world energy

we.

OCTOBER 2018

SAFE & CIRCULAR

Number Forty

World Energy no. 40/2018 - Targeted mailshot

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- The abbreviation CE throughout all this number of the magazine, means "circular economy".

world energy we

Quarterly
Year 10 - N. 40 October 2018
Authorization from the Court of Rome
No. 19/2008 dated 01/21/2008

Publisher **eni spa**
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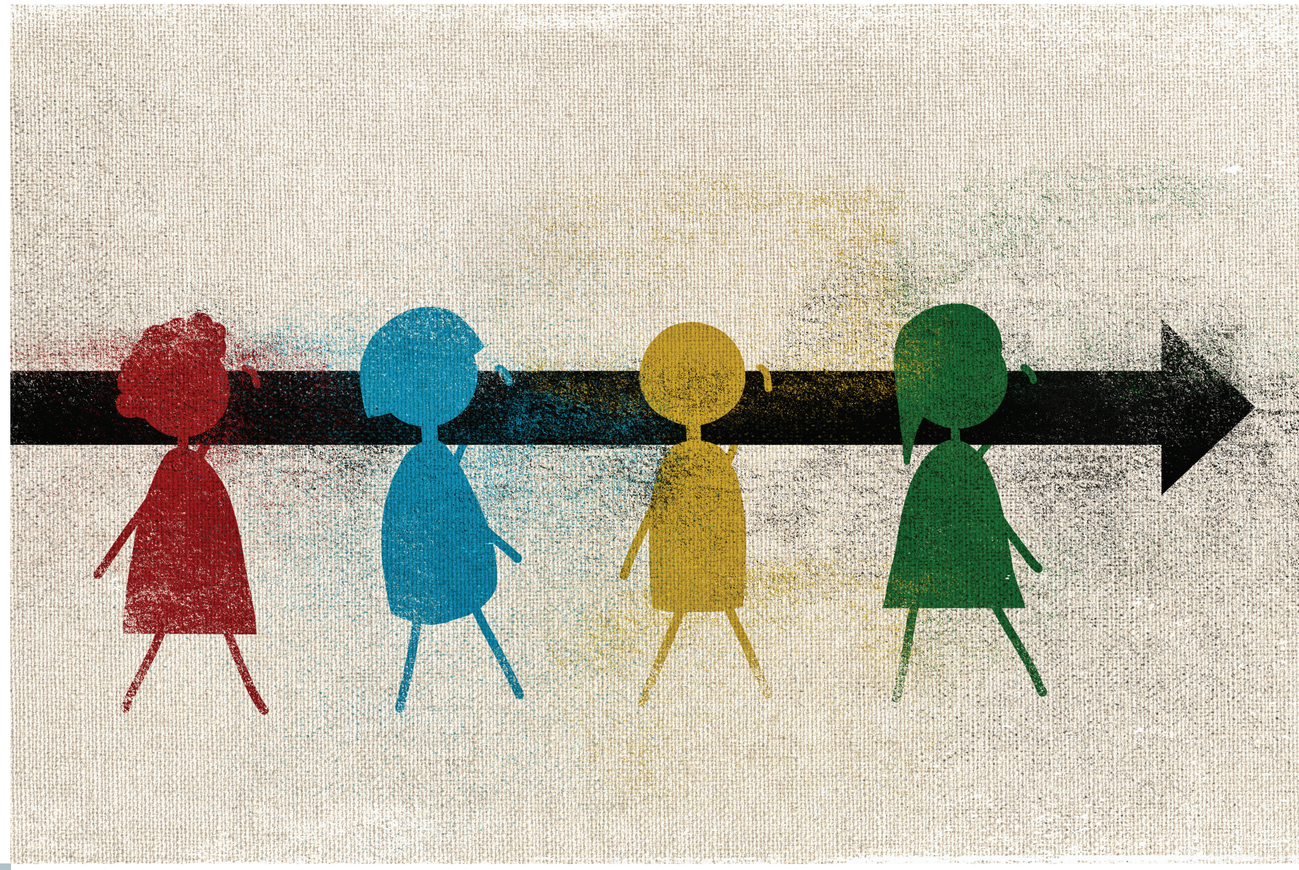
Sent to press
on October 22, 2018

MIX
Paper from responsible sources
FSC® C100565

Paper: Magno Natural 100 grammi

Editorial/From black gold to the circular economy

Ten Years That Have Changed the World



Our story began forty issues ago, in 2008, the year of the global financial crisis. At the time, we were asking ourselves how much longer the world's oil reserves would last. Today, the energy transition is in full flow and we are looking at new consumer patterns and new business models



t began life as *Oil* magazine. It was the year 2008 and its cover page asked the question "For how much longer?" In other words, how long before we would run out of oil? More than ten years have passed since then; the world has been turned upside down and we have entered a stage of rapidly advancing energy transition. *Oil* has become *WE*, and what you are reading is the fortieth issue in a long and fascinating story—ours and yours. It is the story of a changing world.

