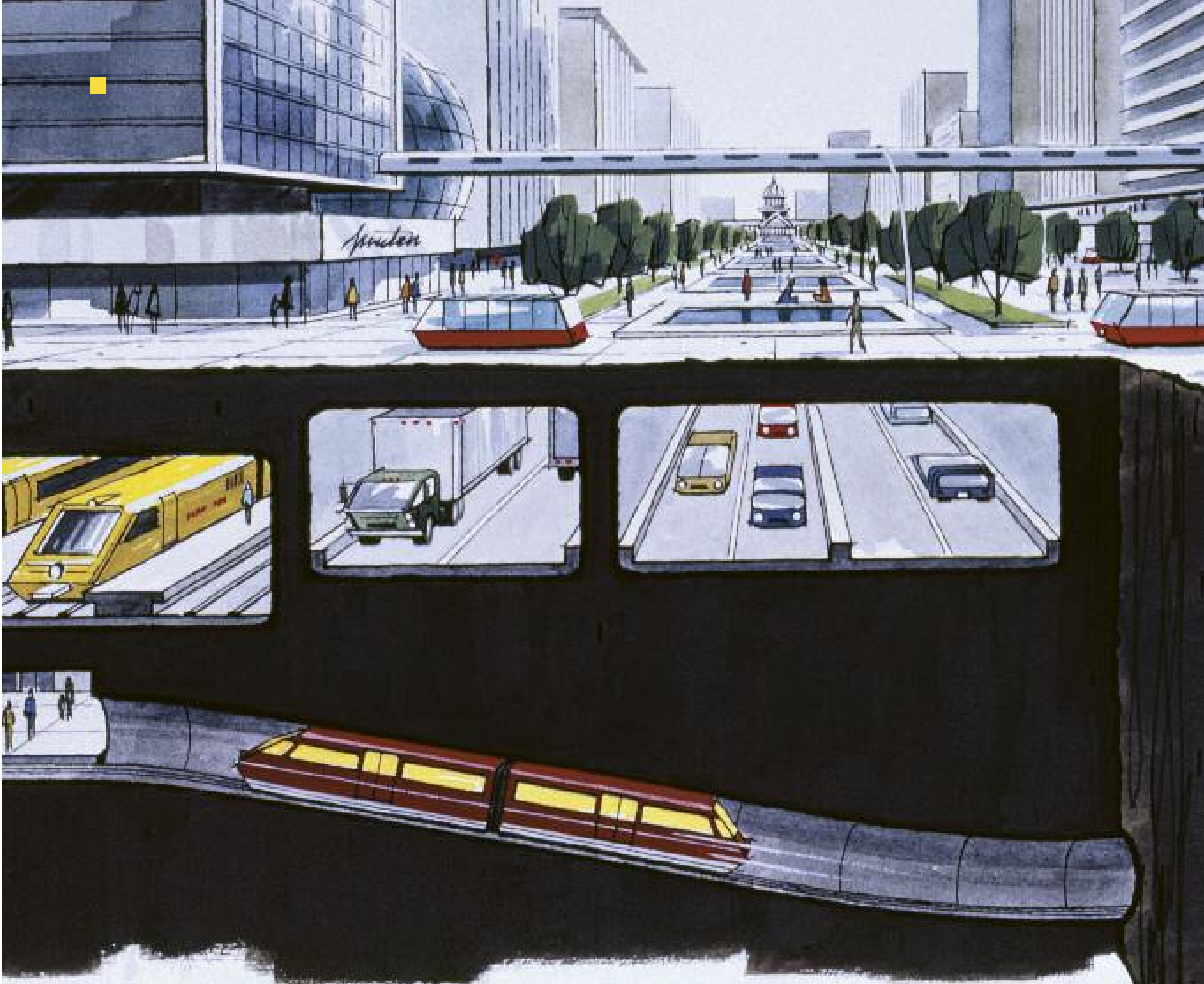
THE FALLING COST OF RENEWABLE SOURCES

In the last 5 years, the costs of solar and wind energy have decreased by 80 percent and now tend to be equivalent to those of electricity generated from fossil fuels, if not even lower in some markets. A clear trend is therefore emerging: the gradual replacement of large centralized electrical systems with modular systems located closer to consumers.

perilous climate trajectory that humanity is pursuing. More, faster and bolder changes are necessary and the electricity sector needs even deeper reforms. Whether the positive changes discussed here will prevail over the still immense political obstacles that block faster progress remains to be seen. But what is indisputable is that electricity has emerged as the big green hope in the do or die struggle for a cleaner environment. It is imperative to act as our survival is at stake.

AN INCREASING CIVIC AND CORPORATE COMMITMENT TO A LOW CARBON ENERGY ENVIRONMENT

Through the We Mean Business coalition, almost 900 international companies operating in all sectors have decided to take drastic climate measures. RE100 is a global association that brings together commercial entities committed to reaching 100 percent of electricity from renewable sources and includes nearly 200 multinationals that have set out to achieve this goal by 2050.



Transport/Key applications for the mobility revolution

An Extra Gear

The transportation sector is responsible for almost a quarter of energy-related gas emissions. The use of artificial intelligence can produce the radical innovations needed to speed up the transition to a more sustainable system

AIDAN O'SULLIVAN

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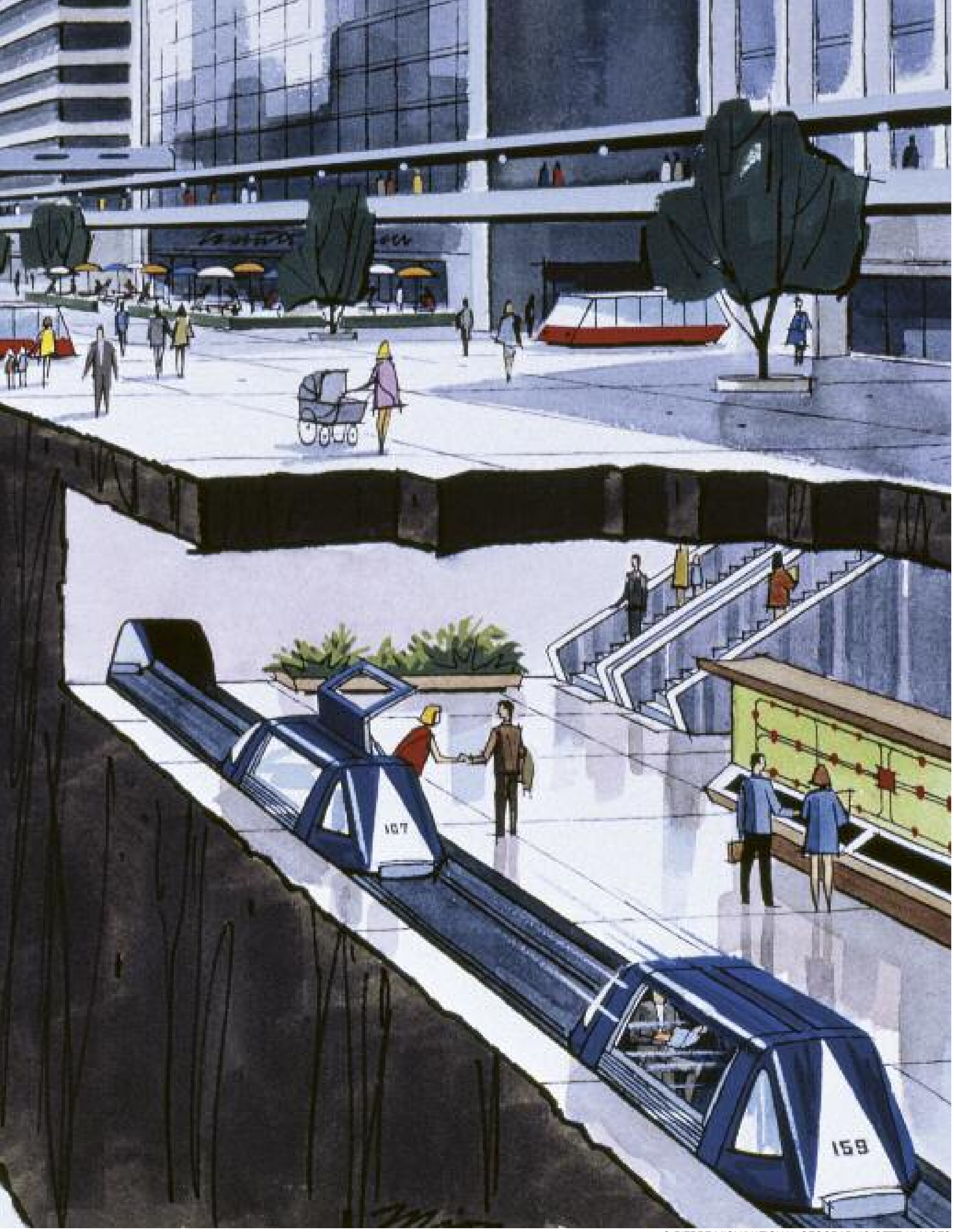
Transportation has been fundamental to human society and economies throughout the ages, enabling trade through the movement of goods and materials and the transfer of skills, ideas and the growth of communities through the spread of people. The democratization of transport and increased access to travel has been key to enabling more people to venture ever further in the modern globalized era in which the world has become "smaller." However, current levels of mobility are an unsustainable threat to our future, for the global transport sector now accounts for 23 percent of energy-related carbon emissions (in some countries such as the UK, it is the largest contributing sector to carbon emissions). Despite efforts progress towards more sustainable mobility has been slow with the World Bank stating: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VIRTUAL CITIES
The combined use of artificial intelligence and big data provided by mobile telephony could produce a "virtual city" that is realistic enough to allow the development of solutions tailored to the specific problems of an urban area.

"The world is off track to achieving sustainable mobility. The growing demand for moving people and goods is increasingly met at the expense of future generations."
José Luis Irigoyen, Senior Director of the Transport & ICT Global Practice at the World Bank

Indeed, the contribution of the transport sector to global emissions is likely to get worse with global air traffic passenger demand currently growing at an annual rate of 7 percent averaged over the last five years, equivalent to a doubling rate of total passenger demand over 10 years. Furthermore, there is a need for improved access to transport in developing countries. About 450 million people in Africa, more than 70 percent of its total rural population, are estimated to have been left unconnected to transport. Increased growth there could see emissions could grow by 40 percent by 2040 (Global Mobility Report 2017). Additionally, in the UK, the Committee for Climate Change has criticized the sector for failing to make anything like the progress demonstrated by the power industry in responding to the threat of climate change.

Radical change is needed

It's clear from this picture that radical change is needed in transport and it is critical that a sustainable mobility revolution is launched to make the kind of progress required in a sector where emissions reduction is challenging. There are reasons to be optimistic, though, and believe that this sector can be transformed. In the last decade, digital technology has enabled the emergence of innovative new business models, such as the ride sharing platform Uber, that have brought major disruption to the transport sector, challenging established norms and creating multi-billion dollar companies at breakneck speed. This is the type of radical change and innovation needed. Fully decarbonizing the transport industry presents major challenges, particularly in sectors like aviation. However just as progress in digital technology brought disruption, recent progress in the fields of big data and artificial intelligence has the potential to solve many of the sustainability challenges and enable the sustainable mobility revolution. Indeed, one of the key challenges that AI can help with is the sheer complexity of transport systems.

The global trend of urbanization, with ever more people drawn to live in cities, places the urban environment on the frontline of the climate battle as a dense concentrated source of emissions where air quality has major health implications. However, urbanization also presents the opportunity and motivation to make progress in developing a more sustainable urban transport infrastructure. Urban transport systems are made up of numerous competing and interacting modes of travel with different characteristics of service, cost, frequency and speed. Coupled with this is the heterogeneity of city residents and their differing transport needs, and the spatial distribution of the city in terms of land use mix and accessibility. The complexity of such a system presents a major challenge to the methodology used to inform decision making and to assess the best allocation of resources and their impacts because non-linear →

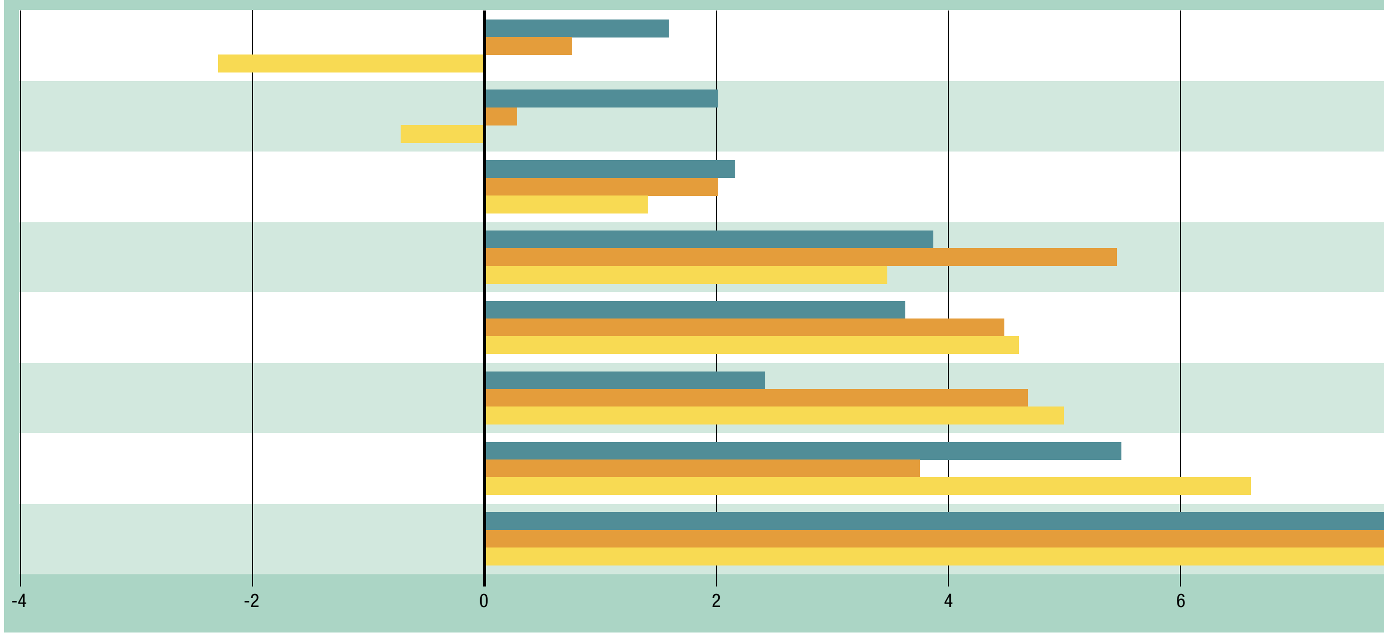
interactions and feedback are difficult to model mathematically. One solution to this is found in agent-based modeling, where the complexity of a system is modelled by faithfully reproducing the components of the system and allowing them to interact intelligently. Artificially intelligence agents that faithfully capture the everyday decision making of individuals as they travel through the city would be a huge boon to understanding how urban transport systems work and would inform decision makers about how to make them more sustainable. While these modelling tools have been developed, the sheer scale of modelling a city in high fidelity is a gargantuan task and previous attempts have required approximations and heuristics. However recent progress in neural networks and scaling these methods hold promise for more sophisticated agents. In addition to this, mobile phone data is increasingly used as an invaluable resource to understand how people move through a city and the combination of these two technologies could produce a type of "virtual city" environment of sufficient realism to enable the development of unique solutions for specific city problems. For example, based on demographics and culture the type of transport system required in a young Asian city may be completely different from that required in a slow growing European city.

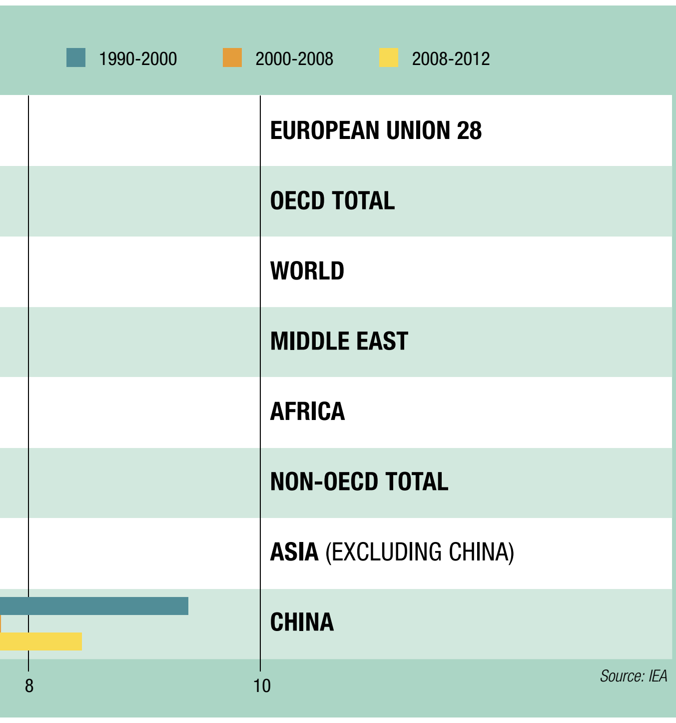
AI's potential

While AI can help model cities make strategic investments in infrastructure virtually, it also enables new forms of transport in flexible on demand services. More flexible use of resources across a city involves large scale decision making that AI enables in terms of managing a complex portfolio of distributed assets. It also requires "context aware" decision making and an understanding of the factors driving travel demand. An example of this is rare events. Rather than over-engineer the transport system to cope with rare peak events such as a huge concert or international sporting event, the ability to shift capacity and adapt frequency in expectation of these events would improve the operation of urban public transport systems by incentivizing greater ridership and reducing private transport emissions. Natural language processing, the AI field associated with developing algorithms that can understand human language, has made great progress in translation and recognition, but we are still far from systems that "understand" the meaning of language. Further progress in this area could enable an advanced trans- →

UNSUSTAINABLE MOBILITY
The current levels of mobility are an unsustainable threat to the future. The global transport sector is responsible for 23 percent of energy-related greenhouse gas emissions. In the picture, Bangkok, Thailand, January 31, 2019: due to pollution levels, the government ordered the closure of schools and advised citizens to wear masks when traveling outside.

GROWTH OF CO_2 EMISSIONS DUE TO TRANSPORT IN THE VARIOUS REGIONS

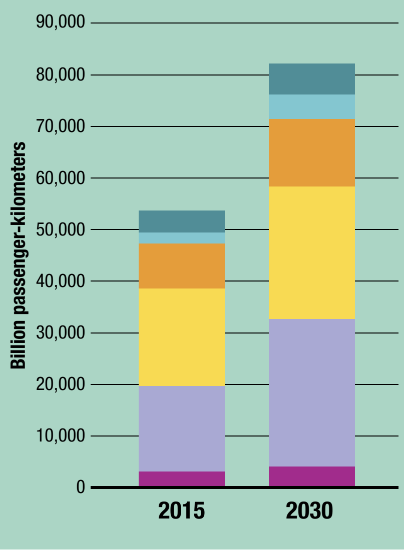




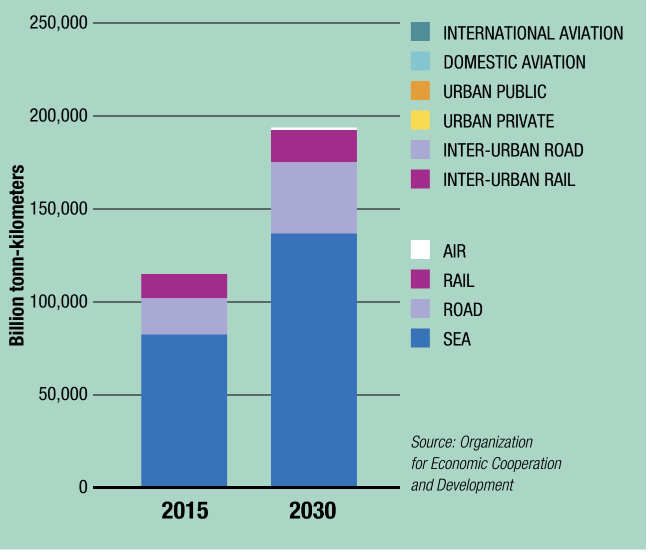
Source: IEA

GLOBAL TRANSPORT WILL CONTINUE TO GROW

Passenger transport volumes
(Business as Usual 2015-2030)



Freight transport volumes
(Business as Usual 2015-2030)



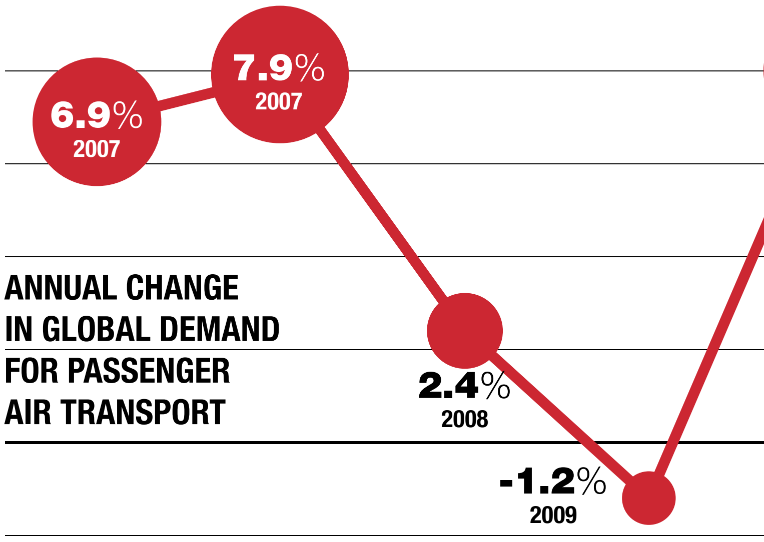
Source: Organization for Economic Cooperation and Development port oracle that takes in information about the world from the news, ticket websites, weather forecasts, music charts, sports tables and based on this information about an event reconfigure the transport system to meet travel demand needs by making better use of existing resources. Furthermore, in the developing world flexible on demand services driven by data have the potential to help by "skip a generation," just as we've seen with mobile technology. For example, in a Data 4 Development project sponsored by Orange Telecom, researchers at IBM redrew the bus network based on using mobile phone data and found they were able to reduce travel times by 10 percent. Technology like this combined with AI can allow bus networks to reconfigure themselves in real time based on the location information of users. It is impossible to discuss AI and transport without considering autonomy. More than any other technology, autonomous vehicles have the potential to bring about radical transformation in this sector. Currently a number of methods are on trial such as LIDAR based navigation. However as AI and Computer Vision progress it seems inevitable that the future system will be designed around cheap camera sensors that use sophisticated AI algorithms to "see" the world, thus enabling the roll out of self-driving vehicles that can exceed human performance in terms of safety and reliability. Clearly these vehicles need to be electrically powered in order to have sustainability benefits. However, autonomy enables a new form of business model, Autonomous Mobility On Demand (AMOD). Similar to ride-sharing, under this paradigm car ownership would disappear and either a government or company would supply a fleet of autonomous vehicles which could be hailed by passengers through their mobile phones to take them to their desired locations. Simulation studies have shown that it's possible to serve significant numbers of passengers with much fewer vehicles on the road through this type of shared resourcing, which reduces congestion and the consumption of resources for a more sustainable system. This business model could also be a key enabling factor in the financing of Electric Vehicles which have high upfront costs but much lower operating costs, so operating this asset in an AMOD scheme would be an excellent means of maximizing revenue.