This issue, No. 40, means many things to us:

1 | We can begin to look at our story with a long-term perspective, the kind of perspective we adopt when considering important things that are not ephemeral and leave a mark;

2 | We have a physical and metaphysical space in which to engage in serious thinking. The space is physical because, over time, we have a measurable quantity of facts—the real numbers on which to weave ideas and give an interpretation of yesterday, today and tomorrow. It is a metaphysical space because forty issues and ten years provide sufficient scope for historical and philosophical memory and speculation;

3 | In the dematerialized world of digitalization, our computer memory does not coincide with our true memory. The bit will never be a "hot" flashback but will always remain a "cold" pixel operation. It enables us to "recall" data and can produce a click or a weak flash on the screen, but nothing more than that. The signifier and the signified do not evaporate in *WE* as they do in the digital world. The presence of our forty cover pages bears testimony to the contemporary, solid and lasting value of our magazine. Paper has become "a presence" and an asset. We only have to look at the covers and see how their design has evolved—from two-tone images to an explosion of color—to enter into a dimension filled with a sense of history and retrospective vision. Behind them is the history of a company: *WE* is an important part of the historical memory of its publisher, Eni.

Having made these three points, we can say that we have had ten incredible years. This latest issue talks about the circular economy, while the first asked itself what would become of oil. A hundred and twenty months on, oil has not come to an end but a whole world has. The cover of the third issue featured the faces of John McCain and Barack Obama. The former is no longer with us and is riding across the heavens while the latter has left the White House and his presidency is about to be judged by history. Today, that world seems very far away, and the year when this magazine's adventure began marked a historic watershed; it was a new beginning that started off by smothering the flames of the old world. The global financial crisis had exploded. While McCain and Obama were fighting for the presidency of the United States, Lehman Brothers was filing for bankruptcy (September 15, 2008), and the cover of that issue of *Oil* says it all as to the magazine's topical, immediate, focused and timely way of capturing historical shifts, a magazine whose raison d'être is the mix between a long-term perspective and capturing the moment.

A long and fascinating story

Oil began at the same time as another story broke out and unfolded. It was a huge unforeseen event that brought one stage of globalization to an end and set in motion a process whose unexpected consequences led to the geopolitical effects we are witnessing today. For the world of energy, this financial shock and the long recession it caused were tantamount to tectonic shifts, with booms and busts in the prices of raw materials, the reorganization of production processes, the collapse of investments, the search for new energy sources and technologies, the fall of certain players and the rise of others. The crisis, a term that means decision or choice in Greek, had the effect of a gigantic asteroid. It was not the end of oil, it was the end of everything. What had been before was now beginning its life (over again) in another dimension.

Not surprisingly, issue No. 4 of *Oil* magazine was titled "The World of Tomorrow" (December 2008). We always try to envisage what tomorrow will be like when yesterday has gone out like a flame in the dark, leaving us with a feeling of anxiety.

It was clear that, from then on, nothing would ever be the same as before. Everything that happened "after" the event was only bewildering to those who refused to see what was happening. Like volcanic islands, new priorities rapidly emerged for the world of energy. They included a strong commitment to environmental protection issues; the shifting of the race for development towards the East (cover of the June 2011 issue on "Chinaoil" and of the July 2014 issue on "Asia the Energy Pivot"); the surge of American shale and the role of the United States as an oil and gas producer and exporter; the Iranian question, which encapsulates the instability of the Middle East and its troubled oil monarchies; and the issue of a world of winners and losers ("Winners & Losers," March 2015),



where the hope was that the old-new cooperation forums ("Hope OPEC", July 2015) would have the necessary tools to regulate the naturally irregular and shock-prone factors of output and prices. All this became "Energy Revolution" (March 2015).

These titles and related illustrations evince the ongoing effort to capture something fleeting, unexpressed and unfinished. Today we know that behind that desire to capture a ghost was history itself. It was unfolding before our very eyes, but it still wasn't clear where it would lead us and what the final outcome would be. With a series of remarkable fits and starts we have come to the current scenario, which in turn is unfinished because time has accelerated once again.

The new disruption

This forward surge, this roaring of the engine of history, has been captured once again by our cover pages. The Mediterranean has come back into play as a space of shifting geopolitical and energy balances (in August 2015, Eni discovered Zohr, the largest gas field in the Mediterranean Sea) and we are all naturally asking ourselves what will come next ("What's next?", March 2017), while the energy companies are reorganizing, buying and selling. Everyone is playing their own game in an era of "Big Deals" (opening issue of *WE*, October 2017), and the future tells us of China's plans to become the leading global economic power ("China, the Overtake", December 2017) and, somewhat ahead of time ("The E.U. after the E.U.", March 2018) but supported by news reports on the end of the Merkel era in Germany, we are looking at Europe's frenzied future as we go to press. We don't have any crystal balls, but history is already sending out signals and we need to pick them up. America, Europe and China. Placing our Old Continent in the middle is not a random choice. We tend to view Europe as being the center of everything, but that is no longer the case. Today, being positioned in the middle is a problem for the European Union, squeezed as it is between two giants and with all the uncertainty about its future. Who are we? And what do we want? In the United States, Obama's second term came to a close—and during his presidency American energy production underwent a revolution, and in the White House today we have Donald Trump, who is acting with all the power (unprecedented in this shape and form) of the leader of an energy producing country. In the last encounter with OPEC, things didn't go well for the United States, but this is a permanent playing field and the prize is there to be won every day.

Where are we? We are living through a period in which traditional links are being disrupted and new opportunities are emerging ("Disruption and Opportunity", July 2018). The shock of this very disruption will ultimately lead to discovering and joining disconnected links, creating new chains like the circular economy, to which we have dedicated this issue, our fortieth. Production, innovation and the environment. There are simple everyday behaviors—as you will discover while reading this issue—that can change the world. Governments should make a firm commitment to disseminating and incentivizing this culture. We are naturally optimistic, but realism tells us that we are walking in the opposite direction from the goal of humankind, that is to live a better life and in peace.