Autonomy in the aviation sector

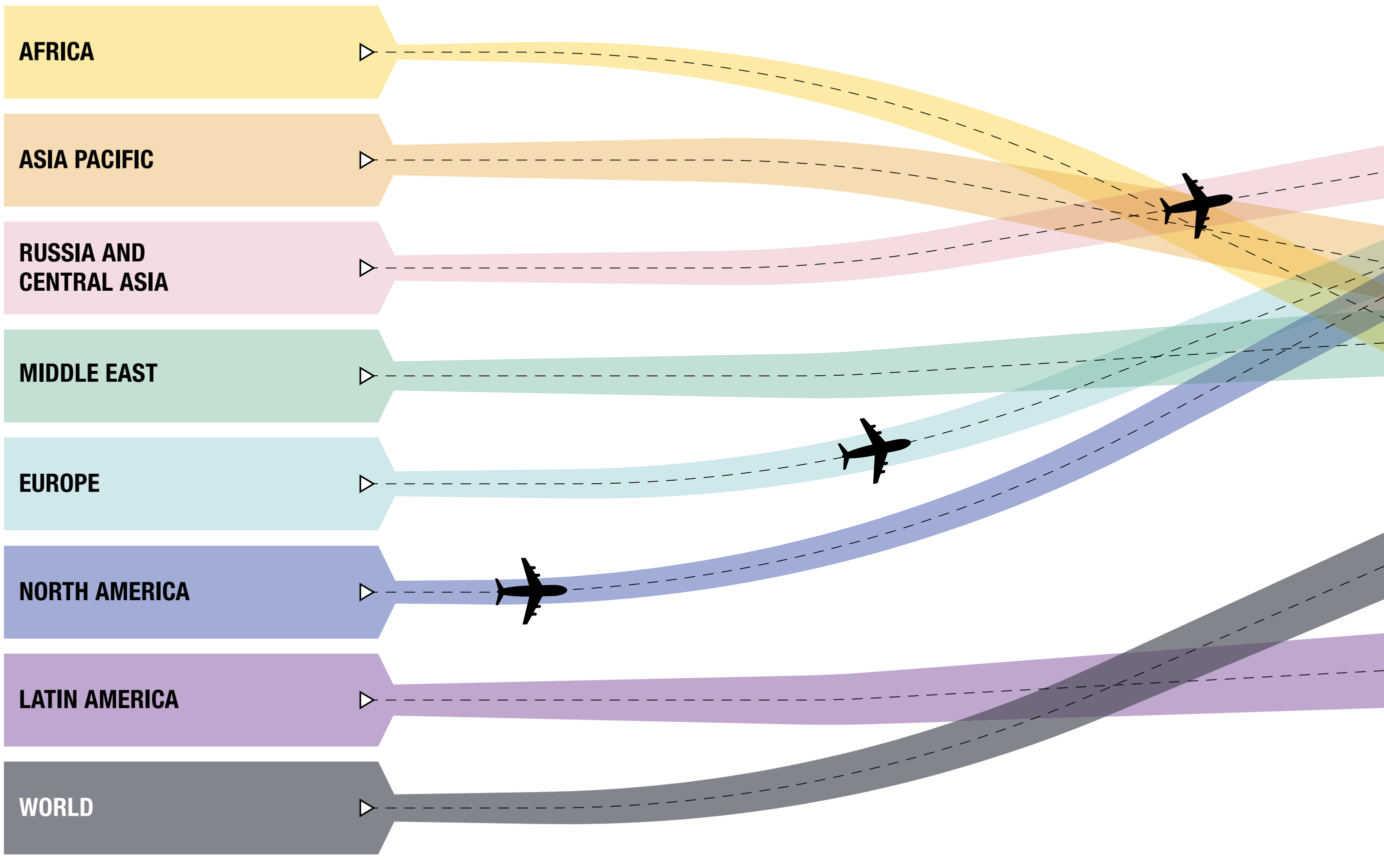
Autonomy is not just limited to road vehicles and may be even more transformative in the aviation sector. This sector of transport faces considerable challenges in achieving zero carbon aviation, as the energy density of aviation petroleum products is challenging to match. While electric power boasts greater efficiency in conversion of stored energy, battery technology will need to evolve considerably to be viable for powering current aircraft such as an A320 or Boeing 747. But autonomy may allow us to rethink aviation. Airbus is developing a new type of vehicle through its Vahana project that includes plans for an electrically powered vertical take-off and landing autonomous air taxi. Since the vehicle is autonomous it does not face the costs associated with a pilot that modern aircraft incur and which clearly scale with the number of aircraft. This could enable a business model for air travel different from the mass transport of 180+ passengers in a single rigorously scheduled vehicle becoming the way of the past and the future being much greater numbers of far smaller electrically powered craft transporting passengers autonomously. This is similar to developments we are seeing in freight where companies like Amazon are funding research into replacing large delivery trucks with autonomous flying delivery drones. Clearly navigating a city safely requires a level of AI that currently doesn't exist but progress in this area as well as in swarm intelligence could allow for self-organizing fleets of delivery drones that work together to deliver packages more efficiently and sustainably and replacing fleets of delivery trucks. In the near term, freight companies are already using AI and data to make better use of resources and the U.S. parcel delivery company UPS has demonstrated impressive results from investing heavily in an analytics program known as ORION (On-road Integrated Optimization and Navigation) which is the firm's fleet management system. Optimizing the routing of trucks and delivery of packages is estimated to have saved UPS 100 million miles per year or a reduction of 10 million gallons of fuel. While this has obvious revenue benefits, it also aids sustainability by reducing carbon emissions by 100,000 tons.

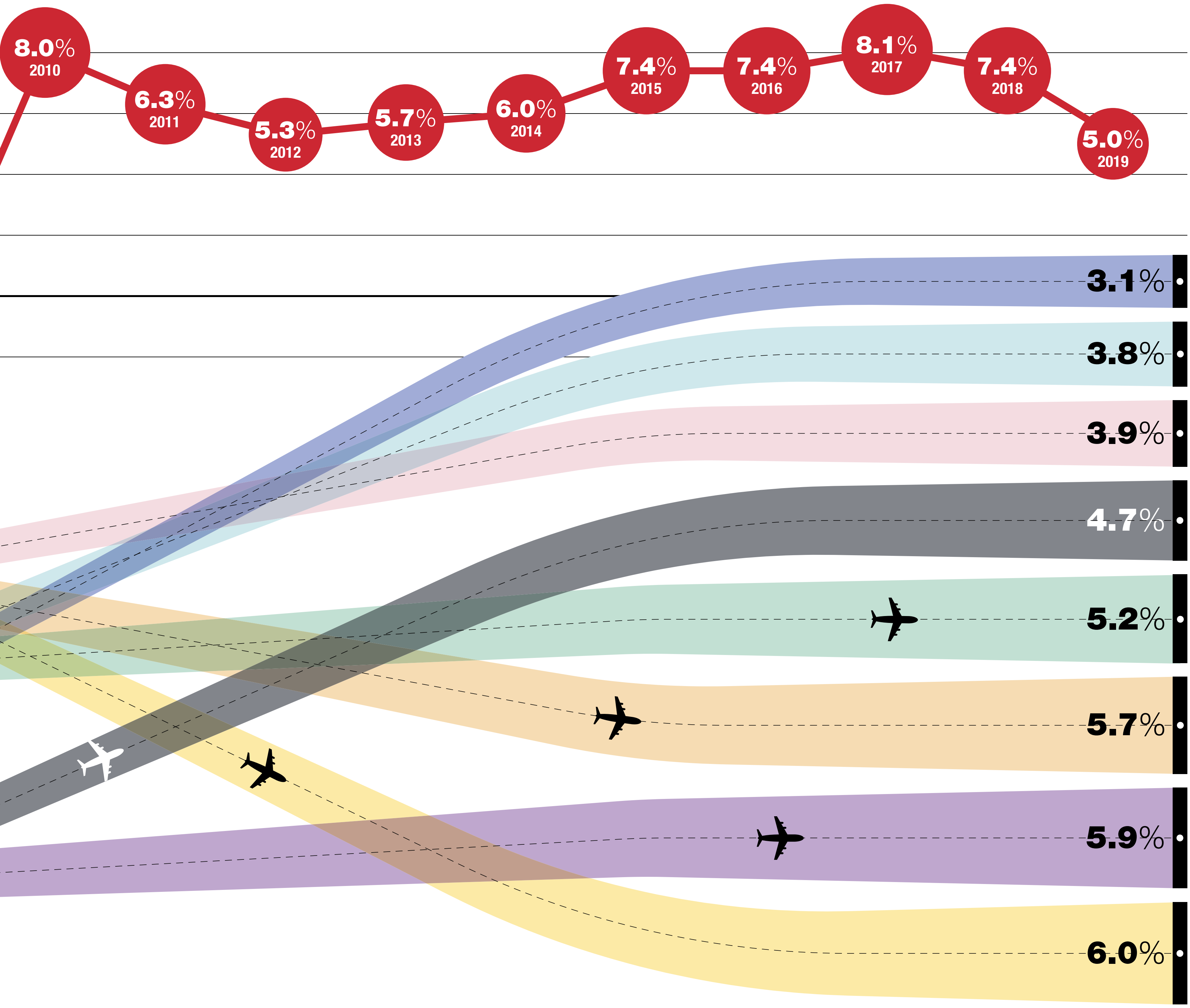
The unstoppable growth of air transport

Global passenger air transport demand has grown at an average annual rate of 7 percent over the past five years, as you can see in the figure on the rigth. The increase in demand is expected to slow down to 5 percent in 2019. The graph below shows the expected annual growth rates for air passenger and freight transport from 2018 to 2037, broken down by region. The RKP (the number of paying passengers transported multiplied by the number of kilometers flown) is expected to grow by 6 percent in Africa by 2037.



ANNUAL GROWTH RATES IN AIR TRANSPORT FROM 2018 TO 2037





Towards "smart" batteries

Battery technology is set to be a cornerstone of the move to a more sustainable transport system with electric vehicles charged by renewably generated electricity representing a zero-carbon solution to our transport needs. While the chemistry places a fundamental limit on what is achievable in terms of some aspects of battery performance, AI can still play a role in intelligent battery management systems which optimize temperature and performance within the cells of the battery to extend its lifetime, thereby reducing capital costs associated with the technology. Capital costs are one of the chief drawbacks of electric vehicles, which are far cheaper to run but require greater upfront investment. On a more radical level AI algorithms can be used to test millions of different combinations of battery chemistries in simulation to develop the next generation of battery technology. This is akin to computational drug discovery, where the space of possible combinations is vast and intelligent algorithms such as genetic evolution methods are required to search the space efficiently as even with today's sophisticated computing infrastructure a brute force search is infeasible.

To conclude it is vital that a sustainable mobility revolution be launched and soon. Progress in AI allowing for "narrow AI" algorithms that can make complex decisions to solve specific tasks in uncertain and dynamic environments have been able to demonstrate superhuman performance and are a vital technology in enabling and supporting this revolution. Application of this technology in the transport sector can produce the radical innovation desperately needed to accelerate the transition to a more sustainable transport system. Key applications that are actively being researched and have the potential to solve some of the particular challenges associated with the transport sector include AI virtual city models for transport planning, algorithms that enable flexible on demand public transport services that are context aware and adaptive to the state of the world, autonomous vehicle technology in both road and air vehicles, advanced drone delivery technology replacing current freight fleets and AI algorithms that can enhance current battery technology and aid the development of new technology. However, these examples are just the tip of the iceberg—many more radical applications of AI will be needed in the sector in the coming years.

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Sustainability/Policies to create a safe environment

Europe, the Answer to Pollution is Technology

ROBERTO VIOLA

He is Director General of the DG Connect of the EU Commission since 2015. Previously he was Deputy Director General, President of the European Radio Spectrum Group (RSPG) and President of the European Regulatory Group (ERG). From 2004 to 2012 he was General Secretary of the AGCOM, the Italian regulatory authority for electronic communication, postal, audiovisual and media services.

Digital can be a remarkable help in the fight against climate change especially in regards to efficiency as shown in the smart grid. The European Commission promotes its contribution to interoperability where it is a model for the rest of the world

We owe it to ourselves, to the generations to come and to our planet to support the transition to a smart, secure and sustainable energy system. In order to implement the Paris Agreement and lead the global fight against the impact of climate change, the EU has committed to a drastic reduction in its greenhouse gas emissions, and this means that the energy sector will have to step up its efforts. Bringing together the digital and energy sectors could offer real benefits.

Most observers believe that by the middle of this century, our energy systems will be well on the way to sustainability, driven by the ongoing switch from fossil fuels to renewables. By 2050, the share of electricity in the final energy demand is expected to be around 53 percent, and Europe will continue to lead the way towards this goal.

Fundamental progress has already been made in transforming Europe's electricity production. The global expansion of renewable energy, led by the EU, has produced massive cost decreases in the last 10 years, in particular in solar and on- and off-shore wind. Today, more than half of Europe's electricity supply is free from greenhouse gas emissions.

By 2050, more than 80 percent of electricity will come from renewable energy sources. Electrification will open up new horizons for European companies in the global clean energy market, which is already worth around €1.3 trillion. For the EU, where six of the world's 25 largest renewable energy businesses are based (employing around 1.5 million people), this will be a unique business opportunity. It will also give an important role to so-called prosumers (people or organizations that both produce and consume energy) and to local communities in encouraging the residential take-up of renewables.

Digital technology goes hand in hand with efficiency

In order to reach the ambitious targets for cutting emissions, we need greater energy efficiency as well, and this is one area where digital can play a clear role. As the number of prosumers entering the market continues to increase, digital technologies such as smart meters can help them better understand their energy consumption. Connecting meters to appliances via home energy management systems (the so-called Internet of Things) so that appliances can be activated when energy is cheaper, for example, is a key part of this approach, a "new deal" for consumers that the European Commission proposed in its package on Clean Energy for All Europeans.

As the energy sector moves away from its traditional monolithic working methods based on fossil fuels towards a plethora of suppliers, prosumers and energy sources, digital technologies have a real role to play in helping to deal with this increasing complexity. We need a reliable smart grid infrastructure, as well as a data ecosystem governed by the principles of interoperability and openness. The single energy market and the digital single market must therefore go hand in hand.

Smart grids are a clear example of digital meeting energy. Smart grids are about information exchange and making necessary data available to interested parties. They are where the energy, ICT and telecom sectors come together, an embodiment of the meeting of the EU Energy Union and the Digital Single Market, both in terms of infrastructure and market.

In these times when grids have to cope with an increasing share of renewable energy, decentralized generation and new loads, such as electric vehicles, making them smarter and more self-adaptive is a good solution. They are also an opportunity for European manufacturers to develop attractive smart grid solutions and boost their global competitiveness.

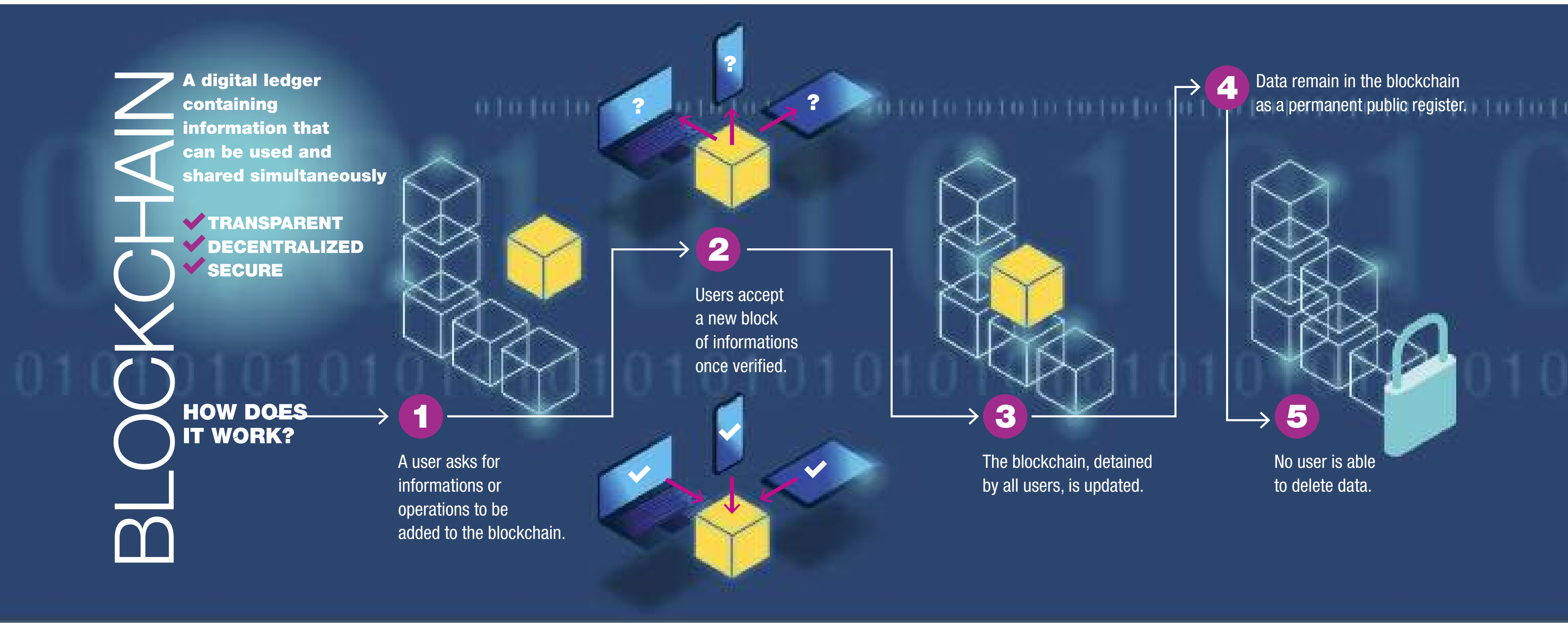
There are already many promising examples in the EU. For instance, by connecting all electric vehicles to the grid, we could take advantage of unemployed battery storage. One car manufacturer already cooperates with a heating system producer to optimize the use of electricity between the battery of an electric car and heating systems to reduce consumption from the grid at peak hours.

All these solutions have to be digital to make them work. But if digital connections allow them to talk to each other, they also have to be able to understand each other's language—in other words, they need to be interoperable in order to be fully efficient. Europe has also been leading the way in making sure that interoperability is possible by setting standards such as SAREF, which supports communication between appliances. Four years ago, SAREF became a standard of the European Telecommunications Standardization Institute (ETSI) and the Global initiative for Internet of Things standardization (OneM2M), clear evidence that where Europe leads, the rest of the world often follows. We are now extending this standard to other relevant domains, such as energy, smart cities, automotive, water, manufacturing, agriculture, etc. We are also working to spread the use of these standards and turn them →

into new services for consumers so that they can fully benefit from the opportunities that smart appliances, smart buildings and smart grids enable.
For digital technology to truly make a difference, it needs to be developed in cooperation with the many and varied sectors of industry where it has a role to play. With this in mind, the EU is supporting a number of large-scale pilot projects, funded with €400 million from the Horizon 2020 research budget, focused on the Internet of Things. The aim is to speed up the roll-out of digital technologies in a wide range of sectors, in turn developing true economies of scale. These large-scale pilots provide support tailored to a thriving ecosystem made up of developers' communities across Europe, where APIs (Application Programming Interface) and platforms are open to SMEs (Small and Medium-sized Enterprises) and start-ups working on some of the key technologies in this field: connected cars, electric mobility, smart homes, smart and clean cities, interoperable grids. We should not underestimate the EU's strength in the field. Many leading businesses, start-ups and SMEs are European, offering great products and services, meeting real consumer demands and expectations. The Commission is also closely involved in the development of this exciting new technology through, for example, the Alliance on Internet of Things Innovation, a forum for discussion and policy exchange on the IoT across different sectors.
As the energy sector evolves and diversifies, the many new players involved in generation, supply, distribution or consumption also bring another important source of 'fuel'—their data.
In today's reality where everything is connected, data has become the most valuable resource of our economy. New European rules on the free-flow of non-personal data will enter into force in May 2019, helping to create a truly European data space without unjustified or disproportionate national rules restricting companies' location choices for data storage and processing. As a result, Europe's data economy could double its value to 4 percent of GDP in 2020 and create more than €1.9 billion additional revenue in the manufacturing sector.

The benefits of the data market for the energy sector

The energy sector, like many others, stands to gain from this expansion of the data market. But it will have to be prepared to work in new and different ways if it wants to benefit fully: in addition to sharing its own data, it must also be open, for example, to supporting the testing and application of innovative data-led services.
Access to increased quantities of data is particularly important for artificial intelligence (AI), which is expected to be one of the key drivers of economic and productivity growth in the future. It is estimated that AI could contribute up to €13.3 trillion to the global economy by 2030—and the energy sector has great potential to embrace it.
Concretely, machine learning could be used to forecast supply and demand in real time and optimize economic load dispatch: AI algorithms will able to recognize patterns of behavior on a weekday evening in 2025, when millions of electric vehicle drivers arrive home and put their vehicles on charge. By distinguishing between drivers who habitually use their cars overnight and those who leave vehicles charging until the following morning, the



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AN INTELLIGENT STANDARD
Europe promotes interoperability through the definition of standards such as SAREF (Smart Appliances REFerence ontology), which allows intelligent devices to communicate with each other. The EU is now expanding this standard from telecommunications to other important areas, such as energy, smart cities and the automotive sector.

smart grid will ensure that the battery is sufficiently charged in time for the driver's next journey, without exerting simultaneous load on the grid.

AI could also be used to help consumers choose their energy retailer based on their preferences—such as energy generation type, how much they are willing to pay and their consumption patterns—and then scanning the market for the most suitable offers.

Developing the potential of AI is a top priority for the Commission—→

ONLINE SECURITY

1 MALWARE

It is a software created specifically to enter or damage a computer without the owner knowing.

THE MOST COMMON FAMILIES OF MALWARE BY TYPE

Cryptocurrency Mining	32%
Remote access trojans	17%
Spyware	13%
Botnet	12%

92% — 92 percent of infections from malware detected arrive via email

Most recurring objective IoT devices

2 ATTACKS ON THE WEB

All available techniques concern redirection of browsers to malicious sites.

THE TOP 4 COUNTRIES TARGETED FOR ATTACKS

US	46%
Holland	26%
Germany	5%
France	5%

Incidents related to Content Management Systems (CMS) are increasing

3 ATTACKS FROM APPLICATIONS/WEB INJECTIONS

Switch to vulnerable inputs for vulnerable mobile servers or mobile apps with the aim of injecting malicious code.

51% — The most frequent attacks are SQL injections

They are often connected to huge violations world data

4 PHISHING

Attempt to steal / intercept username, password and banking credentials using fake emails and counterfeit websites.

Responsible more than: 72% Data breaches in organizations

90% Infections from malware

+85% Phishing attacks on mobile devices they have grown with an annual average 85% since 2011

5 DDoS

Distributed Denial-of-Service: Targets companies and organizations and make systems or networks inaccessible to users.

59% of the attacks happens in China

55% of the attacks lasts less than 90 minutes

Source: European Union Agency for Network and Information Security (2019)

its possible applications stretch far beyond the energy sector—and late last year we presented a Coordinated Plan on Artificial Intelligence alongside the EU Member States that sets out in concrete terms what we propose to do to reach the ambitious goals we have set ourselves in this area. The energy sector is one of the Commission's priorities when it comes to AI research and deployment. Our policy support for AI will be backed up by financial support too. As well as ongoing support from the Horizon research budget, we have proposed a new funding program from 2021, the Digital Europe Program, which will focus specifically on digital technologies of strategic importance for Europe, including AI, supercomputing and cybersecurity. One of the key focuses for AI will be the rollout of large-scale testing and experimentation facilities for AI deployment in a number of strategic sectors, such as healthcare, autonomous and automated driving, as well as in energy. In total, €2.5 billion of the €9.2 billion proposed for the Digital Europe program will be for AI.
Perhaps the other most exciting future technology as far as the energy sector is concerned are blockchain and other distributed ledger technology applications. Blockchain has the potential to change the way consumers and the Internet of Things interact with the energy system, by providing a secure and trustworthy way to integrate actions by, for example, solar panels or an electric car battery that can inject energy into the grid. By reducing transaction time and costs, blockchain technology has the potential to empower prosumers, creating a customer-empowered energy system and contributing to the democratization of the energy system, enabling peer-to-peer trading and facilitating new models for energy market design.
To support the work on blockchain, the European Commission in February 2018 launched the EU Blockchain Observatory and Forum, which aims to accelerate blockchain innovation and the development of the blockchain ecosystem within the EU, and so help cement Europe's position as a global leader in this transformative new technology, of which the energy sector could be a key beneficiary.
Blockchain brings a superior level of trust and security to transactions and exchanges within the energy system, but we also have to ensure that all of our digital operations—and the data they carry—are safe as well. While a smarter European power grid brings clear advantages for the energy sector, it also presents new technical challenges, notably in terms of cybersecurity. Simply put, the more devices become digitally smart and connected to the energy and power system, the more they offer potential access points for cyberattacks on critical infrastructure.