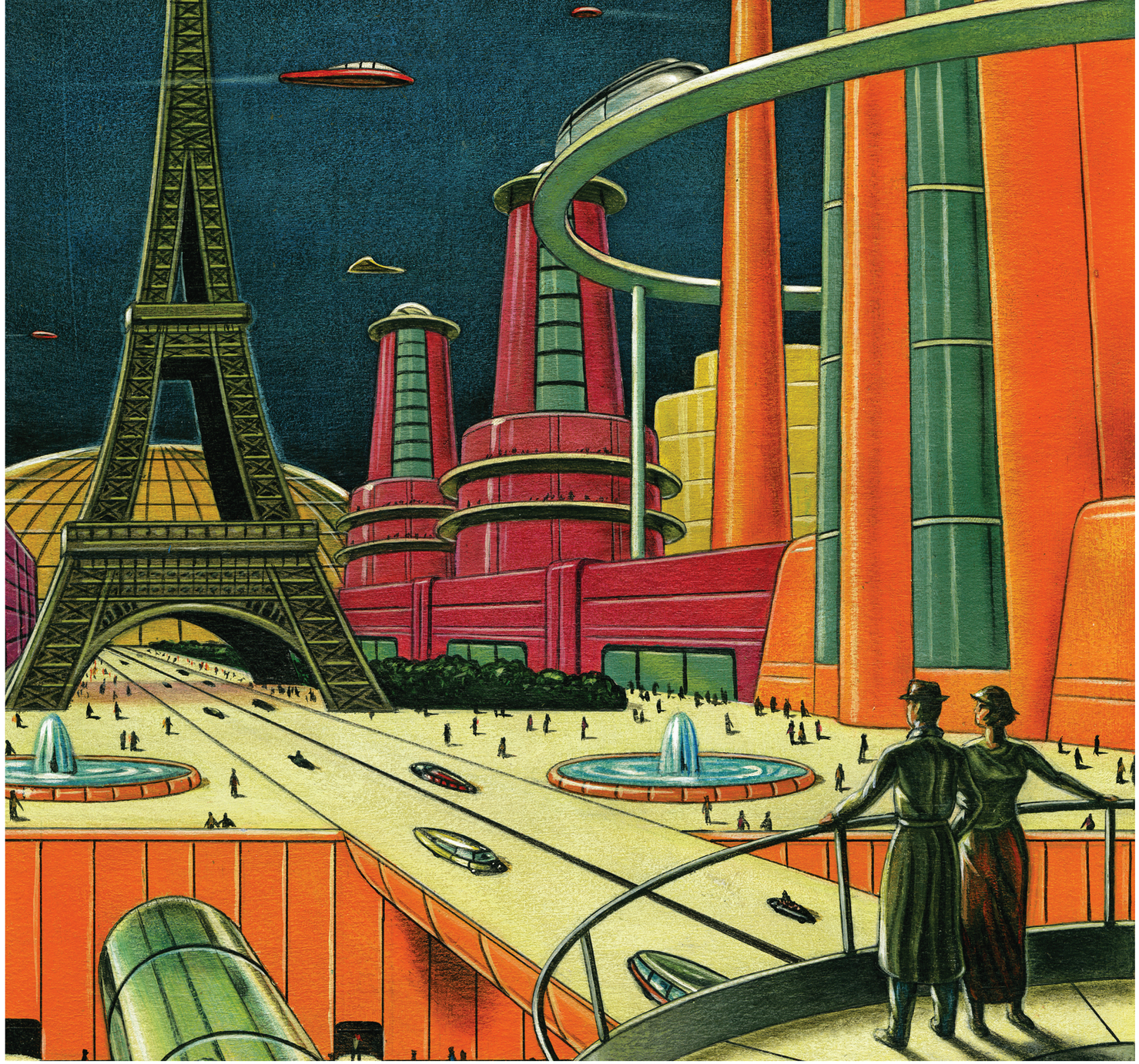
Our story began forty issues ago, in 2008, the year of the global financial crisis. That was ten years ago, when everything was different. Ten years later we are living in a different universe, and we must choose whether to consume our planet or preserve it.

And here we come to the future, the usual question we raise each time we start thinking about a new issue of *WE*. The answer continues to be partial and it cannot be otherwise. The shift that began back in 2008 is still in the process of producing its effects. Technology is helping us in the transition, it is accelerating change towards a new world, but by itself it will not save us from making the same mistakes we made ten years ago. We are consuming, but I have quite a few doubts as to whether we are advancing.

Scenario/"Back to the future"

The Time Machine

Thanks to technology, the world of energy today is cleaner, safer, more diversified and more economical than we could have imagined 10 years ago. But nothing can be taken for granted and everything could be quickly overturned



Left, Marc Burkhardt's 1996 illustration for the U.S edition of Jules Verne's posthumous book, *Paris in the Twentieth Century* (Random House). Written in 1863, the book wasn't published until 1994, when the manuscript was found in the achieves of the French publisher, to whom the young writer had entrusted it.

MARC BURCKHARDT
An illustrator and painter, his work has been featured in numerous magazines, publications and on book covers and includes product design and much more. His work has been commissioned by publications such as *TIME*, *Rolling Stone*, *Atlantic Monthly*, *The New York Times*, and Major League Baseball, and prestigious companies including Porsche, Honda, Simon & Schuster, Random House, and Pentagram Design.
Burkhardt has exhibited his work at Art Basel (Switzerland & Miami), Copro Nason in Los Angeles, La Bash Contemporary in San Francisco, Mindy Solomon Gallery in Florida, Silas Marder, Blank Space and Arts Students League in New York.

Flash forward was a short-lived American TV series that imagined you could see a projection of your life on a specific day in the future. What will we be doing in ten years' time? Who will be governing us? Will we be living in a different country? After a spectacular start, the series quickly lost viewers and was cancelled after the first season. As a result, the fate of the individual characters remained unknown. If in 2008 we had been given an opportunity to flash forward, how would we have imagined energy to be in September 2018?