The importance of maintaining cybersecurity

Because of the central role that energy infrastructure plays in our economy and society, it is paramount that we avoid any disruption and minimize the vulnerability of industrial control systems in the electrical, water, oil, gas and data parts of it. As cyber-threats know no borders, it is imperative that there is a permanent framework of operational cooperation and exchange of information when it comes to cybersecurity incidents.
At EU level, such a framework is set by the Network and Information Systems Directive, adopted in July 2016, which is the cornerstone for strategic cooperation among Member States and for improving the resilience of critical sectors including energy and transport. Consistent implementation of the directive across different sectors and Member States is provided by the NIS Cooperation Group, which decided to establish a dedicated work stream on cybersecurity in the energy sector in 2018. The purpose of this dedicated work stream on energy is to provide support to Member States on identifying the particular characteristics of the energy sector when implementing the Directive.
In addition to the NIS Directive, the recently adopted Commission Package on Clean Energy for All Europeans includes provisions for the adoption of future technical rules for electricity such as a network code on cybersecurity. And last June the Cybersecurity Act, which envisages the creation of a European certification framework for the creation of tailored certification schemes, came into force. The development of certification schemes for critical or high-risk applications—including components of energy networks - is among the priority areas.
Over the past five years, we have worked hard to create the regulatory and legislative framework necessary to making the Digital Single Market a reality. Now we need to take it to the next level, weaving digital technologies into every other industrial sector, including energy. The potential is great, for efficiencies, for improvements and for greater sustainability. The onus lies on us all now to make it happen.

Climate change/Brussels' policies on the climate, energy and renewables

Europe's Gamble

Europe's ambition to become the most important global change agent in technological innovation will depend on wise use of the budget devoted to it in the next 7-10 years. The EU feels that it could be the first global power in this field

ROBERTO DI GIOVAN PAOLO

A journalist, has written for, among others, ANSA, *Avvenire* and *Famiglia Cristiana*. He was Secretary General of the Italian Association for the Council of European Municipalities and Regions, and he is a lecturer at the University of International Studies of Rome.

Whether or not you agree with the climate policies or have doubts about the Intergovernmental Panel on Climate Change (IPCC) report adopted last October by the United Nations, Europeans, whether leaders, entrepreneurs or ordinary citizens, can not ignore the policy framework proposed by the Commission and European Parliament, as it provides a basis for the work to be done by the new Commission President, Ursula Von Der Leyen. The framework—based on the budget proposal that was finalized in May 2017 and which was to be approved last May 9th at the Sibiu Summit (it was then delayed due to the European Parliament elections)—is not expected to change substantially, thus expressly dedicating 25 percent of the Commission's budget and related structural funds for the period 2021-2027 to the battle for climate change, the environ- →

1

GERMANY'S ENERGY REVOLUTION

Germany leads Europe's energy transition. For several years the German government has supported a remarkable effort to bring the country to renewable sources, especially wind and solar. Its policy, called "Energiewende," is supported by 92 percent of the German people. Roughly 27 percent of Germany's electricity is from renewables and the goal for 2050 is at least 80 percent. Pictured on page 45 is the nuclear reactor at Kalkar, a plant finished just before the 1986 explosion at Chernobyl, Ukraine, and never used. It's now an amusement park with a ride in what would have been a cooling tower. Fear of nuclear power spurred Germany's transition.

Luca Locatelli is an Italian artist combines fine art photography and photojournalism. His work revolves around the interactions between people, technology and the environment. Luca is a *National Geographic Magazine* photographer and contributor for *The New York Times Magazine* and often collaborates with other medias such as *Time*, *The New Yorker*, *Bloomberg Businessweek*, and *Wired*.

ment and renewable energy. Behind this plan is an ambition, supported by the document approved in November 2018, for the European Union to play a leading role on these issues and be the first to achieve zero emissions. The new President reiterated this during her investiture speech in the European Parliament and the negotiations that preceded her "début" in the European Council, under the Romanian Presidency last June. She detailed policy outlines with a final document that dedicates a paragraph to "the importance of tackling climate change in line with the Union's commitment to implement the Paris agreement and the UN's sustainable development goals."
Therefore "programs and instruments should contribute to the integration of climate actions and the achievement of the general objective of allocating (at least) 25 percent of budgetary expenditure." What does this mean in daily practice for each Member State, which should have presented a general plan by December 2018?

EU 27 commitments and funds

I should point out first of all that we are talking about a draft budget and funds for 2021-2027. These are currently being debated by the new European Parliament, which can approve or reject them in their entirety but not propose individual amendments. Given that, following the European Council's decision to postpone the final decision and the related agreements, outgoing legislators only issued an "interlocutory report" on the multi-year financial framework and in theory any changes can only be made following a laborious meeting of the "sherpas" from each individual country, who are analyzing the budget and its items, calculating losses and related gains. However, it is highly likely that the general framework will not change and the allocation of approximately 1.246 billion euros at current prices, or 1.08 percent of the EU 27's Gross National Income (GNI), will be confirmed. (The United Kingdom and its position as a net contributor of 8-10 billion

2

3

4

1 - Finowfurt, 100 miles south of Berlin, is today an active small airport and one of the biggest solar installations in Europe and in the world. Generating roughly 82 million kilowatt hours, the power plant can cover the annual needs of 23,500 households.

2 - A German technician inside an environmental chamber for humidity testing at TUV Rheinland a leading testing company in the solar industry, based in Cologne.

3 - From the command deck of the Baltic Queen: ferry became a residential facility for offshore workers. It is possible to see a wind farm 30 miles from the German coast.

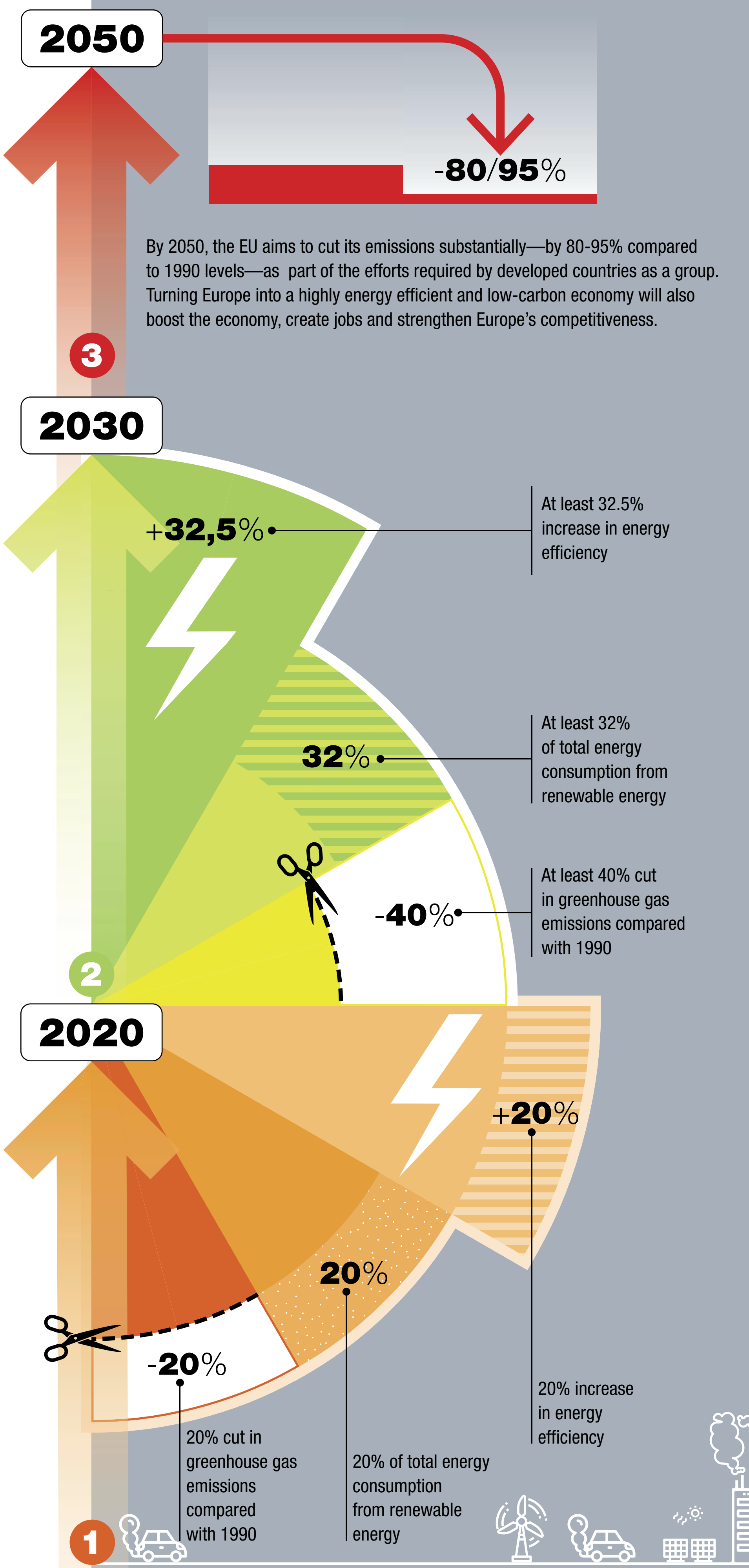
4 - A Siemens maintenance vessel floats among wind farms more than 30 miles from the German shoreline. The vessel can hold up to 40 technicians, has a workshop, holds small turbine parts, and can safely deliver workers to turbines in eight-foot swells.

euros a year will be lost.) Within these figures is a commitment on the part of the European Union to climate, renewable energy, combating emissions and the circular economy in line with the projections of the 2015 Paris Agreement for a two degree decrease in global warming, bringing it to at least 1.5 degrees by 2030. The EU has set itself a first threshold of a 40 percent reduction in its contribution to global emissions and also, starting with Africa, making a contribution to improving conditions in countries with which it has a stable trading relationship.
The objective, however, is ambitious, considering that a quarter of the EU budget and funds will be devoted to it, and it involves all EU policies (or almost all of them—the proposed action concerns energy and its efficiency, the development of renewables, mobility, industry, infrastructure and European infrastructure connections, the bio-economy of biomass and the circular economy), the thorny issue of the transition from coal and the organization, both administrative and social, of a sustainable society, particularly in a continent where 75 percent of the people live in a situation that can be defined as "urbanized."
The road has already been marked, and it is a very long road map that requires intermediate stops, verifications and monitoring. Launched with current funds, the program calls for a 20/20/20 option for 2020: a 20 percent cut in the 1990 parameters for CO_2 emissions, 20 percent more renewable energy and 20 percent more efficiency in the use of existing energy resources.
This program is objectively almost completely in sight, so much so that the European Union has relaunched it with new targets for 2030, bringing success rates to 40 percent for emission cuts, 32 percent for sharing renewable energy and finally 32.5 percent for more efficient use of available energy in its entirety. In short, the European Union feels that, in the wake of the US trade wars and China, it might be able to seize the opportunity to be the number one global power in this field, with repercussions on the economy, society, innovation and employment. (In this respect Brexit could be significant, because the UK has been one of the countries that has most ardently marched in sync with the EU's demands in field.)
The budget is in fact based on the "long-term strategy for 2050," which lists possible actions also divided territorially within the Union, taking into consideration the substantial social and industrial differences between Scandinavian countries and the continental or Mediterranean economies. Eight specific scenarios are considered: the production of lower emissions, the widespread use of renewable energy and decarbonization, transport and mobility policies, the use of land, the environment and new agriculture, an innovative and technologically cutting-edge European industry in the world, the sustainability of cities, the construction of socially informed and resilient communities and the social "experience" of a circular economy. Concrete measures, replicable actions, stringent checks and huge costs, both in the public and private sectors, must be carefully considered.
In the first scenario above, a lot of attention is being paid to the current condition of the continent's buildings: "energy efficiency will be decisive and the most visible drop in energy demand will occur in buildings, both in the residential sector and in the service sector, whose energy consumption now stands at 40 percent. In 2050, most of the building stock will be made up of buildings that already exist today. The rate of refurbishment needs to be stepped up, switching to different heating fuels so that the vast majority of houses are heated by renewable energy (electricity, district heating, renewable gas or thermal solar power), disseminating the most efficient products and equipment, using intelligent building and equipment management systems and improving insulation materials", the European Commission writes.
There is also widespread discussion about the current problems of transport and mobility, which produce →

CLIMATE ACTION

Preventing dangerous climate change is a key priority for the European Union.
Here are the numbers of intentions and commitments for the near and long term.

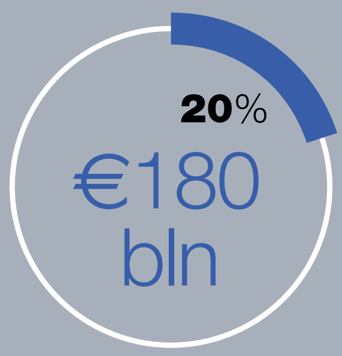
EU TARGETS FOR 2020, 2030 AND 2050



By 2050, the EU aims to cut its emissions substantially—by 80-95% compared to 1990 levels—as part of the efforts required by developed countries as a group. Turning Europe into a highly energy efficient and low-carbon economy will also boost the economy, create jobs and strengthen Europe's competitiveness.

Source: European commission

FINANCIAL SUPPORT



At least 20% of the EU's budget for 2014 to 2020—as much as €180 billion—should be spent on protecting the climate. This is on top of funding from individual EU countries.

The EU finances low-carbon energy demonstration projects from the sale of emission certificates. This includes technologies to trap carbon dioxide from power stations and other industrial installations and store it in the ground, so-called carbon capture and storage (CCS)

REGULATION

The EU's emissions trading system is the key tool for reducing greenhouse gas emissions from industry at the lowest cost.

EU countries are required to support renewable energy sources such as wind, solar and biomass to reach the green energy targets.

EU countries have to reduce the energy use of their buildings and industries are required to improve the energy efficiency of a wide array of equipment and household appliances.

Car manufacturers have to reduce CO_2 emissions from new cars and vans.

25 percent of current EU emissions, two-thirds of them from road transport alone, not to mention that everything that travels by sea, from or to Europe, consumes one billion tons of fuel per year, producing 3 percent of global/world-wide emissions. Here too the EU is providing funds for switching to other fuels, greater efficiency in energy use and renewing the European shipping stock, starting with fishing boat fleets. There is also a commitment to create financing lines for projects related to the climate and energy challenge, as well as European Union plans to invest in remote, rural or island areas, or projects in neighboring Africa, including providing economic support for technological upgrading and change in regions that have long been struc-

turally committed to coal and linked to its economy, and finally investments in industrial sectors and technological and public and private mobility hubs.

These actions provide for millions of euros of integrated investments in each of the seven different areas of the European budget and could, according to Juncker's EU Commission, which is now passing the baton to Von Der Leyen, bring the Union's commitment in this field from 2 percent of GDP currently invested to around 2.8 percent as early as 2030. This percentage of GDP equals 550 billion euros of total public and private commitment, including around 200 billion in investments alone. This is why the EU is already showing its satisfaction and reaffirming its commitment with the 70 billion euros a year invested in supporting the European energy system. This would guarantee a 1 to 1.5 percent increase in employment levels according to Commission documents, new employment derived from the policies on climate change, the circular economy and technological innovation for new renewable energies.

A challenge that Europe is setting for itself

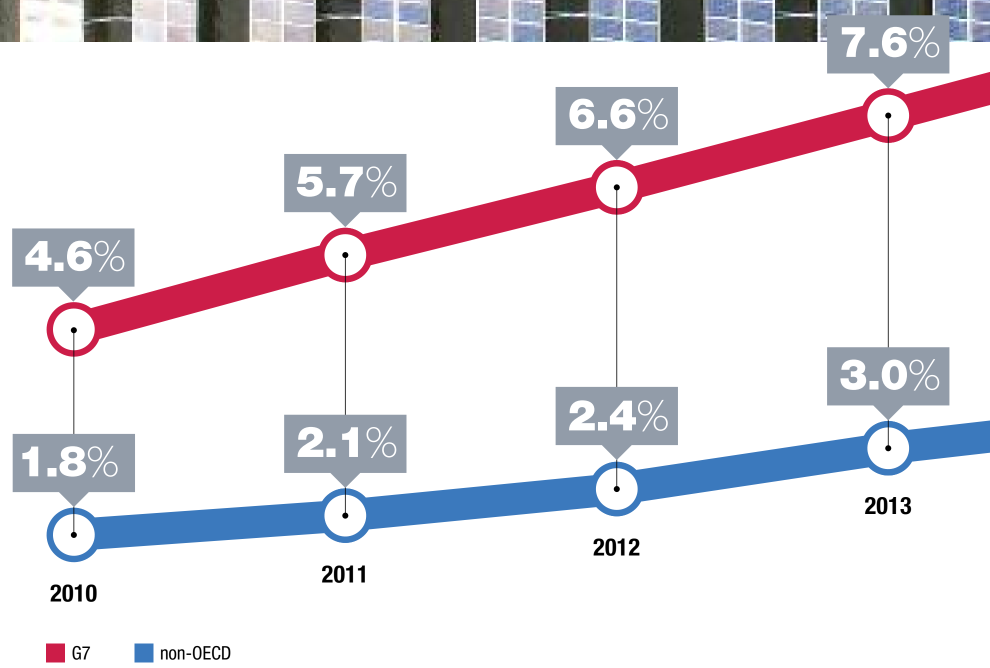
Here, then, is the paradox: while those who zealously denounce the risks of climate change scramble to define as "post-truth" the reasons that Trump and the detractors of the IPCC and the United Nations believe to be the actual global "post-truth" that needs to be fought, the leaders, entrepreneurs and citizens of the European Union, whether willingly or not, have to deal with a challenge that will mobilize resources, projects, initiatives and actions with an economic lever that the European Union estimates to be around 312 billion euros over the next seven years (this being only the "public" part of the Union, not taking into account the power that can be exercised on private financial commitment in these sectors). Whichever way you look at it, this is a commitment not just for the EU but also a challenge that Europe is setting for itself, not only as an institution but as an economic and social community. The worst thing would be to pretend that the challenge/opportunity does not exist.

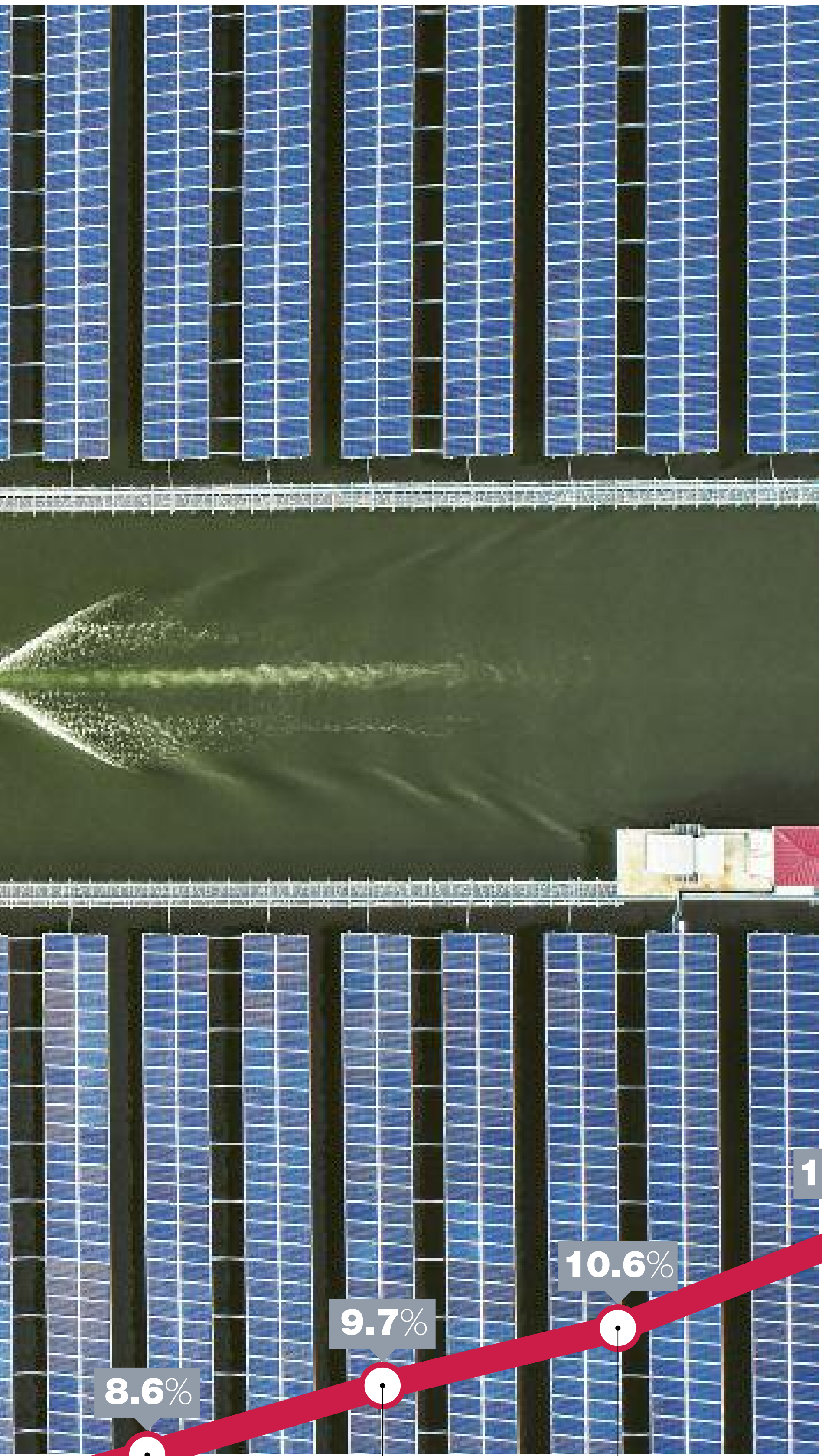
Outside the village of Feldheim, visitors tour the wind park. It sells electricity to the national grid—but also supplies a local grid that makes Feldheim self-sufficient.

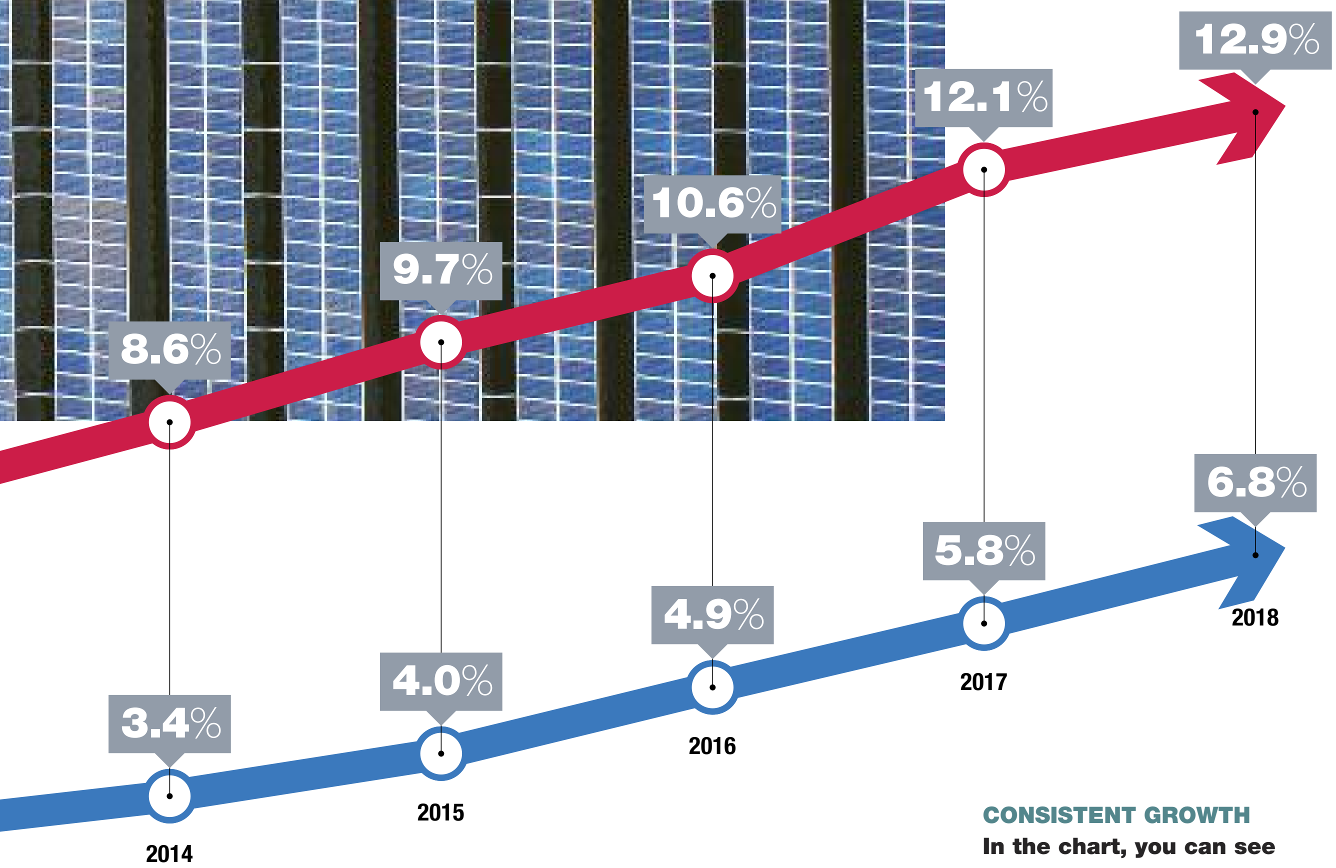
Climate and energy/Measuring the real results of green techniques

"Yes, but" to Green Technology

Not all green technologies are as green as they seem. It's crucial to analyze them more comprehensively, using measures such as ecological footprint. Further, we must recognize that the world is unlikely to stop using fossil fuels in the next twenty years







CONSISTENT GROWTH
In the chart, you can see the growth in the share of renewables in electricity production (excluding hydroelectric) in the G7 and non-OECD countries.

ALESSANDRO LANZA

Consultant for institutions and agencies on energy issues and climate change. Former Principal of Eni Corporate University. Previously, Executive Director at the Eni Enrico Mattei Foundation and Chief Economist at Eni.

According to recent studies conducted in the United States by NASA and NOAA (the National Oceanic and Atmospheric Administration), the average temperature on this planet in 2018 was 1.1 degrees Celsius higher than in the 1980s. This increase was largely due to the emissions into the atmosphere of greenhouse gases, primarily carbon dioxide, the concentration of which has increased from 300 ppmv (parts per million by volume) in the pre-industrial era to over 400 ppmv today. The key mechanism of climate change is well-known. The Earth is surrounded by the atmosphere, a very thin layer of gas that is crucial to the balance of the planet. Its composition varies depending on altitude, but consists mainly of nitrogen (78 percent), oxygen (21 percent), argon (0.94 percent) and carbon dioxide (0.035 percent). The atmosphere, through which solar radiation passes unimpeded, is opaque to radiation emitted from the Earth's surface. Much of the solar radiation is then "captured" from the atmosphere and re-emitted in all directions, partly back to the surface of the planet. The greenhouse effect—to give it its unscientific name—is first and foremost a natural and extremely important phenomenon, bringing as it does the average temperature on Earth to its current +15°C. This is a crucial detail: without the greenhouse effect, the average temperature would be -18°C, like on the Moon, a satellite with no atmosphere, unlike Earth. Without the greenhouse effect, there would be no liquid water on the planet, only ice. The oceans, the rivers, life as we know it, must therefore be able to co-exist with the greenhouse effect.

The problem—now ubiquitous—is that because of human activities, for the most part due to the burning of fossil fuels, the concentration of gases responsible for the greenhouse effect, primarily carbon dioxide, is increasing worryingly, now reaching the highest level measured in the last 400,000 years.

The IPCC position

The Intergovernmental Panel on Climate Change (IPCC) is the scientific organization established in 1988 by two United Nations bodies, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), with a mandate to study global warming. The IPCC is a multi-disciplinary organization (involving climatologists, biologists, physicists, ecologists and economists). By publishing its reports (the first in 1990, the next, the sixth, in 2022), it has increased awareness of climate change among the public and politicians, and reported the increasingly alarmed →

URGENT SOLUTIONS

The solution to climate change is complex and will require cooperation and coordination among states and governments, as well as more comprehensive analysis of new technologies.

opinion of the scientific community. The IPCC does not conduct any scientific research or carry out any specific climate monitoring operations, but rather periodically issues extensive reports on current knowledge and possible forecasts for current worldwide climate change, in order to provide valuable scientific support to the United Nations Framework Convention on Climate Change. Each report is divided into three sections, drafted by three Working Groups:

- WG I assesses the scientific aspects of climate change;
- WG II deals with the impact of climate change on natural and human systems, emphasizing their vulnerability and adaptability;
- WG III researches methods to mitigate climate change and reduce greenhouse gas emissions.

To date, five reports have been published: the first (FAR) in 1990, used by the United Nations Conference on Environment and Development in Rio in 1992; the second (SAR) in 1995, used at the Kyoto Conference of the Parties in 1997; the third (TAR) in 2000; the fourth (AR4) in 2007 and the fifth and final one (AR5) in 2014. The next report is scheduled for around 2022. Historical analysis of the reports published so far, supported by increasingly clear scientific evidence, suggests that the problems related to climate change have increased significantly over the years, leading to greater concern about their impact and thus calling for stronger decisions on mitigation processes and the related policies. The reports available to date clearly show the role of human activity, which affects global warming by over 90 percent. This rising concern is due to the greater certainty of estimates, as a result of the increase in the number of studies and the extension of existing ones.

But is green technology really green?

The solution to one of the main apparent problems of this century is undoubtedly complex and requires cooperation and coordination of different policies, made and shared by many states and governments. The road still to travel remains very long. This can be demonstrated by a very simple statistic. In 1987, 81 percent of global energy consumption came from fossil fuels. Thirty years later, in 2017, the share of global energy consumption in the total had not changed, despite endless discussions on the role of renewables. Two asides: this is a global average and the local situation in each country can vary greatly. It is also only right and proper to jointly consider the issue of productivity, i.e., what proportion of GDP was produced with that amount of energy both in 1987 and 30 years later. In any case, the role of technology, as adopted and studied, is clear and central to the analysis of these problems. In this sense, there is frequent discussion on the possibility of considering energy technologies—especially those related to electricity generation—in greater depth and more comprehensively. That is, instead of simply observing to what extent emissions are associated with the production of a single kW/h via fossil or non-fossil technologies, we should focus on more comprehensive measures such as ecological footprint or input-output analysis. The underlying idea is conceptually very simple. Let's consider one or more technologies that produce electricity. The CO_2 emissions from such a hypothetical plant would be as follows:

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$$\textit{Total Emissions}_i = \textit{Construction Emissions}_i + \textit{Decommissioning Emissions}_i + \textit{Operations Emissions}_i + \textit{Indirect Emissions}_i.$$

The total emissions of a power plant depend not only on those produced during operations—which would be zero in a plant powered by renewable energy—but also on those related to the construction and decommissioning of the plant. Moreover, and this is a crucial aspect, all indirect emissions, i.e., those related to the construction of the components of any plant, whether a coal-fired power station or a wind farm, should also be taken into account. If the question is conceptually simple, it is less so from an application point of view. The first question is normalization, i.e., the concrete challenge of comparing very different plants. The only way to compare them is to divide total emission values by total production, or how many kilowatts a plant has produced during its life span. Although the operation can be conducted easily, it is clear that the ever-present risk is to compare objects that are actually very different. A medium-sized 640 MW coal-fired power station—just for example—produces 3.2 TW/h in one year (640 x 5000). If its life span were 40 years, it would have produced around 128 TW/h by the time it is decommissioned. This is an optimistic and very rough estimate, which does not take into account the obsolescence of the plant, among other things. During these 40 years of useful life, the plant would also have produced 120 megatons of CO_2. To understand the difficulties of the comparison, it must be noted that 90 percent of the photovoltaic power plants installed in Italy (corresponding to 20 percent of the country's electricity) produce less than or equal to 20 kW of power. Over the course of its lifetime, a 50 kW solar park produces 0.016 TW/h. It would take 8,000 TW/h to bring it into line with the production of the coal-fired power plant above. Normalizing these two technologies is a very complicated exercise because it is not only emissions that count, but also the production of energy per euro of investment. In Italy during 2018, the 54.4 GW of installed power, from more than 800,000 plants, generated 114.7 TW/h of electricity. Production from renewable sources in Italy thus increased by 11 TW/h on 2017, mainly due to hydroelectricity. By very roughly dividing the installed power by the 800,000 plants, the average power output per plant is 68 kW. In fact, if we discount hydroelectric plants (few in number and generally characterized by their major power production capacity), the value drops significantly. The fact is that the vast majority of photovoltaic power stations are domestic (with a peak of 2-3 kW), which clearly benefit from important incentives. It's like measuring the length of a baby's foot in its crib compared to measuring that of a running elephant.

What we can't see

The operation is simple: to measure the length of a foot. In fact, this proposition is only liminally possible. Two final considerations. The first is that not all green technologies are as green as they appear and the debate on the life cycle of electric cars is serious and should be followed attentively. Secondly, the world is unlikely to stop using fossil fuels within the next 20 years. To remain in the field of electricity—only a subset of the problem—the quantities at stake are so large that significant investments in storage (chemical or physical) would be needed, which could not pay off in financial and technological terms.

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Transition/What is really behind the green revolution?

Green is the New Black

Contrary to popular belief, renewable sources are only really sustainable when they are generating electricity. In all the upstream activities they are more like fossil fuels


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FRANCESCO GATTEI

He is the Americas Upstream Director of Eni. Previously he was Executive Vice President, Scenarios, Strategic Options & Investor Relations of Eni and before that responsible for theE&P portfolio at Eni, where he also held numerous planning, negotiation and commercial roles in Italy and abroad.

A world of electricity that is finally free of oil cartels and fears of a depletion of resources. A smart and clean world that takes over from the nineteenth-century world of mining and combustion. Is the achievement of this new Arcadia really what is at stake in the energy transition, or are we dealing with a very generous narrative in support of the new resources? Looking at the production cycle as a whole, we can see that in reality this antagonism between opposing structures appears to be a great simplification. In fact, behind the so-called green revolution there are industrial and energy models that are the same as they have always been. In fact, in some cases, such as the mining activities needed to extract the minerals to make electric motors and batteries, they appear to be even more invasive.

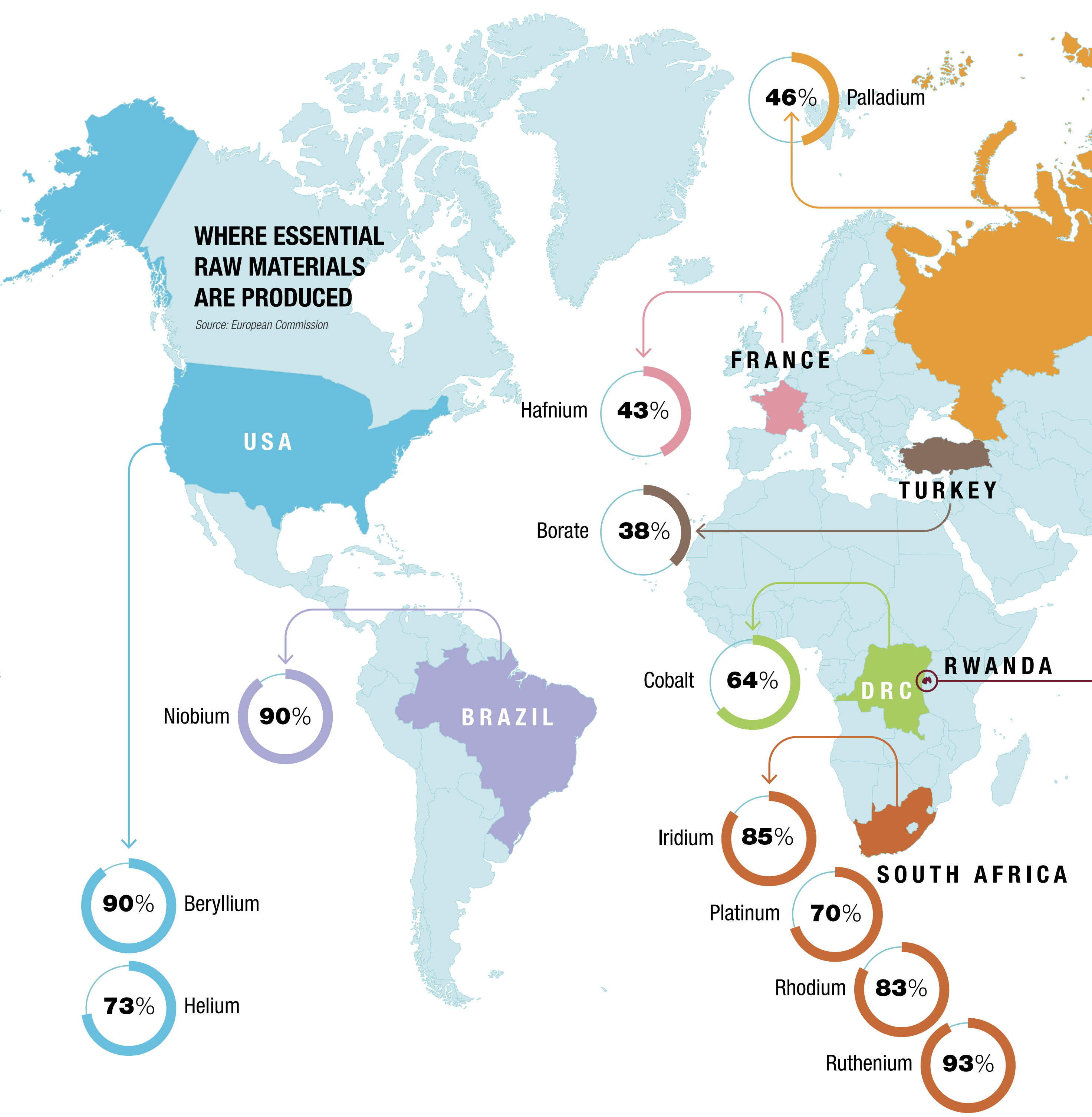
Metals of the past and present

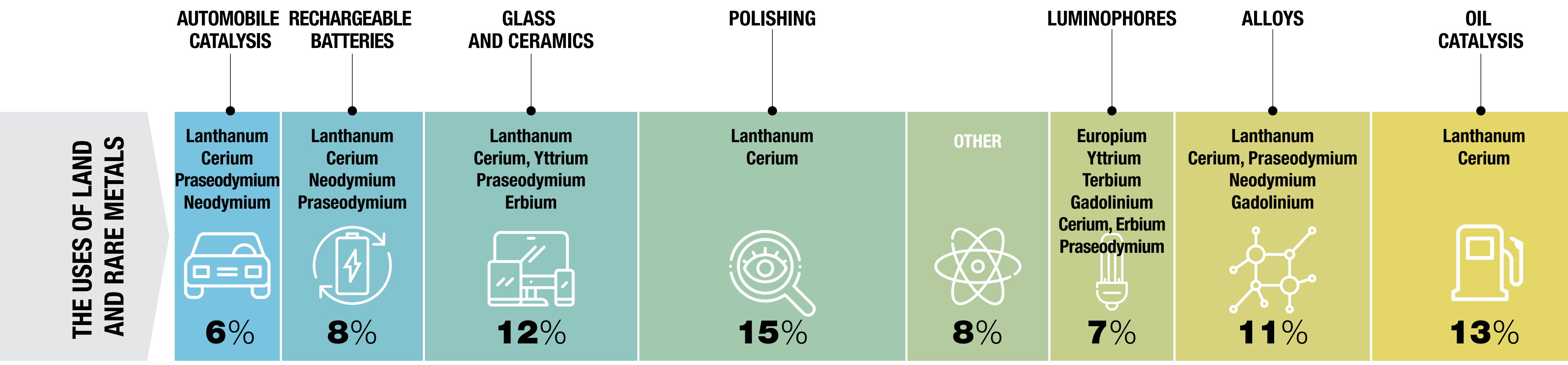
Until the 1970s, the world only used about twenty metals. With the boom in electronics and then renewable resources, we began to use almost the entire periodic table of elements and its eighty metals. These are metals with magnetic, catalyst, accumulator and conductor properties. For batteries, the ions of lithium, the lightest metal, are preferred because they have a high energy density, allowing more energy to be stored. The first cell phones used lead and weighed around a kilo in batteries alone and had a range of just thirty minutes. Lithium has ten times the energy density of lead and allows phones to be made that weigh little more than a pound, allowing 14 hours of conversation.
Cobalt (kobolt was the diabolical sprite that led German gold diggers to find a useless metal) is also essential for the batteries of electric vehicles that contain up to 10-15 kg of the mineral. Manganese and nickel are used to make cathodes, graphite for anodes. We have recently started to use lanthanides: the 15 elements from lanthanum to lutetium (atomic numbers 57 to 71), as well as scandium and yttrium. These 17 elements are mistakenly called “rare earths” because they are difficult to produce (they are often concentrated in less than 3 percent of the rock they are extracted from) rather than their availability in the subsoil. The most useful are neodymium (magnet used in electric motors), dysprosium (from the Greek “difficult to get there”), praseodymium, gallium or cerium. 60 percent of rare earths are used as magnets or catalysts. Like lithium, which has a high energy density, lanthanides provide a high degree of susceptibility for a low weight. In short, in order to make in- →

**Above, a wind turbine blade transported by road.
Center, mining activity in Mutanda, Democratic Republic of Congo.
Below, Baotou, Chinese city dedicated entirely to mining, with a landscape reminiscent of Blade Runner.**

The resource node

Essential raw materials are strategically very important, both industrially and economically, but their extraction often involves environmental and geopolitical challenges, because the materials are only present in nature in a few countries. The main global supplier of essential raw materials is China, which fulfills 70 percent of the world demand. Other important producers are Brazil (niobium), USA (beryllium and helium), Russia (palladium) and South Africa (iridium, platinum, rhodium and ruthenium). The risks associated with the concentration of production in a few countries are in many cases compounded by low recycling rates.



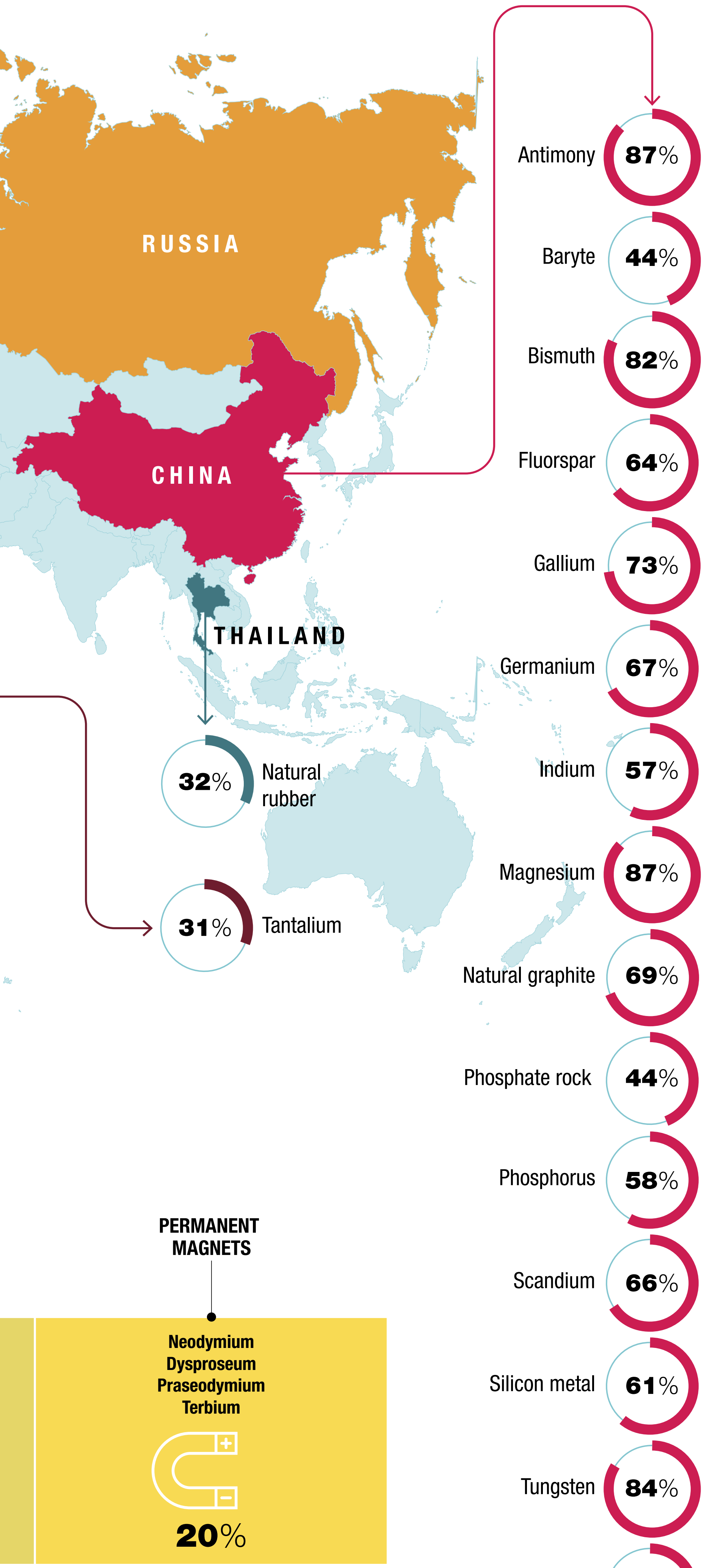


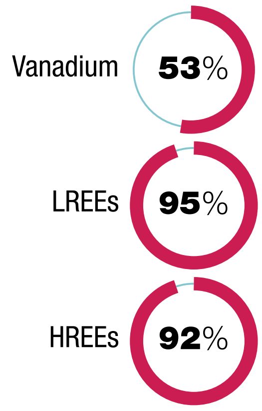
Source: BRGM

creasingly gourmet recipes, we have filled the kitchen not only with rosemary or sage but with red saffron or albino caviar as well. Strong flavors in small quantities. And we're having fun finding ways to use them.

Mining is brutal and painstaking work

But producing these minerals is a complex operation, for people with a strong stomach. In fact, mining metals is not like producing oil or gas from pressurized rock (drilling up to 5 km deep with thin straws—the final diameter of a well is slightly larger than a side dish at a restaurant) but requires the excavation of tons of rock from which to extract the key materials. The mining work is brutal and painstaking at the same time. In fact, the minerals are almost never found in a pure form, they are often combined with others. For example, a kilo of rock can yield 66.5 milligrams of cerium, 19 of gallium and 0.8 of lutetium. Every year, the world uses 150,000 tons of cobalt and 170,000 tons of rare earths, which are in turn extracted from billions of tons of other materials and purified. To do this, the rocks are refined with water and solvents and reagents, including sulfuric acid, to extract pure products. Every ton of rare earths requires 200 cubic meters of water. And the processing residues have a highly toxic or radioactive content. Lithium, on the other hand, is produced as a carbonate by drying





salt pans found mostly in the Andean triangle between Bolivia, Chile and Argentina. A well is drilled to extract a salt brine, which is left to dry for 12-18 months. Alternatively, it is produced in the old way, that is, in a mine. Even from a geopolitical point of view, we are not faced with a radical change, but only a geographical one. Despite having reserves dispersed across different regions, many of these metals are produced in a few countries (in practice, where mining is still carried out invasively and at a lower cost). We are increasingly dependent on China—it produces 70 percent of some key metals and performs 90 percent of their processing. For example, 120,000 tons of rare earths are produced in China (the mining town of Baotou looks like a scene from Blade Runner), while in the United States production is just 15 thousand tons. Two thirds of all cobalt is produced in open-cast mines (with a widespread use of child workers) in the Democric Republic of the Congo, and then processed almost entirely in China. Ninety percent of lithium is produced in Chile, Argentina, Australia and China.

How green are "green" energies?

But the most ancient face of renewables is not limited to mines. There is a heavy footprint of traditional fuels in the manufacturing of production plants. The construction of generation systems, such as wind turbines or solar panels, requires the use of coal, oil and gas (for example, in the melting of steel or concrete for pylons and rotors or of glass and polymers for solar panels). A 400 MW wind farm requires installation of 150 turbines, 100 meters high, made of steel and cement. Each wind turbine blade consists of 260 tons of steel, produced by melting iron and 170 tons of carbon coke. Considering that in the world there are 2 million MW of coal-fired electric capacity, the potential replacement of this power generating stock with wind farms would simply displace the use of coal for generating power to its use to make steel. And even the machines used to transport material from these plants to the production sites are not electric but are powered by petroleum products. Offshore wind installations bear a strong resemblance to oil rigs and make extensive use of special boats driven by traditional combustion engines. A further example of the implicit alliance between the new world and the old traditions is the combination of fossils and renewables in power generation. In fact, the back-up during periods of calm or darkness is largely provided by traditional power generation sources that ensure continued generation for 80-90 percent of consumption hours during which renewables are switched off. In fact, in the absence of an effective storage technology, renewables are the ideal electricity source for midday and sunset, when the wind strengthens. But they are not useful at all other times when electricity is used, including at night when, presumably, most electric cars will be recharged. Added to these factors is the dispersion and multiplication of many small production sites that derives from the low power density of renewables. More materials, more networks, and more electronics are not the ideal recipe for optimizing economies of scale and reducing the impacts of emissions along the production chain. This is why renewable sources are only truly "green" when they are generating electricity. But they are more like fossil fuels and decidedly mineral in all upstream activities. Throughout the entire life cycle, they can at times emit carbon to a greater extent than the sources they intend to displace, a gap that can only be filled by establishing a long life cycle for these assets and accumulating the environmental benefit during the generation cycle. A true net calculation of the cost versus savings, in terms of emissions from all the factors described, is not available.

A hybrid and shared system

What is certain is that the idea that the energy transition is a struggle between good and evil, between modernism and obscurantism, cannot be further from the truth. We are just moving emissions from one room to another, expanding some externalities upstream in the generation chain and intensifying the use of the lithosphere. We are doing this in China, Chile and the Congo, and in Russia in the future. It doesn't look like progress in geopolitical terms either. It is therefore evident that what is described as an antagonism is instead a much more hybrid and shared system. The green revolution does not have the features of a radical change, it is only a different way of depending on mined resources, emissions, combustion and geopolitical relations. An improvement— where possible—of the current forms of use but also the continued dependence on the most classic industries, which are the backbone of our economic and productive system. And, paradoxically, all the scenarios of a drastic reduction in the production or consumption of fossil fuels would primarily have an unwanted victim, the growth of renewables, the cost of which would increase significantly. As in Aesop's fable, the scorpion needs the frog on which it rests to cross the river. Otherwise both will drown. Green is every fashion designer's favorite color these days. But if you look closely, there many shades of black among the folds in the fabric.

Blockchain/The emerging of active consumer

Developing a Smarter Network

This all-purpose technology promises to make electricity more efficient, decentralized, digital and democratic, but only if it is accompanied by an adequate regulatory framework and consumer involvement

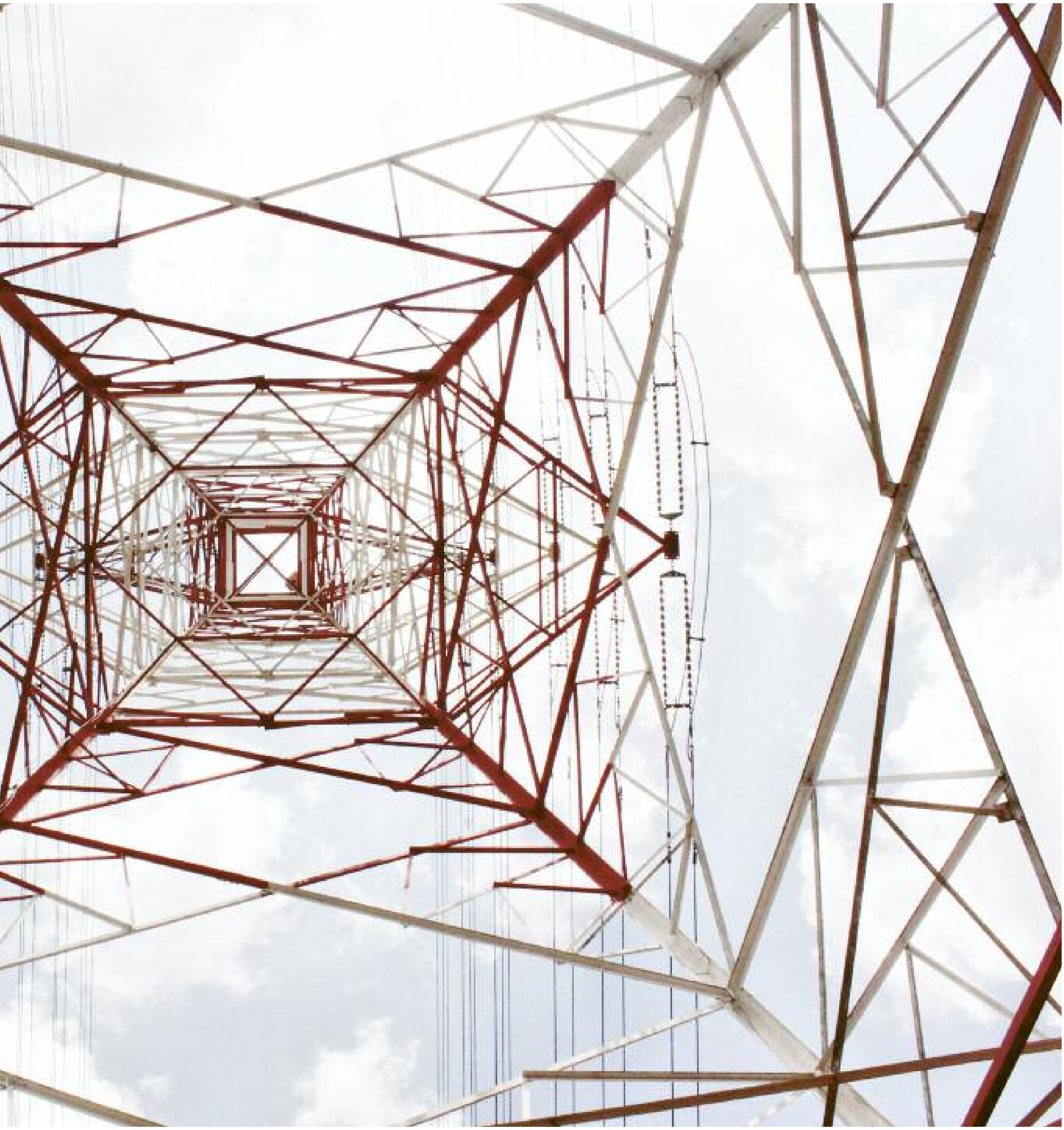
MARZIA ZAFAR

She is Director of Innovation and Insights at the World Energy Council (WEC). Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with more than 3000 member organizations located in over 90 countries.

Blockchain used to be synonymous with Bitcoin. Well, to the average person it probably still is the same thing. But this technology that we're all hearing about—blockchain—is so much bigger than Bitcoin. Its potential to automate, decentralize and democratize operations in any sector is almost limitless. Blockchain's unique advantage is trust. Existing networks rely on a central authority—the utility, independent energy service providers, the bank, the credit rating agency—to establish and transmit trust. Blockchain applications allow for decentralized trust, where verification comes from the consensus of multiple users. In the electricity sector, blockchain technology is promising to introduce data and automation to enable the movement toward much deeper decentralization and digitization of the electricity grid not to mention the democratization of the grid. Blockchain wants to give the power to the consumer (i.e. democratization)!

The grid which we utilize today to power our homes was designed more than a century ago. This century-old grid was designed to take centralized power located far away from load centers and deliver it to our homes and businesses. Big utilities had big power plants and used their long transmission lines to ensure that when you turned on your switch there was light. The consumer in this model is a captive ratepayer—unable to make decisions beyond paying the monthly bill and without timely information to change behavior or understand the impact of his/her consumption.

For the past two or three decades, because of new technologies and new policies and the ever-increasing threat of climate change, we have an opportunity to re-think the way the grid is designed and the way it generates power and delivers power. We also have an opportunity to turn captive ratepayers into active consumers in charge of their own energy decisions.



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The active consumer at the center of the new energy paradigm

The new energy paradigm is characteized by the rise of digitally enabled ecosystems, data-centric services and the emergence of a new agent: active consumers. It is evident also in the shift from centralized generation and vertically integrated monopolies (utilities) towards decentralization, digitalization, energy clusters, micro-grids, interconnection and diversification of supply and storage options. So, where does blockchain fit in this new energy paradigm and why should we care?

To answer this two-part question, let us start with smart grids and smart meters. Smart grids are the foundation for the transformation of the electric industry from a passive and reactive system to one that can seamlessly adapt new technologies and have the flexibility to accommodate decentralized power generation. By using today's technology, a smart grid empowers consumers to manage their electricity use and save money, help utilities reliably deliver power, and exponentially increase the use of renewable generation. So, are we there yet? Is the grid a smart grid? Not really, because building a smarter grid has always been a journey. This journey has been going on since the grid was originally designed, but the term—smart grid—was coined a little over a decade ago and that's because globally the shift →

toward renewable generation began to take shape. Renewable generation doesn't have to be centralized and more often than not it is distributed throughout the grid (i.e., distributed energy resources or DER). A first step in this journey is to transition away from analog meters and onto smart meters. Smart meters give consumers daily if not hourly usage information; they allow for remote control, which opens up opportunities for demand response programs (i.e., shifting load from peak time to off-peak time) and energy efficiency gains. The journey from smart meters to a smarter grid continues as utilities introduce automation and better technologies to create a system that is more transparent and more open to accommodating distributed energy resources such as solar and wind that can be distributed throughout the system especially in residential units. A smarter grid journey continues until every home can be its own microgrid, i.e., capable of producing its own power to meet the demand of that household or maybe even produce enough power to sell back to the grid.

The role of the blockchain

Where does blockchain technology fit in the smart grid journey? Let me provide a simple analogy that is similar in concept. Think of blockchain as a sophisticated database or better yet think of blockchain as Google Docs. Google Docs can be used by multiple authors in real time from different locations making it much easier and faster to modify a spreadsheet or power point presentation. All participants can see who made specific changes and when those alterations were done. The key additional feature with blockchain is the decentralization piece—so with Google docs, an attacker could take down the database through a single attack vector on the centralized store of information. With blockchain, because everyone has their own unique database copy, an attacker cannot alter the record in the same way.

As a distributed ledger technology (DLT), blockchain provides a platform for the management and transaction of high-value data. The use of blockchain technology similar to Google Docs allows all participants access and transparency. Blockchain by itself does not allow access to the electric grid, rather, it enables information exchange between participants in specified areas of the electricity market. Blockchain is a way to verify the accuracy of data without the need for a central authority. So, blockchain is really a data management tool. Because it is a database without a central authority shared between every peer in a network, it provides real-time information and automatically verifies transactions with sophisticated encryption algorithms. The verification process ensures that all members can add to the blockchain, but no subsequent revisions are possible. This enables direct, trusted peer-to-peer transactions without an intermediary, such as a bank or utility.

A good example of using blockchain in the energy space is creating a digitized energy marketplace, able to include smaller DERs alongside incumbent utilities, and cater for a more cost competitive, transparent and modern energy system. Another excellent example of using blockchain in the energy space is a blockchain-powered renewable-energy certificate (RECs) platform. This platform powered by blockchain brings together renewable originators and buyers, with the goal of integrating more renewable sources of any size into the energy system in real time. Having an open-source, global blockchain infrastructure will encourage standardization across geographies, thereby enabling frictionless cross-border REC transactions. Blockchain technology can record trade certificates, providing a reliable verification process - and all without the need for an expensive centralized management entity.

Undoubtedly the area of blockchain application with the most hype surrounding it is peer-to-peer (P2P) trading. P2P is the "talk" of the sector—the prospects for blockchain technology to make transactive energy a reality, to upend the framework of the grid and the energy sector as we currently know it. Smart contracts allow a blockchain to be programmed with a set of conditions that when met, automatically prompt transactions, enabling producers, consumers and prosumers all to participate into a sale process based on price, time, location and the type of energy source. With the right business model and the right regulatory framework, blockchain's ability to make transactions faster, simpler and cheaper can allow for wider participation into the energy market, down to individual households.

A long and uncertain path to travel

The World Energy Council's global survey of energy leaders—the Issues Monitor—identified blockchain as an open question, meaning that energy leaders from across the world were still figuring out what it meant for them and their businesses. Consequently, the Council, in partnership with PwC, interviewed a number companies/organizations to understand the maturity of blockchain technology in energy and also to understand its potential and its impediments. We interviewed companies pushing new business models, traditional oil and gas companies, regulators and utilities from across the globe to find out what is going on with all the blockchain hype. We found the following:

- Technological feasibility and scalability are hurdles to be sure, but the market, or rather those interviewed for this study, were confident that with time, testing and refining of the technology these will be crossed.
- Blockchain in energy is in its infancy. 85 percent of those interviewed who had pilot projects said that they were in early stages and their pilots not mature yet
- Like many new initiatives in the energy world, the success of blockchain is very much dependent on a reframing of regulation and large-scale customer engagement, but that doesn't mean blockchain cannot bring immediate optimization for the existing system.

Blockchain in energy has the potential to upend the energy system that

The innovators' agenda

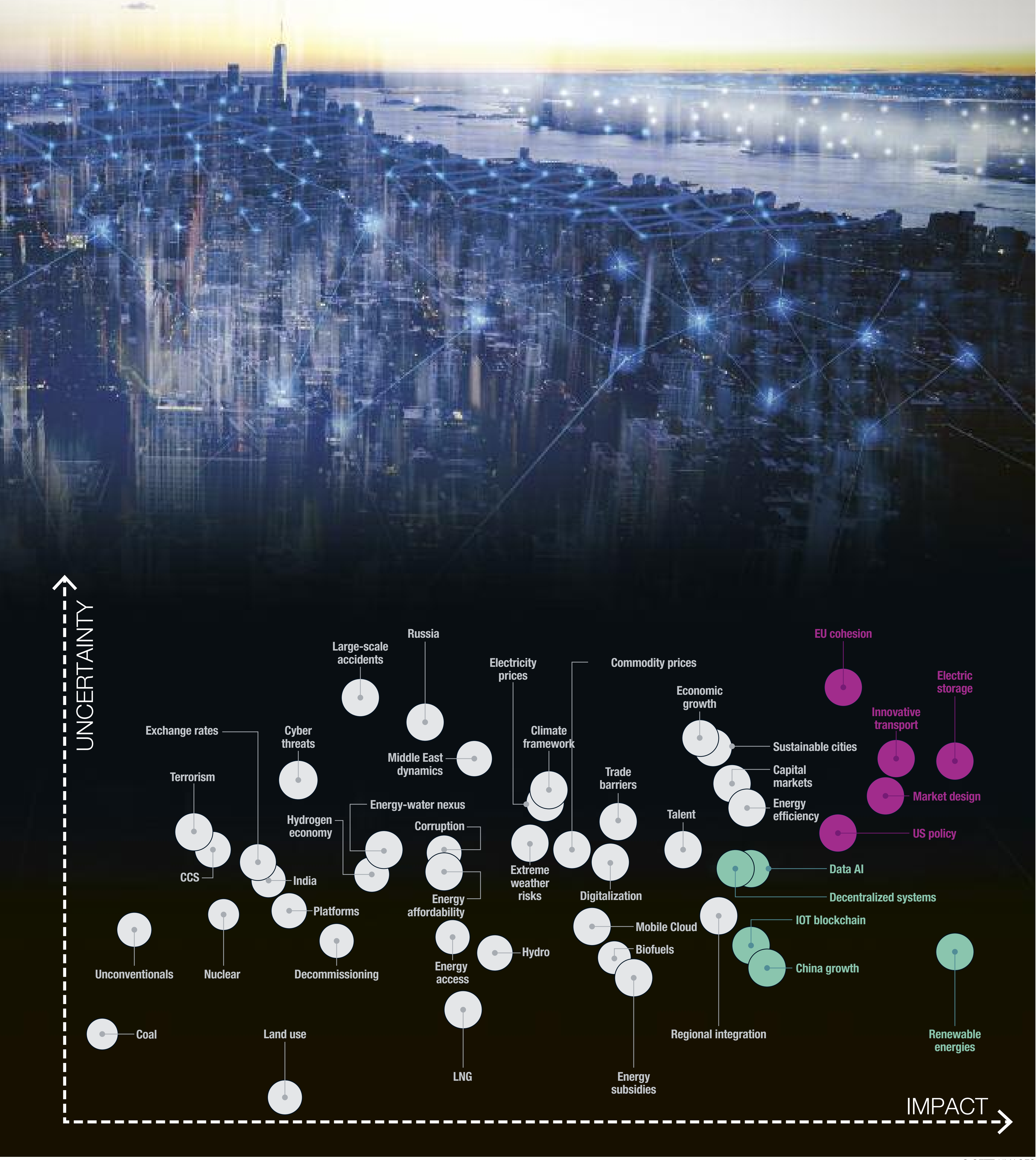
The 100 most promising international energy start-ups in 2019 consider the blockchain to be a priority for the energy sector. Already in 2018, the application of this technology was defined as "crucial" and able to have a "lasting impact" on the sector, but then the future of the blockchain still seemed uncertain.

WORLD ENERGY ISSUES MONITOR 2019 – SET100*

- **Critical uncertainties**: what keeps energy leaders awake at night
- **Action priorities**: what keeps energy leaders busy at work

Less urgent ○ ◯ ◯ More urgent

*Start Up Energy Transition (SET) is an international platform hosted by the Germany Energy Agency (DENA) in collaboration with the Council supporting innovation in Energy Transition7. It is comprised of the annual SET Award and SET Tech Festival. This initiative brings together the 100 most outstanding international start-ups in the energy field with key stakeholders of the sector.



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was created over a century ago, but it has a long way to go. In the meantime, it is certainly pushing the envelope and forcing market players to innovate and create new business models to bring a cleaner, reliable and equitable energy system for everyone. Regulation and customer engagement are key factors in how far blockchain can transform the electric grid. While regulators will need to update rules and regulations to allow for a more distributed grid and more customer engagement, I would note that customer engagement may not be a requirement for all use cases and business models arising from the use of blockchain technology in the energy space. However, it is very much a necessity for a P2P market. A fully scaled P2P market is dependent on residential customers becoming prosumers. What the Council learned from the interviews with regulators, innovators and incumbents is this:

Regulators must clearly state their philosophy and long-term vision: The current regulation is defined for vertically integrated utilities. Regulators need to redefine policies so that they are suitable for and do not unintentionally constrain new business models enabling transactive energy systems. Defining a transition policy is a key first step to be taken.

The future outlook for energy blockchain is both highly promising and yet uncertain.

1 | PROMISING because it is fueling a rethinking of the energy value chain and accelerating a transition from energy as a commodity to energy as a service.

2 | UNCERTAIN because we don't know how and whether the regulatory framework will change and adapt and will consumers engage.

In my view, blockchain is another enabler toward an energy transition that is greener and increasingly less reliant on a centralized model. We are on the journey toward a smarter grid and technologies like blockchain will continue to shape this journey and dictate its pace, but regulation and customer engagement will ultimately decide their fate.

Techno-finance/Toward universal access to energy

Fintech is the Future

Financial technology means innovative solutions can be developed to maximize decentralized access to energy in developing countries. Smartphones and pay-as-you-go will reach the poorest areas of the world

NICOLÒ SARTORI AND NICOLA BILOTTA

Nicolò Sartori is Senior Fellow and Head of the Energy Program of the IAI (Institute for International Affairs), where he coordinates projects on the issues of energy security, with a focus on the external dimension of Italian and European energy policy.

Nicola Bilotta is a researcher at the IAI, where he works on projects of international political economy, digital economy and "geofinance."

Universal access to energy is one of the great global challenges and one of the main factors of uncertainty for the socio-economic progress of humanity. In a context of increasing vulnerability caused by climate change, access to low-carbon and sustainable energy sources and services contributes to increasing the complexity of this issue, and at the same time makes the actions to be taken to address it even more urgent. The data speak volumes, as demonstrated by the delays in meeting the goals of the UN 2030 Agenda, in particular the SDG7 targets for Affordable and Clean Energy. Despite the progress made in recent years, it is widely and unanimously believed that, at the current levels of ambition of national and international policies, the energy targets set by the UN for 2030—universal access to modern and affordable energy services; a substantial increase in renewables in the global energy mix; and doubling the rate of energy efficiency worldwide—can definitely not be achieved.

Troubling figures for access to energy

In particular, the situation regarding access to energy remains dramatic. Today, 840 million people—more than 10 percent of the world's pop- →

Rubén Salgado Escudero was born in Madrid, Spain. In 2014, he began an on-going project "Solar Portraits" which has gained support and has been published by National Geographic Magazine, Time, El Pais, Spiegel, and the United Nations. Rubén's works have been exhibited and sold in more than over 20 cities across the world, including New York, London, Tokyo and at the "Rencontres D'arles" festival in France. He is a member of *The Photo Society*, a community of National Geographic Magazine photographers.

SOLAR PORTRAITS

The International Energy Agency estimates that roughly 1.1 billion people in the world still live without access to electricity, more than 95 percent of these people are either in sub-Saharan Africa or developing Asia. In these parts of the world, almost all rural labor is still unmechanized, candles—which are both expensive and dangerous—are the only source of light available once the sun sets. As building the requisite infrastructure to connect remote, rural villages to the grid will still take a long time, solar energy is a viable and much-needed solution that has the potential to improve the lives of millions immediately. These portraits depict the lives of inhabitants of remote areas who for the first time have access to electricity through the power of solar energy. Each subject was asked how having electricity has affected their life. The scenes have all been lit only by solar powered light bulbs, which are contributing to the improvement in these people's standard of living.

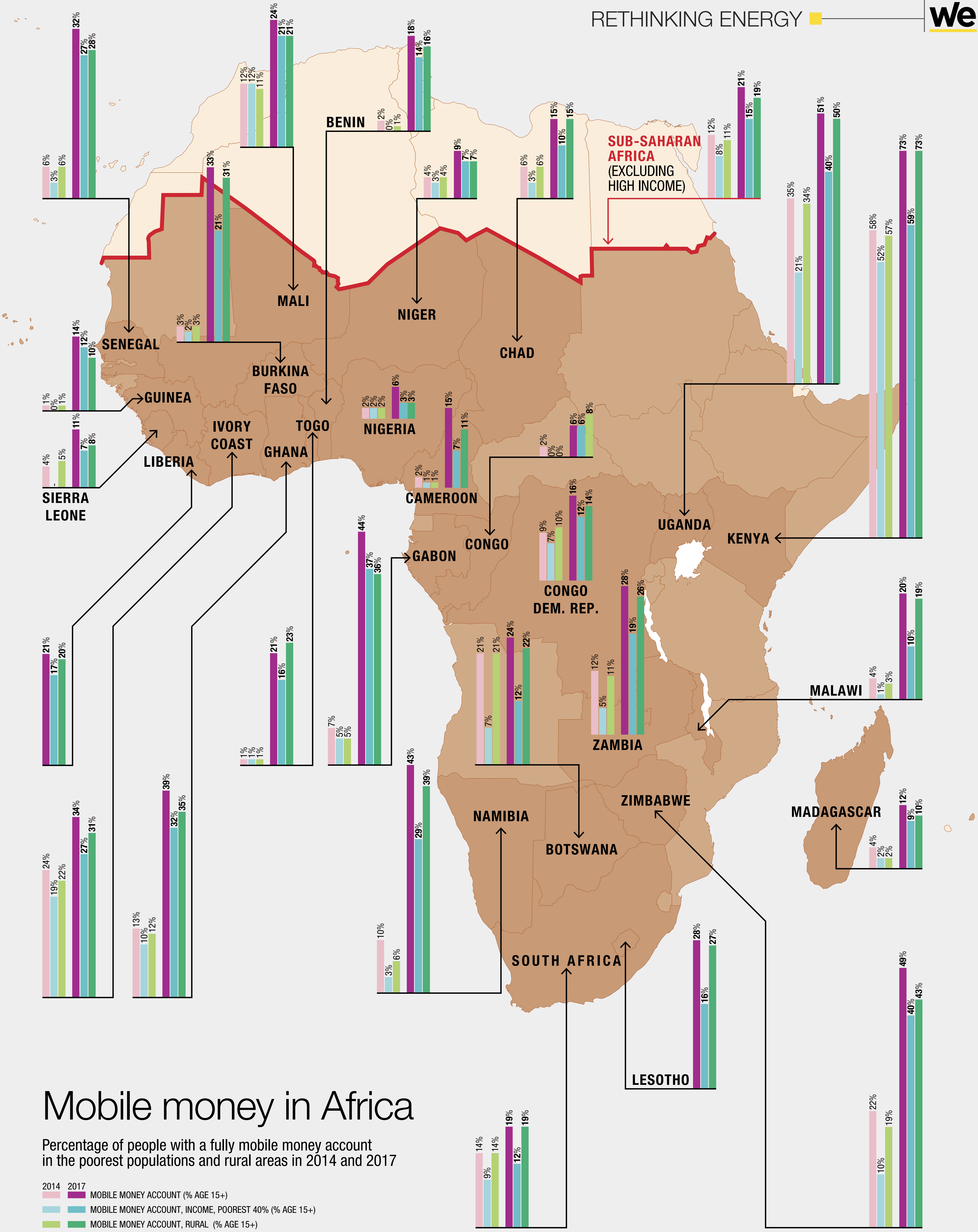
In the opening photo, village leaders walk through Inn Gaung Village illuminated by a solar panel energy system. Pindaya Township, Shan State. Just 26% of Myanmar has access to electricity, at least half of whom live in cities.

Above, Julio Cantú Castro checks up on his honey bee hives to make sure that other insects are not threatening the colonies. His bees produce around 700 kilos of honey per year which he sells around his municipality of Iliatenco (Mexico).

Below, Denis Okiror (30) began using solar lights at his barbershop in Kayunga two years ago. He says most of his customers prefer to visit him in the evening. Electricity is a rare luxury in Uganda.

ulation—still have no access to basic electrical services, while almost three billion people use rudimentary systems in the home (for example, for cooking or heating). It should be noted that there has been a significant increase in recent years in the annual electrification rate and the number of people without access to electricity has decreased from 1.2 billion in 2010, due in large part to the progress made in India, Bangladesh and Myanmar from 2015. In that year, the worldwide electrification rate began to accelerate significantly, and in the following two years—based on a one percent year-on-year growth rate—more than 300 million people were able to access electricity services for the first time. At least in theory, this trend could ensure the achievement of universal access by 2030, as envisaged by the UN Agenda. However, the main challenge is that of population growth trends in areas with a more limited spread of energy services. Populations are growing faster than the rates of electrification and access to clean cooking systems, canceling out in relative terms the progress made thus far.

Despite the encouraging data, the critical issues remain profound and multifaceted in some contexts. A case in point is sub-Saharan Africa, →

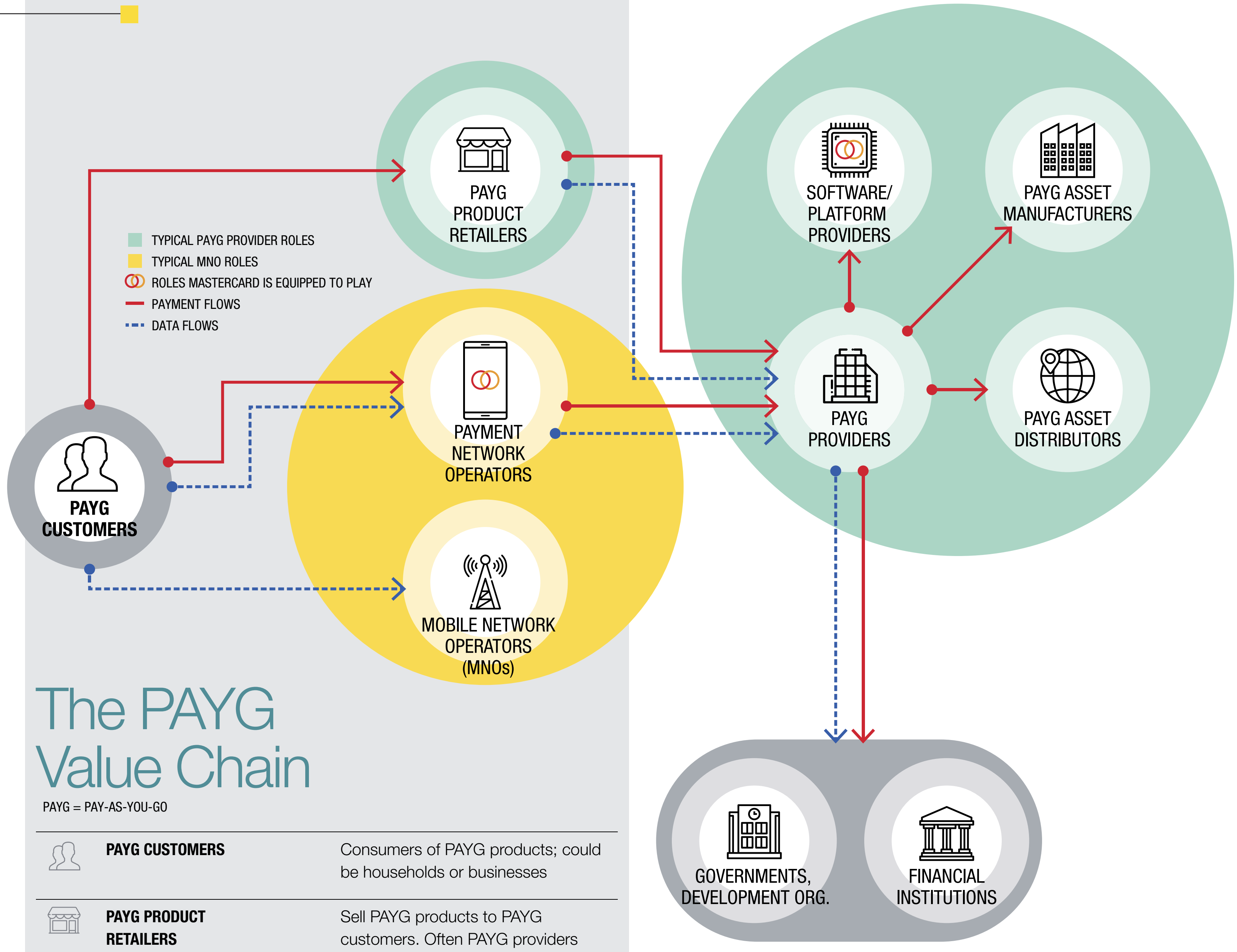


Mobile money in Africa

Percentage of people with a fully mobile money account in the poorest populations and rural areas in 2014 and 2017

2014 2017
- MOBILE MONEY ACCOUNT (% AGE 15+)
- MOBILE MONEY ACCOUNT, INCOME, POOREST 40% (% AGE 15+)
- MOBILE MONEY ACCOUNT, RURAL (% AGE 15+)

Source: The Global Findex Database 2017



The PAYG Value Chain

PAYG = PAY-AS-YOU-GO

PAYG CUSTOMERS	Consumers of PAYG products; could be households or businesses
PAYG PRODUCT RETAILERS	Sell PAYG products to PAYG customers. Often PAYG providers or licensed sales agents
PAYMENT NETWORK OPERATORS	Provide the infrastructure to facilitate payments. In existing PAYG model, this is typically assumed by MNOs through mobile money platforms
MOBILE NETWORK OPERATORS (MNOs)	Supply mobile connectivity to facilitate the PAYG process
PAYG PROVIDERS	Own the customer and operate the PAYG model through payment collection and ownership of PAYG asset
SOFTWARE/PLATFORM PROVIDERS	Technology players that provide the software and back-end services required in the PAYG model
PAYG ASSET DISTRIBUTORS	Distribute PAYG assets to PAYG providers, often assumed by the PAYG providers themselves
PAYG ASSET MANUFACTURERS	Manufacture the PAYG asset
GOVERNMENT, DEVELOPMENT ORG.	Provide regulatory support, seed money and grants, and liaison between providers and other ecosystem stakeholders
FINANCIAL INSTITUTIONS	Provide financing and working capital to PAYG providers to fund business operations and investment

where the vast majority of the "energy poor" are currently concentrated, and where initiatives to improve rates of energy access are struggling to get off the ground. In the African subcontinent, 573 million people—more than half of the population—still have no access to electricity services. In light of the rapidly expanding demographic trends in the region, these numbers are expected to increase further to 650 million by 2030, a far cry from the goals set by the United Nations. Unsurprisingly, Burundi, Chad, Malawi, the Democratic Republic of Congo and Niger form the bottom five countries in terms of electrification rates worldwide. Even more dramatic are the data on clean cooking, an area where only four percent of the world's population newly gained access to clean modern technologies and systems between 2010 and 2017, reaching a modest 61 percent worldwide. This increase has been driven in large part by progress in Asia (most of all in the Indian subcontinent and Southeast Asia), where access rates were around one percent over the period, almost double the global average of 0.5 percent. Under these conditions, achieving the 2030 targets—for which rates of new access to energy must reach three percent per year—seems highly unlikely. Again, sub-Saharan Africa is the region most exposed to this gap (890 million people, 80 percent of the total population, still use charcoal and traditional biomass). However, even major global economies such as India and China, with a total population with no access to clean cooking systems and technologies of around 1.3 billion (20 percent of the Chinese population plus 25 percent of the population of India), contribute to these staggering data.

The lack of progress in access to electricity services and clean cooking technologies has a devastating impact on the economic, social and political resilience of the regions concerned, but they also have serious repercussions on the international scene. Access to energy, in particular to electricity, is an essential and unavoidable factor for so-

cio-economic development and human progress. On one hand, electricity offers many obvious advantages to the productive fabric: it provides basic services (or rather those considered as such in industrialized countries) including efficient lighting, and access to advanced information and communication technologies. Electricity also makes it possible to use machinery and systems that can improve economic processes, in terms of both manufacturing and business. On the other hand, access to energy can transform traditional dynamics in the domestic sphere, with important social and cultural repercussions, in particular with regard to the emancipation of women and the empowerment of the younger generations. Access to safe and accessible energy sources encourages improvements at school and educational levels, meaning that teaching systems based on state-of-the-art technologies can be employed, as well as the possibility of study and training, including in the evenings. At the same time, it has a clear impact on the conditions and health of women in the home. In addition to freeing women from the burden of finding traditional biomass to ensure basic energy services, the availability of modern electrical services and technologies ensures better refrigeration capacity at home, as well as the possibility of maintaining food supplies. Availability and access to safe and clean energy sources also has a wider impact on the health of the population, limiting the negative effects of air pollution in the domestic context. It is estimated that every year, 3.8 million people, largely women and children, lose their lives due to diseases related to the use of rudimentary energy sources. Better basic health services are also making a difference, through the continuing operations of hospitals and treatment centers, and better storage of drugs and medicines.

The role of Fintech

In this critical context, it seems urgent to start a process of transformation in the provision of basic energy services in the areas of greatest criticality. Financial technology (Fintech) enables the development of innovative solutions that can maximize the potential of decentralized energy access arrangements for poor households in developing countries. Historically, one of the most important barriers to buying new energy technologies is the high upfront cost that must be borne by consumers with very little economic means and no savings. For example, the cost of an LPG kit is around 85-100 dollars, while the price of a solar kit is almost 600 dollars. At the same time, manufacturers and distributors are not always able to offer incremental or installment payment solutions to financially excluded customers with no credit history. The growing popularity of smartphones, which can easily provide access to cheaper financial instruments than can traditional banking channels, encourages payment and mobile money solutions, thus offering an alternative to cash by mitigating their transition, safety and transport costs. Interaction be- →

Farmer Naunje Gorreth (35 years) weaves a traditional matt in her home after a day on the field in Sango Bay, Uganda. Sanyo Bay is a small fishing village with 120 households standing on the shore of lake Victoria.

Above, Daw Mu Nan, 45, a Padaung farmer and mother of 8 at her grandson's home in Pa Dan Kho Village, Kayah State. Just 26% of Myanmar has access to electricity, at least half of whom live in cities. In rural areas, of the estimated 68,000 villages in the country, just 3,000 or so have any sort of access to power.

Below, grade 11 students do their homework in a solar-powered after-school community center near in Taman Chan Village, in Dala Township.

tween end consumers and energy service providers is made cheaper and easier through the medium of the smartphone. In Southeast Asia, it is estimated that, by 2025, 82 percent of the population will own a smartphone with mobile internet access. In Africa, this figure will double from 36 percent in 2018 to 66 percent in 2025. Between 2018 and 2025, these two macro-regions will increase their mobile user base by over 524 million. According to Global Findex data, published by the World Bank, the spread of mobile money accounts is also being consolidated in the poorest sections of developing countries. The availability and coverage of mobile telecommunications infrastructure is different from country to country, thereby influencing the penetration of smartphones and mobile money at both macro and individual levels. But the trends of substantial increases in users connected to mobile networks makes the potential of these payment solutions increasingly relevant. In Uganda, for example, the number of consumers paying their electricity bill with mobile money increased from 2.9 percent of total users in 2012 to 52.5 percent in 2017.

More and more start-ups are leveraging the option of mobile payment solutions and mobile micro-loans to facilitate the purchase of modern energy kits by developing affordable products and services. Based on this synergy, the pay-as-you-go (PAYG) payment method is rapidly being consolidated as a means of energy inclusion. End consumers are able to purchase a decentralized energy solution by paying a small initial percentage or providing a security deposit (between 10 and 30 percent of the total cost), then paying for their energy use in installments or on credit, offering a flexibility and ease of transactions that had previously been unimaginable.

At the same time, companies can manage customer solvency with mobile payments and SMS payment codes, reducing the costs and risks of a door-to-door agent-based system. Through a machine-to-machine connection between home devices and central servers, managers can remotely monitor, communicate and administer device operations. For example, in the event of non-payment, manufacturers can block the delivery of the service remotely, reactivating it only when the customer tops up their account.

There are two main business models for these solutions. The first, lease-to-own, allows the end consumer to make a long-standing purchase of the technology they are using.

The second, energy-as-a-service,

"Oozie" Too Lei, poses for a portrait on his 11-year-old elephant Ba Lei Shu at a logging camp in Bago Division, Myanmar where some households have solar panels. Oozies, or elephant handlers, have worked closely with elephants for logging since over 300 years. In rural Myanmar, over 85% of the population lack access to electricity so solar light has the potential to improve lives overnight. The portrait was set up using solar lights as the only source of illumination.

where the asset remains owned by the company throughout the cycle of use, whereby the consumer usually pays a one-time fee for installation and a small monthly sum for use. For example, Shenzhen JCN New Energy Technology offers the option of buying a solar kit with a deposit of about 10 percent of the total value of the kit—about 80 U.S. dollars—to be supplemented by customers with small monthly payments to pay off the total cost of the device. Via remote control of the kit, customers will receive a code on their mobile phone to activate the device once the payment has been made. M-Kopa, on the other hand, offers solar kits with a deposit of 35 dollars, topped up by a daily fee of 43 cents, paid via the M-Kopa mobile money app. KopaGas is using an alternative PAYG system to provide LPG kits in a pilot project in Tanzania, where 48 percent of their customers live on less than 3.10 dollars per day. The GSMA Association has estimated that about 1.6 million PAYG transactions per month are made for solar kits. PAYG systems integrated with LPG kits are however still rare. According to the Lighting Global report, in 2022, 20 million solar kit units supported by PAYG payment systems are expected to be sold, an increase of 80-90 percent, highly concentrated in Africa (98 percent) with the remaining 2 percent in Asia. Between 2011 and 2017, the number of solar kits supported by PAYG was more than 1.3 million in East Africa, 176,000 in West Africa but only 48,000 in Southeast Asia.

Future prospects?

The opportunities developed by the Fintech sector are an important enabler for the process of transformation (or, in some cases, construction) of the energy sector in the poorest areas of the world. The rapid expansion of individual and personalized financial services, and their application to credit-related sectors (i.e., telephony, the internet) offers new options and new vehicles to encourage investment and achieve the target in access to energy services by 2030.

However, the characteristics and complexity of the energy and electricity sector in the first place (i.e., infrastructure, the need for balancing) require more than a "one-solution-fits-all" approach, and require ad hoc systems and applications to be identified and developed by the stakeholders.

In this sense, the establishment of strategic partnerships and joint initiatives between the most cutting-edge stakeholders in both sectors—and the promotion of public policies to support them—could be one of the cornerstones of freeing up the potential economic and social aspects of a section of world society that still remains too considerable.

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Bitcoin/Libra, Facebook's cryptocurrency

A Fistful of (Virtual) Dollars

Starting in 2020, Mark Zuckerberg's hi-tech giant will have its own digital currency, based on blockchain technology. For now, it is difficult to understand how the cryptocurrency will be managed and controlled. Many are fearful

CHRISTIAN ROCCA

He is editorial director of *Linkiesta* and columnist of *La Stampa*. His last book is *Close the Internet - A modest one proposal* (Marsilio editori).

Facebook cannot be said to lack imagination or nerve. The titan of Menlo Park, California is accused on both sides of the Atlantic of undermining public debate in the West, of endangering democratic processes in the free world, and of favoring populist and anti-establishment movements. Facebook is also accused of facilitating the spread of ethnic hatred and helping authoritarian regimes crackdown on dissent, as well as repeatedly violating users' privacy, abusing its dominant position and evading taxes. Even so, Mark Zuckerberg's group has decided to take another quantum leap, printing money as if it were the largest sovereign state in the world.

Starting in 2020, Facebook will have its own virtual, digital currency, named Libra and based on blockchain technology. The community of 2.5 billion friends will be able to exchange money, buy products and at some point use financial services traditionally offered only by banks, such as deposits and loans.

Operations, regulations and supervisory authorities

The new currency will be backed by an ad hoc fund, already joined by 28 major companies, including Uber and Mastercard, each paying at least 10 million dollars. The 28 are expected to grow into 100 founding members by the launch date. However, little else is known beyond Facebook's announcement. Libra will be regulated by the Libra Association, a Swiss institution independent of Facebook, to be appointed by the founding companies, and the cryptocurrency will also have its own central bank known as Libra Reserve. We know nothing more of the rules and governing bodies that will control the operations of the digital currency.

Facebook's challenge is to make cryptocurrencies mainstream, popular and commonly used, while avoiding the risks of fluctuations in value seen by Bitcoin and other players in the current market. Libra payments can be incorporated into any business wishing to adopt the new digital currency, while Facebook will launch an app, Calibra, a digital wallet integrated into its social media, from Facebook and WhatsApp to Instagram. The only step required will be to upload ID (to Libra), providing the option to make or receive payments anonymously.

The information provided by Facebook adds little else; analysts and politicians wonder whether Libra will be a currency, a security or a fund. This is no small matter as the nature of Libra will have significant consequences from the perspective of independent regulations, not those self-imposed by Facebook, but those with which it must comply. Its nature is also a major concern in terms of which body will be responsible for overseeing its work. Zuckerberg is attempting to convince international regulators that Libra is not intended to transform Facebook into a bank or fund, just as it has so far refused to be treated as a publisher or telecommunications platform, requiring rules divergent from convention and suited to these times of digital revolution.

This is where the issues begin, given the history of Facebook. Doubts have arisen over replacing currencies issued by central banks with one →

LIBRA, WHAT WE KNOW

WHEN WILL IT ARRIVE?
There is no firm date yet. The assumption is the first half of 2020.

WHAT IS IT?
It is a cryptocurrency, a currency that exists only in digital form. It will be a stablecoin, i.e. a currency anchored to a basket of real activities to guarantee its stability. It is not a bitcoin, therefore, which is subject to price volatility and speculations.

HOW DOES IT WORK?
Libra will allow payments to be send via Facebook, WhatsApp or Messenger. Transactions, the cost of which will be very small, will be recorded in the Blockchain software logbook.

HOW MUCH WILL IT BE WORTH?
As a stablecoin, Libra has a predetermined value that links it to the value of a currency, the dollar. This means that the exchange rate with any other currency can be calculated at any time.

SECURITY SYSTEMS
Facebook has given an assurance that it will enter into agreements with banking authorities to prevent money laundering and other financial crimes.

WHO MANAGES IT?
The currency will be managed by a non-profit organization based in Switzerland, the Libra Association, which will act as the currency's central monetary authority. The partners include MasterCard, Visa, PayPal, Uber, eBay, Paypal, Spotify, Vodafone and other members, around thirty so far, but the aim is to get to 100. Recently, however, given the constant doubts raised by international financial authorities, some giants of the financial sector, including Visa, Mastercard and others, are apparently thinking of pulling out of the agreement.

libra

THE VIRTUAL WALLET
Libras will be kept in a digital wallet, similar to the one currently used for other cryptocurrencies, which will be called Calibra and will be managed by Facebook. The hi-tech giant has already pointed out in a press release that the financial data in Calibra will be held separately from the social media data.

WHY THE NAME?
Libra refers to the *libbra*, a unit of measurement of Roman origin derived from the Latin term *libra*, meaning scales. And libra is also the astrological sign for justice. David Marcus, the former PayPal executive in charge of the Libra project for Facebook, has also added that *libre*, with an "e", also means "free" in French, so behind the name are the concepts of freedom, justice and money.

governed by Facebook, in particular whether their cryptocurrency can be entrusted to a digital platform which, in recent years, has breached every possible rule, first by denying any wrongdoing, then by apologizing but continuing to betray the trust of users and regulators.

It therefore seems unlikely that a world committed to limiting the power of Facebook—not only in terms of their business monopoly, but also in terms of their weakening of society's intermediary bodies and public opinion, with detrimental effects on open society—would permit the Silicon Valley giant to also revolutionize the global payments system and let it take a dominant position in financial services as well.

Telegram tries to overtake by launching Gram

The Telegram messaging app is preparing to launch a new cryptocurrency, stealing a march on Facebook and the launch of its virtual currently Libra. The new cryptocurrency coined by Pavel Durov's company will be called Gram and will be available to around 200 million users around the world, who will be able to use the Telegram app to exchange money in real time. The TON (Telegram Open Network) blockchain network, which will manage the currency entirely, was given the green light by the SEC (Securities and Exchange Commission, the US federal body in charge of stock exchange supervision) at the beginning of October.

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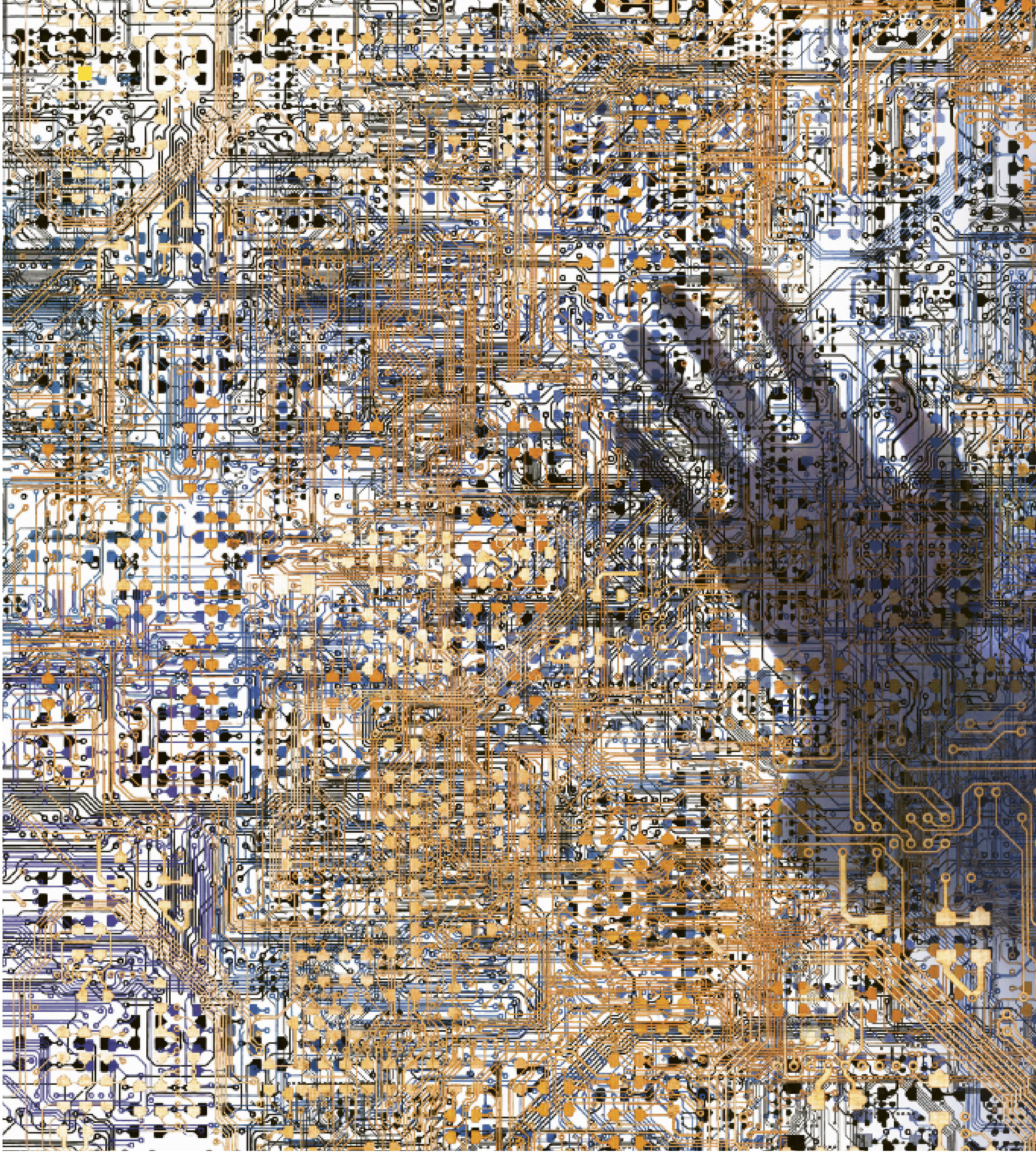
What others think

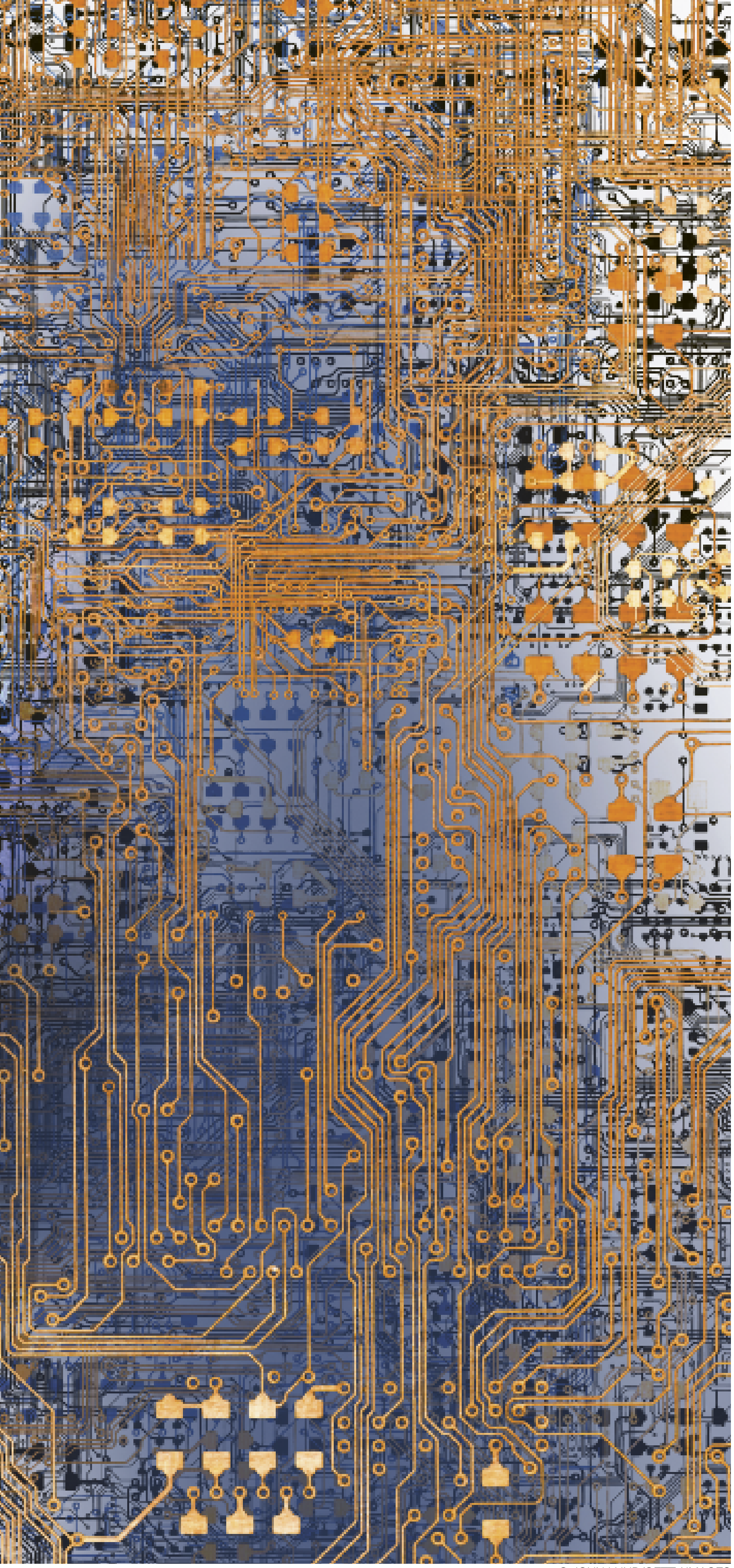
The G7 decided to address the issue, by speaking out against the idea that a private company could have the same privilege—granted to sovereign nations—of creating payment instruments without democratic controls or obligations of any kind. The same doubts have been cast by the European Central Bank and the Bank of England. India has said it is ready to ban its circulation and even Donald Trump has spoken out negatively on Twitter. U.S. Senate hearings have resulted in the same negative outcome, while the Bank for International Settlements, the central bank of the central banks, has warned of the potential risk to competition, financial stability and the welfare state in the event that Facebook is allowed to launch Libra. The risks are obvious: via Calibra, the digital wallet, Facebook will be aware of the income and expenditure of its users and could offer merchants a sophisticated algorithm to maximize the price that each individual user can afford for any given product.
Facebook will also know all the secrets of companies that move money through its digital wallet, resulting in a competitive advantage over any other commercial operator. There will be no commissions on payments, but Facebook and the other founders will be able to reap the interest accrued on the dollars and euros deposited in the bank to buy Libra, so much so that a return on the initial investment is expected in a short time.
Governments, regulators and antitrust authorities will also have to ask themselves what would happen if the currency were digitally stolen or the Libra system were hacked: who pays, who guarantees the deposits? It is very dangerous, experts say, to allow the launch of a private system of global payments that, in the event of problems, will be too big to fail and will need public money to settle losses.
Facebook's challenge is consistent with its long-standing strategic goal, to directly connect as many people as possible without regard for the consequences of the possible disintermediation of relations between customers and banks, supervisory authorities and monetary systems. In early 2019, Zuckerberg hinted that in the face of criticism of his business model, centered on profiling users for advertising purposes, Facebook was beginning to transform itself from a public square into a virtual ring where it could exchange money and goods in a safe and easy way. In technical terms, we could say "out of the frying pan into the fire."



Cybersecurity/The risks for the energy sector

The Dark Side of the Digital

Technological progress, which is fundamental to satisfy the growing global demand for low cost electricity, has increased the vulnerability of industrial control systems to attack and cyber threats



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Revolution

ANNABELLE LEE

She is the founder and Chief Cyber Security Specialist of Nevermore Security. Lee's experience comprises over 40 years of technical experience in IT system design and implementation and over 25 years of cyber security design, specification development, and testing. Over the last 15 years, she has focused on cyber security for the energy sector.

Over the last decade, the rise in cyberattacks on critical infrastructures, particularly in the energy sector, has resulted in cyber security becoming a central concern among industrial control systems (ICS) manufacturers, operators and users. These attacks are aimed at disrupting industrial activity for monetary, competitive, political or social gain, or even as a result of a personal grievance. The advances in technology and the inclusion of Industrial Internet of Things (IIoT) devices has expanded the attack surface of the ICS with the impact extending to all parts of the organization operating critical infrastructure, supply chain, and ultimately the end-use customer. Current cyber security solutions cannot provide comprehensive protection against all the known and unknown threats to the digital components that operate the critical infrastructure, and specifically the energy sector, and defenders are constantly playing catchup in cyber security. Cyberattacks may be launched by malicious insiders or nation-states, via the supply chain, inadequate network access controls, limited operational technology (OT) cyber security procedures and by unauthorized remote access. Unfortunately, attackers only have to be effective once and defenders need to be effective 100 percent of the time. This is not an achievable goal. The next page gives some examples of the high profile attacks on drop against critical infrastructure OT systems.

Historical perspective

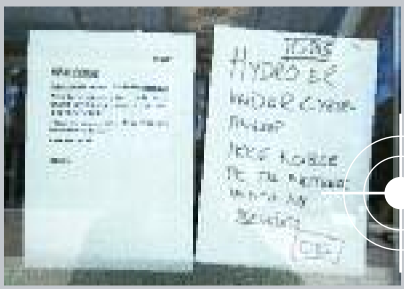
Traditionally, power sources were centralized, with most power produced by large generating stations. Power flowed one way, from the generation sources to the loads. Transmission grids were monitored and controlled via supervisory control and data acquisition (SCADA) systems that ran on specialized hardware, with proprietary software including proprietary operating systems and applications. OT that operated the grid was completely separate from IT that was used to run business functions such as finance and human resources. Communications between the SCADA systems and the grid devices were largely hard-wired; many of these grid devices, such as sensors, were analog and the protocols used to transmit information and controls were proprietary. This was the era of "security by obscurity" and "security by air gap."

Modern grid

Since then, a lot has changed:

- Integration of Commercial Off-The-Shelf (COTS) products: OT systems have been migrating away from using proprietary systems to using COTS technologies, for ex- →

The most important cyber-attacks of the last years



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2019
Norsk Hydro attack, March 18-19, 2019

Information Technology (IT) systems in most Norsk Hydro business areas were affected, including the digital systems at its smelting plants. Several metal extrusion plants also had to be shut down. Acting to avoid infection from one plant to another, Norsk Hydro quickly isolated its plants. The source of the infection was ransomware known as "LockerGoga" and there is currently no known way to unlock or decrypt the systems and files encrypted by LockerGoga. Deployment of the ransomware is manual, and administrative privileges are needed for successful execution.

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2015-2016
Ukrainian power grid attacks

In 2015, power outages were caused by remote cyber intrusions at three regional electric power distribution companies (Oblenergos) impacting approximately 225,000 customers. The cyber-attack was reportedly synchronized and coordinated. When power was restored, all the impacted Oblenergos continued to run under constrained operations. The cyberattack was reportedly synchronized and coordinated, probably following extensive reconnaissance of the victim networks. According to company personnel, the cyberattacks at each company occurred within 30 minutes of each other and affected multiple central and regional facilities. The 2016 attack occurred at a transmission facility and was not as far-reaching.

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2003
Slammer worm attack on Ohio nuke plant network

The Slammer worm penetrated a private computer network at Ohio's (USA) Davis-Besse nuclear power plant in January 2003 and disabled a safety monitoring system for nearly five hours. The monitoring system, called a Safety Parameter Display System, had a redundant analog backup that was unaffected by the worm. The breach did not pose a safety hazard since the plant had been offline since February 2002.

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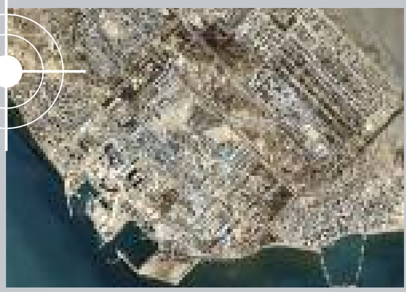
2014
German steel mill attack

Hackers struck an unnamed steel mill in Germany by manipulating and disrupting control systems to such a degree that a blast furnace could not be properly shut down, resulting in "massive"—though unspecified—damage. The report, issued by Germany's Federal Office for Information Security (or BSI), indicates the attackers gained access to the steel mill through the plant's business network and successively worked their way into production networks to access systems controlling plant equipment. The attackers infiltrated the corporate network using a spear-phishing attack. Once the attackers got a foothold on one system, they were able to explore the company's networks, eventually compromising a "multitude" of systems, including industrial components on the production network. "Failures accumulated in individual control components or entire systems," the report notes. As a result, the plant was "unable to shut down a blast furnace in a regulated manner" which resulted in "massive damage to the system." According to the report, the attackers appeared to possess advanced knowledge of ICS.



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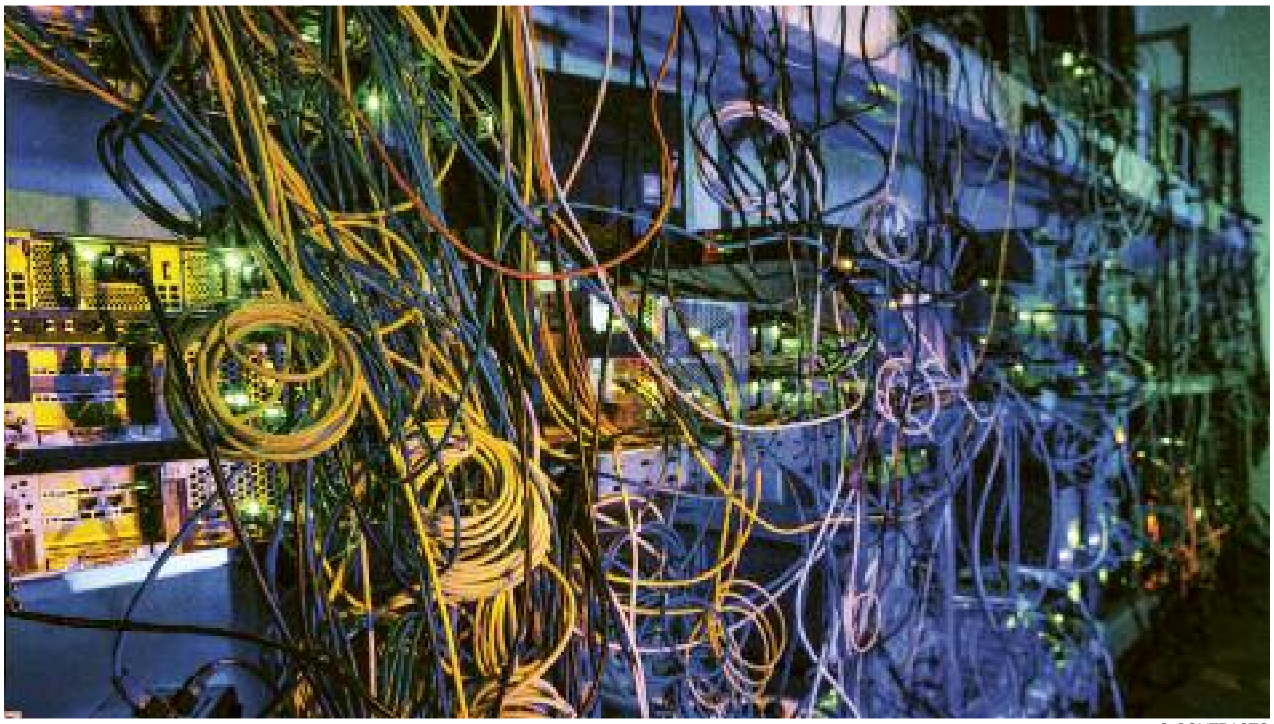
2010
The attack on Iranian centrifuges

Stuxnet is a computer worm that was originally aimed at Iran's nuclear facilities and has mutated and spread to other industrial and energy-producing facilities. The original Stuxnet malware attack targeted the programmable logic controllers (PLCs) used to automate machine processes. The virus searched each infected PC for signs of the Siemens Step 7 software, which industrial computers serving as PLCs use for automating and monitoring electro-mechanical equipment. After finding a PLC computer, the malware attack updated its code over the internet and began sending damage-inducing instructions to the electro-mechanical equipment the PC controlled. At the same time, the virus sent false feedback to the main controller. Anyone monitoring the equipment would have had no indication of a problem until the equipment began to self-destruct.

ample, in operating systems and applications.
- Interconnected systems: Corporate and OT networks are increasingly being interconnected. For example, with alternative energy sources such as solar power and wind, there is increased interconnection across organizations and systems.
- Communications: Serial communications are being replaced with IP-based communications. The initial focus was on implementing open standards and ensuring reliability. Security, in large part, was an after-the-fact add-on.
- Distributed systems: Power sources are distributed and now include distributed energy resources (DERs) and other forms of distributed generation.

All of these changes have resulted in improvements in efficiency and reliability. However, these advances have also increased the attack surface and the set of vulnerabilities to which utilities are exposed, introducing new risks that could adversely impact the grid's reliability and resiliency. In the OT environment, the impact of a cyber security incident can be wide-ranging, resulting in production losses, brownouts/blackouts, physical damage to power equipment, significant safety or environmental issues and even personal injury or loss of life. Following is a summary of new risks:
- As substations are modernized, the new equipment is digital, rather than analog. This increased digital functionality provides a larger attack surface for an adversary because there are more potential points of entry to a system.
- Communication with external systems and the Internet allows for access points that may be exploited. Also, attacks that are launched using techniques such as spear-phishing to fraudulently obtain credentials such as usernames and passwords have increased significantly because of external connectivity by OT devices.
- Legacy technology in the electric OT environment will be operational for many years, even decades. Therefore, utilities will be operating with a combination of legacy and new technology. Legacy systems frequently have limited or no cyber security controls; for example, usernames and passwords are frequently shared by dozens of people. Typically, it is not possible to retrofit cyber security in these legacy systems.
- While security protections such as firewalls, access controls, and user policies and procedures are put into place, a physical connection to the outside world via the Internet now exists. This opens the way for a determined attacker to leverage zero day vulnerabilities and social engineering to find a path through the corporate network to these once isolated OT systems.
- Aside from targeted attacks, there is also a constant threat of a path opening via firmware and software vulnerabilities. Infected USB drives, websites and everyday social engineering attempts on corporate networks may open up paths to an ICS/SCADA network for adversaries.



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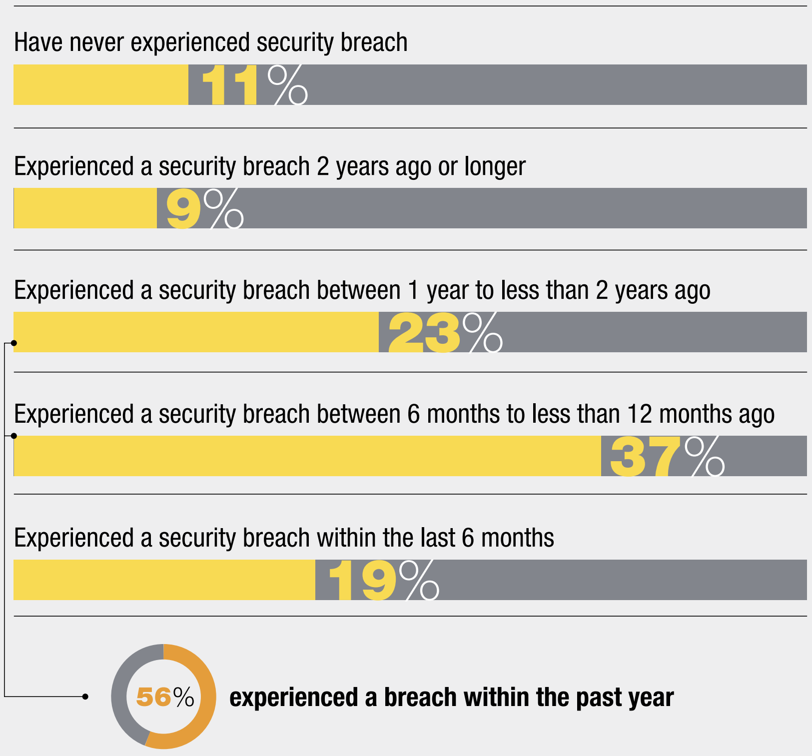
HACKER'S ATTACKS
As time passes, the tools for perpetrating cyber-attacks are becoming increasingly accessible.
Above: server room of the University of Applied Sciences in Gelsenkirchen (Germany), where students learn to fight cyber-attacks.
Below: a hacker in action.

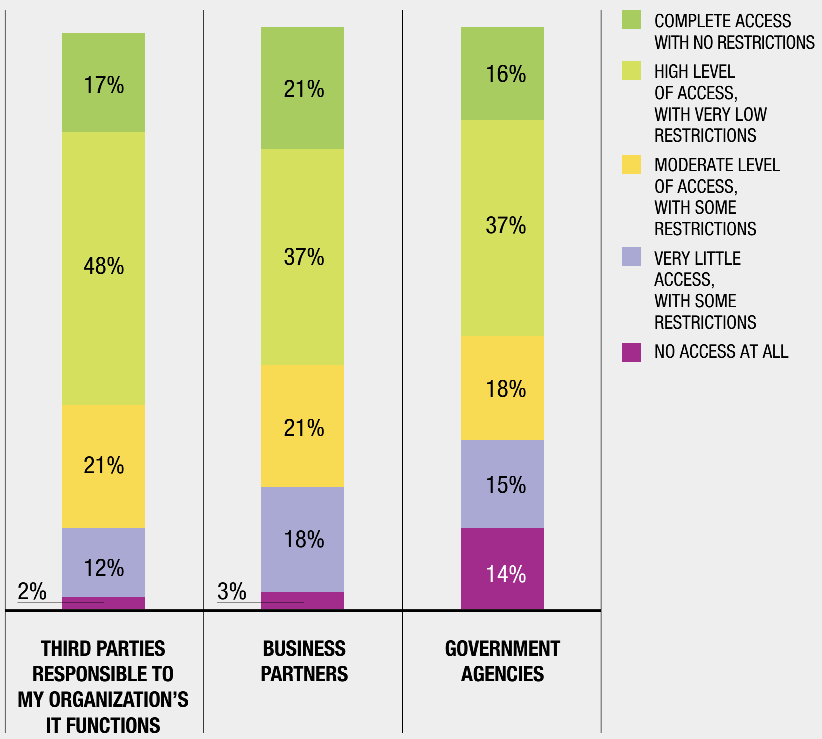
SECURITY BREACH



Base: 429 global decision-makers responsible for security of critical infrastructures, IP-level protection, IoT and/or SCADA
Source: A commissioned study conducted by Forrester Consulting on behalf of Fortinet, January 2018

56 percent of respondents reported a SCADA/ICS breach in the past year, and another 32 percent have experienced a breach earlier. 63 percent of organizations say the safety of their employees was highly or critically impacted by a SCADA/ICS security breach. Another 58 percent report major impacts to their organization's financial stability.

TOO MUCH FREEDOM OF ACCESS FOR EXTERNAL PARTNERS



Base: 429 global decision-makers responsible for security of critical infrastructures, IP-level protection, IoT and/or SCADA
Source: A commissioned study conducted by Forrester Consulting on behalf of Fortinet, January 2018

64 percent of organizations grant external IT suppliers full and high level access to their SCADA and ICS systems, almost 60 percent grant this to other commercial partners and over 50 percent do the same with government agencies.
The sector most inclined to grant full access to external organizations is manufacturing.

- Traditional IT security solutions, such as patching, Intrusion Prevention System (IPS), network scanning and ongoing monitoring are often difficult or impossible to deploy in OT systems due to operational requirements including availability and limited system resources.

Threat agents

Threat agents, either individuals or groups, who seek to exploit vulnerabilities and launch attacks include:

1 | Governments/Nation-States/Nation-State Backed Organizations – These threats are well-funded and motivated by political, economic, technical and/or military agendas. They can execute large-scale and advanced persistent threat (APT) attacks. Nation-states do not fear reprisal and may use ICS attacks as a component of a geo-political conflict.

2 | Criminals – They execute targeted attacks driven by profit, including ransomware attacks. They also will exfiltrate personally identifiable information (PII).

3 | Hacktivists – They promote social, political and/or ideological causes. The intent is to benefit their cause or gain awareness for a specific issue.

4 | Insiders – These are disgruntled employees or contractors that maliciously cause disruption. They may be driven by greed, personal gains or revenge.

5 | Opportunistic – These are typically amateur criminals driven by the desire for notoriety.

Unfortunately, offensive cyber tools are becoming more accessible with a growing library of free tools and techniques available to the adversary to attack ICS.

Threat landscape

Following is a summary of the changes in the threat landscape that are a result of the changes in the threat and technology environments. People are the leading risk for compromised security and this includes insiders (staff and contractors) and vendors. This has been true historically and is still true today. However, because the new OT technology is more IT based and there are increased interconnections among systems and organizations, the impact from compromise by an individual has significantly increased. Based on a Fortinet survey, people present the greatest risk for compromise to an organization's OT/control systems, because the human element lies at the heart of cybersecurity incidents and breaches. Following is a summary of the risks posed by different classes of individuals.

- Insider threat: Insider threats are particularly difficult to guard against, especially in the OT/ICS space, where situational awareness and process knowledge are essential to recognizing a potential safety or security issue. Physical access incidents are dominated by current workforce members (employees, service providers, consultants and contractors). A cyber security event may also be the result of non-malicious activity such as misconfiguring a device or specifying incorrect parameters. Unfortunately, the impact may be the same as for a malicious cyber security event.
- Third-Party Access: According to Fortinet, 64 percent of organizations give third-party IT vendors either complete or high-level access to their SCADA/ICS, nearly 60 percent give other business partners complete or high-level access and more than 50 percent give government agencies the same level of access. When it comes to industries, manufacturers are the most willing to provide complete access to outside organizations.
- Outsourcing: Many organizations outsource some of their SCADA/ICS security. The top SCADA/ICS functions outsourced to IT vendors were wireless security, intrusion detection, network access control and IoT security. According to Fortinet, 56 percent of the organizations surveyed outsource SCADA security to multiple vendors. In some cases, the use of multiple vendors creates a patchwork of defenses that don't work well together.
- Criminals/hacktivists: Malicious attackers continue to be of major concern as is evidenced by several recent ransomware attacks. Although many of the ransomware attacks were not specifically targeted against the energy sector, this new attack vector has the potential to disrupt critical OT operations.
- Nation-states: The increase in geopolitical tension raises the concern that nation-state adversaries may launch cyberattacks to cause temporary or extensive disruption of the energy sector. Both Russia and the U.S. have accused each other of hacking into energy sector systems.

Security architecture: With the increase in system assets, for example, industrial embedded, IoT, and IIoT devices installed in the OT architecture, a comprehensive device inventory is increasingly difficult to develop and maintain. Also, some utilities are now transitioning to the cloud for OT operations. Without a complete architecture for the cloud, "shadow IT" may increase the overall risk. Shadow IT is the infrastructure and applications that are managed and uti-

Computer screens in a control room. The increase in digital capabilities creates more potential entry points, thus providing threats with a wider surface area to attack.

lized without the knowledge of the enterprise's IT department.

Without a complete inventory, developing a comprehensive cyber security architecture for the OT environment that includes the attack surface and attack vectors becomes more difficult, and without a cyber security architecture, the overall OT cyber security risk cannot be determined. This inventory is necessary to define the network security strategy and select the mitigation strategies.

Security by design: Security engineering principles should be applied in the specification, design, development, implementation and modification of a system throughout the system life cycle. This is called "security by design." Because legacy and many IIoT devices do not typically include cyber security, one approach is to "bolt on" cyber security controls. Unfortunately, this approach is not that effective and may adversely impact the performance of the devices.

IT security controls: The differences in how similar technology is used and deployed between IT and ICS networks mean that IT solutions cannot be ported over to the OT environment without tailoring. Some of these IT technical controls include patch management, ongoing monitoring, and vulnerability assessments.

Mobile devices: Mobile devices, particularly laptops used in field technician work, represent a significant risk. There are examples where laptops have been stolen or compromised by family members who installed games or accessed the Internet. In the United States, several US government agencies have banned the use of thumb drives because of cyber security concerns.

Wireless communications: Wireless communications and protocols are some of the most rapidly changing technologies and their use is increasing a means to transfer information from sensor networks in the OT environment. Wireless technologies extend the OT network perimeters and may create an attack vector that is easily accessible by an attacker.

ICS attack evolution

One trend in attack evolution is a two-stage approach to executing attacks. In the first stage, the use of common tactics, techniques and procedures (TTPs) are used for initial access and lateral movement. These initial attack vectors increasingly avoid using custom malware and techniques that provide signs of adversary activity. Because the attackers are relying on system tools that are already on the system, the attacker will *blend in* and there is less chance that the attack will be detected and blocked. Typically, the objective of the first stage is to collect and exfiltrate data about the system that is to be attacked. These first stage attack vectors are called "living off the land" or "fileless" attacks.

In the second stage, a different set of TTPs are used and ICS-specific malware is deployed to execute the attack. This ICS-specific malware may be uniquely designed for the target environment. This two-stage approach allows attackers to take advantage of existing TTPs for initial access and reconnaissance and then execute tailored ICS attack tools.

Conclusion

The advances in technology in the energy sector have resulted in higher resilience and reliability. The new technology is critical to address the increasing need for inexpensive electricity worldwide. However, these advances have also increased the challenge and complexity of addressing cyber security risks. This article includes information that may be used by utilities as they identify the highest priority risks in cyber security.

Privacy/Beijing's model and the search for balance among democracies

The New High-tech Despotism

The global spread of surveillance technologies made possible by artificial intelligence constitutes a radical challenge for the future of democracy, freedom and individual privacy

PAUL SCHARRE

He is a senior fellow and Director of the Technology and National Security Program at the Center for a New American Security. He is the award-winning author of *Army of None: Autonomous Weapons and the Future of War.*

Artificial intelligence technology is advancing and bringing opportunities for society but also profound challenges for individual freedom. AI is a powerful enabler of surveillance technology, such as facial recognition, and many countries are grappling with appropriate rules for use, weighing the security benefits against privacy risks. Authoritarian regimes, however, lack strong institutional mechanisms to protect individual privacy—a free and independent press, civil society, an independent judiciary—and the result is the widespread use of AI for surveillance and repression. This dynamic is most acute in China, where the Chinese government is pioneering new uses of AI to monitor and control its population. China has already begun to export this technology along with laws and norms for illiberal uses to other nations. As AI-enabled surveillance technology spreads around the globe, how it is used poses profound challenges for the future of democracy, liberty, and individual freedom.

The Chinese "big brother"

China is a global AI powerhouse and is breaking new ground in the use of AI tools for surveillance, repression, and social control. The Chinese government is engaged in a massive campaign of repression against ethnic Uighurs in Xinjiang, where over one million people are detained in camps. While many of the Chinese government's tools are low-tech, the government has also begun leveraging data analytics, facial recognition, and predictive policing to monitor Uighurs. Voice recognition, facial recognition and gait analysis are used to track individuals, including at regular checkpoints in major areas. Networks of surveillance cameras use algorithms to detect anomalous public behavior, from improperly parked vehicles to running in certain areas. These tools allow the government to extensively monitor citizens' behavior and control individuals. While ostensibly for "anti-terrorism" purposes, the Chinese government is using these tools, along with low-tech methods such as mass detention and human surveillance, to attempt to systematically destroy an entire culture.

Fabian Albertini is a visual artist, working in photography and installations, who experiments with new materials. He has exhibited his works all over the world and has won a number of prizes, including the recent Life Framer award.

CONTROLLED LIVES

This work by Fabian Albertini investigates the irreversible changes that artificial intelligence is bringing into people's lives. To mention only one example, the Chinese government has set up a vast system of surveillance of the behavior of their population, using facial recognition. The program, which classifies people according to a score on their "social credit," will be fully operational in 2020. The photographs are intended to stimulate reflection on the epochal social transformation taking place. Do we have a way of changing our behavior to protect our privacy from daily surveillance? Perhaps all we can do is to mask, transform or hide our identity.

AI, the race of China

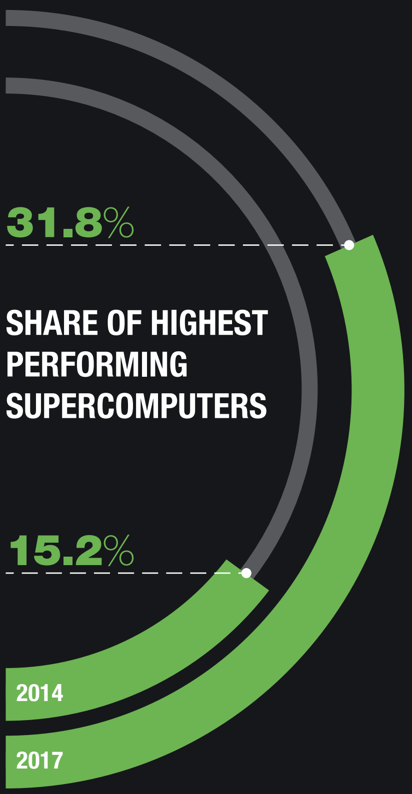
FUNDING

$2.6 bln

ACQUISITIONS OF AI COMPANIES

3

SHARE OF HIGHEST PERFORMING SUPERCOMPUTERS



Source: Eurasia Group, Standford University AI Index

METRICS FOR VARIOUS DRIVERS IN AI DEVELOPMENT GLOBAL SHARE IN %

International market share of semiconductor prod. (2015) — 4%

Financing for FPGA chip-makers (2017) — 8%

Mobile users (2016) — 20%

Number of AI experts — 13%

Percentage of AAAI conference presentations (2015) *(AAAI: Association for the Advancement of Artificial Intelligence)* — 21%

Share of world's AI companies (2017) — 23%

Total investments in AI companies (2012-2016) — 6.6%

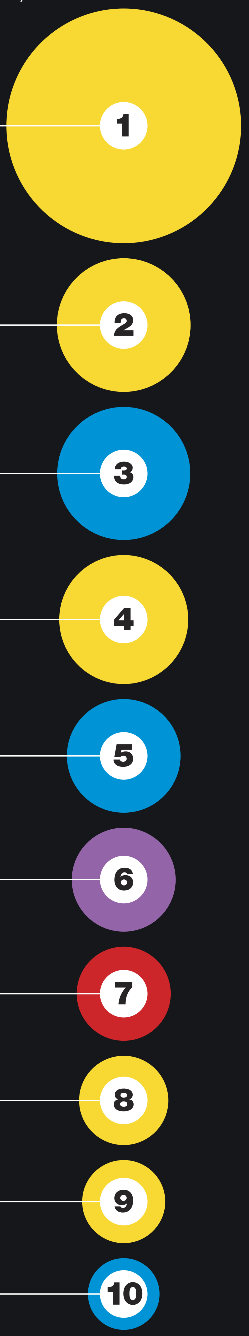
Total global equity funding for AI startups (2017) — 48%

THE WORLD'S BIGGEST ARTIFICIAL INTELLIGENCE STARTUPS

Financing total (in billions, as of 06/06/2018)

CHINA · USA · GERMANY · UK

Source: Nanalyse



1	$3.11	TOUTIAO / MEDIA
2	$1.01	SENSETIME / COMPUTER VISION
3	$1.00	ARGO AI / AUTONOMOUS VEHICLES
4	$0.94	UBTECH / ROBOTICS
5	$0.73	AFFIRM / FINTECH
6	$0.61	MEGVII / COMPUTER VISION
7	$0.50	KREDITECH / FINTECH
8	$0.45	ACORN OAKNORTH / FINTECH
9	$0.39	CLOUDWALK / COMPUTER VISION
10	$0.29	ZOOX / AUTONOMOUS VEHICLES

Xinjiang is also a testbed for AI tools for social control in the rest of China.

Algorithms have begun to supplement the massive network of over 200 million surveillance cameras in China, which are ubiquitous in major cities.

A major feature of surveillance technology in China is its use for "social control" or "social governance"—the control of the population by shaping individuals' behavior. Social control goes beyond catching criminals and aims to control the behavior of citizens in small ways. Electronic billboards name and shame individuals caught jaywalking, displaying their faces to the public like a modern day version of putting criminals in stocks. The Shenzhen-based company Yuntian Lifei Technology has said that their Skyeye intelligent video surveillance system has already identified 6,000 incidents relating to "social governance," leading to the system being deployed in nearly 80 Chinese cities. In some cases, AI tools are used for social control over seemingly trivial infractions, such as monitoring toilet paper use in public restrooms. State-linked organizations have explored options for even more sophisticated AI tools to surveil citizens, such as tracking individual homes' electricity use. These AI tools enhance an already extensive system of social control, from China's Social Credit System and blacklists to ID-linked QR-code tracking of sensitive items, such as knives purchased in Xinjiang.

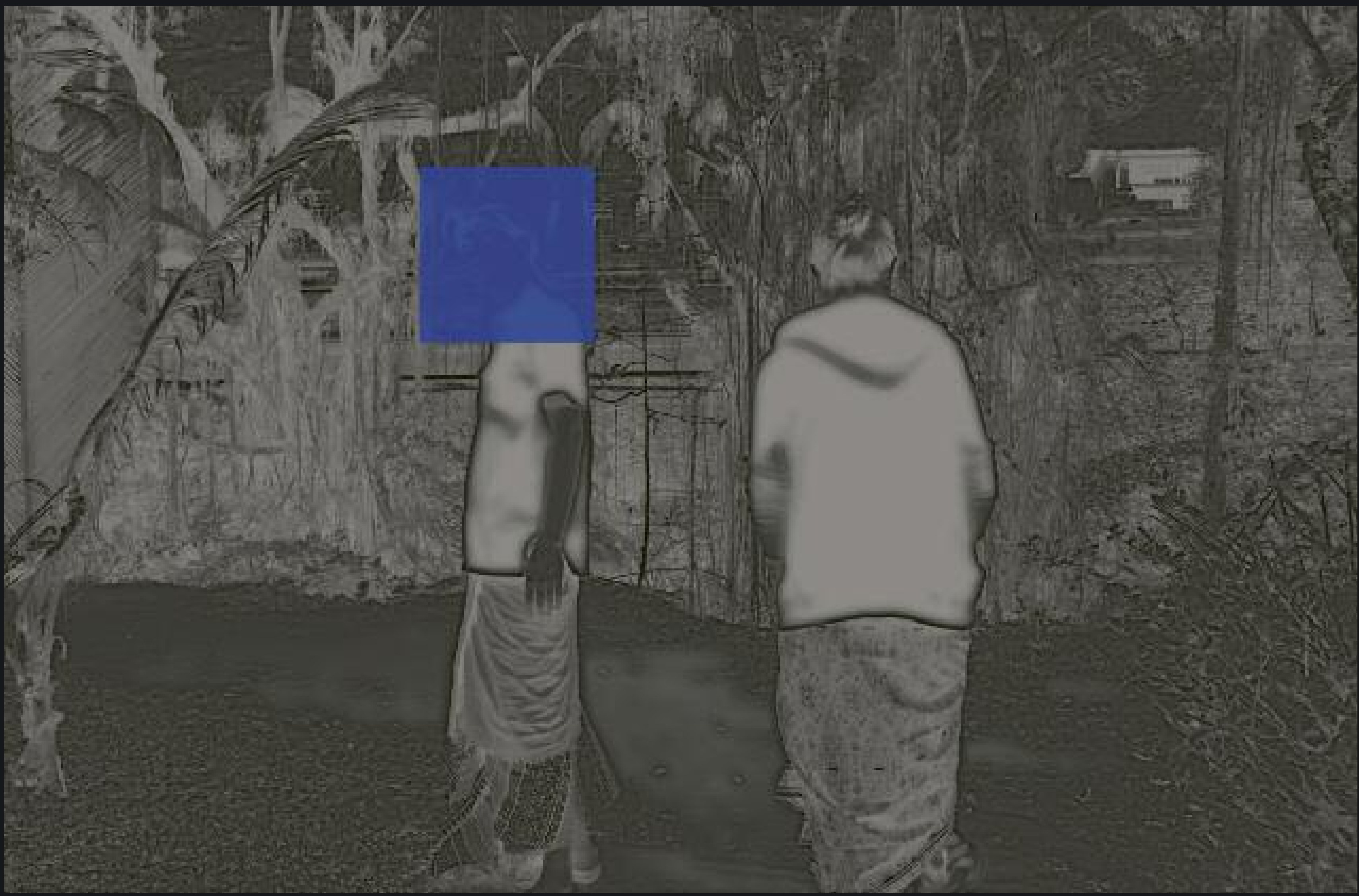
AI tools allow China to not only monitor its population more effectively, but also control their information environment. China already heavily censors online information through a "Great Firewall" to keep out large parts of the internet and punish those who speak out against the government, even in blogs or chat discussions. Simple AI tools will allow the expansion of these efforts by flagging censored content at scale and automating responses and more advanced AI systems will enable more tailored responses. A Chinese think tank funded by the Ministry of Industry and Information Technology published a white paper in September 2018 outlining a number of potential uses of AI for "social governance." These include monitoring public opinion online, providing "early warning" of unfolding events, and the ability to "preemptively intervene in and guide public sentiment to avoid mass online public opinion outbreaks." If implemented, these tools would strengthen China's existing Great Firewall for internet censorship and allow the state to exercise more nuanced and effective targeted propaganda.

The Chinese government can lean on a robust private sector for AI technology. The Chinese company SenseTime is a global leader in facial recognition and object identification and at a $4.5 billion valuation is also the highest-valued AI startup in the world. Half of the top 10 AI startups last year were Chinese. Right behind SenseTime is Toutiao, valued at $3 billion, which uses algorithms to not only curate online content but also automatically generate news stories—a powerful capability with many potential uses. China is home to some of the top AI firms in the world, including Baidu, Alibaba, and Tencent. In addition to top-tier AI companies, China can harness vast troves of data about its citizens on which to train machine learning systems. China's 800 million internet users create exabytes of data on Chinese behavior, preferences and communications. Different legal and cultural institutions in China result in far less privacy protections for citizens' data than exist in Western nations, giving companies ample resources to train algorithms. In 2017, China proclaimed in "New Generation Artificial Intelligence Development Plan" its intention to become the global leader in AI by 2030. It is on track to make that plan a reality.

In the United States and Europe, possible applications of surveillance technologies, such as facial recognition, have sparked heated debates. Unlike totalitarian regimes, democratic societies have many ways to avoid the dangers of out-of-control political power.

US and Europe, balancing freedom with security

AI-based surveillance tools such as facial recognition and predictive policing are being deployed outside China as well. What differs in China compared to democratic nations is the lack of institutional mechanisms to provide checks against state power and protect citizens' rights. Surveillance technologies have sparked vigorous debates in the United States and Europe about their use. In the U.S., the American Civil Liberties Union (ACLU) has criticized Amazon for alleged flaws in their facial recognition system Rekognition and has sued the U.S. government for records about government use. Congressional lawmakers have expressed concern and officials in San Francisco and other cities have banned government use of facial recognition. Even some tech companies are sounding the alarm, with Microsoft calling for government regulation and Amazon arguing that the government should →



Facial recognition is a method of identifying or verifying an individual's identity based on their face. Facial recognition systems use computer algorithms to identify specific and distinctive details about a person's face. These details, such as the distance between the eyes or the shape of the chin, are then converted into a mathematical representation and compared with data on other faces in a database.

specify guidelines for law enforcement use. Democratic societies have many avenues for checks on uncontrolled government power which authoritarian regimes lack. Employees at Google, Microsoft and Amazon have objected to their companies handing AI technology to the U.S. military or police. In the case of Google, employee pressure caused the company to discontinue a Pentagon AI project. Independent media, legislature, courts, civil society and open public discourse all contribute to a balance in democratic societies between security and civil liberties. When Apple disagreed with the FBI's order to unlock a terrorist-linked iPhone in 2016, Apple fought the FBI in court. Even if Chinese tech companies objected to →

In authoritarian regimes, the lack of well-functioning institutions such as a dynamic civil society, free press and an independent judiciary means that governments can use surveillance technologies to tighten the grip of repression, affecting individual civil liberties.

government demands to use their tools for surveillance, China lacks effective independent institutions to check government demands.

These tools are helping China build a techno-dystopian surveillance state, which China is beginning to export to others. In 2018, the Chinese company CloudWalk closed a deal to build a mass facial recognition system in Zimbabwe. The system will consist of intelligent surveillance systems at railways, bus stations and airports as well as a national facial database. At stake in the deal, which is part of China's Belt and Road Initiative, is more than just money. CloudWalk will also

have access to millions of Zimbabwean faces, helping CloudWalk improve its facial recognition systems against darker skin tones. In the age of artificial intelligence, data is the real currency of power.

The Zimbabwe deal follows a longstanding pattern of China exporting its digital surveillance technology along with Chinese-style surveillance laws and policies. China has held training seminars in over 30 countries on cyberspace and information policy, according to Freedom House. In Vietnam, Uganda and Tanzania restrictive media and cybersecurity laws closely followed Chinese engagement. The technology helps China gain access to new datasets as well as inroads for spying abroad. The social "software" of laws and policies help China export its evolving model of digital authoritarianism. Left unchecked, AI-enabled repression poses a profound challenge to freedom around the globe.

Technology is not destiny. Facial recognition and other surveillance technologies will be used in both democratic and authoritarian societies around the globe. The question is how they are used—to what ends, under what laws, and with what degree of transparency and privacy protections. In democratic societies that have well-functioning institutions such as civil society, a free press, and an independent judiciary, the give-and-take between different societal actors can help find the appropriate balance between privacy and security over time. In authoritarian regimes the lack of these protections means that the state can use surveillance technology to tighten its repressive grip, further eroding individual freedoms.

The need for rules to ensure correct use of AI technology

The stakes are high. The spread of AI-enabled surveillance technology risks undermining individual freedom and fostering the rise of a new high-tech illiberalism. Democratic states must work together to counter this trend. To do so they must first lead in technology, for whoever builds the roads sets the rules of the road. Second, democratic states must proactively establish norms for appropriate use of technology. Europe is already leading the way on data privacy with the General Data Protection Regulation (GDPR),, which set a standard for other nations. Third, democratic states must actively work to export the technology, laws, and policies for use, helping to set global norms. Human rights must be a foundational principle of how AI and surveillance technologies are used. Fourth, individuals and organizations from democratic states must not be silent in the face of abuse, whether it is China's repression of Uighurs in Xinjiang or other human rights abuse. As regards artificial intelligence there has been a rapid spread of global principles of AI governance around the globe, with scores of countries, companies and organizations espousing principles for ethical use. This is an encouraging sign, but these principles will only be meaningful if actors live up to them and expose abuses when they exist. Principles must be more than empty words—they must translate to action. Finally, academic researchers, companies and democratic governments must terminate partnerships with those engaged in human rights abuse. Decisions made in the coming years will help shape the balance between freedom and authoritarianism for decades to come. These actions can help push back against high-tech illiberalism and help protect individual freedom and human rights.

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