FRANCESCO GATTEI
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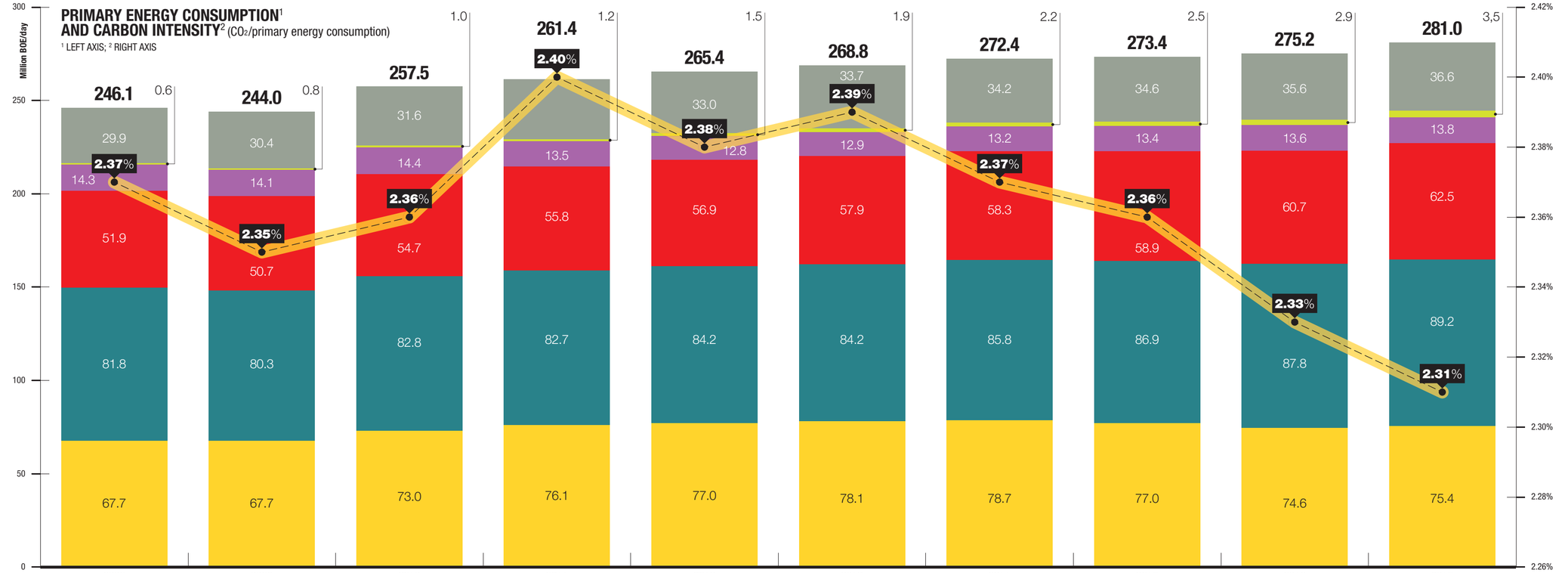
The history of time travel is little more than 150 years old. We have to look to Jules Verne and H.G. Wells at the end of the 1800s for the first accounts of fourth dimension travelers. Their vision of the future is dystopian, negative and dangerous. For the young Verne, with his *Paris in the Twentieth Century*, tomorrow's world (which is now yesterday's world) would have been controlled by communication and a technocracy without feelings. The fate of the protagonist, a poet, was inevitably tragic. Written in 1863, the book was so pessimistic that, to avoid harming the young writer's positive image, the publisher never published the text, which was later rediscovered in a cellar and published in 1994, when the domination of communications and the crisis of poetry seemed a less tragic prospect. Paradoxically, the first to travel through time was Verne's manuscript itself. Because of this publication delay, rather than being the progenitor of time travel novelists, Verne became one of the last imitators of the genre. The official title goes to Herbert George Wells, a modern turn-of-the-century man and a convinced supporter of socialism and free love, who was also fascinated by bicycles ("Every time I see an adult on a bicycle I do not despair for the future of the human race.") In his 1895 book *The Time Machine*, Wells portrayed a world devastated by monstrous beings and, in the final journey through time, almost lifeless. From Zamjatin's *We* to Bradbury's *Fahrenheit 451* and Orwell's *1984*, the future is characterized by a deadly mix of illiberal dictatorships, domination by a negative technology and annihilation of individualism and creativity. In the 1970s, cinema added a further bitter ingredient to these pessimistic themes, one unknown to writers in the past. With *Interceptor*, *Waterworld* or *The Day After Tomorrow* to mention a few, the world of the future is highly polluted and close to if not beyond environmental catastrophe.

An uncertain future

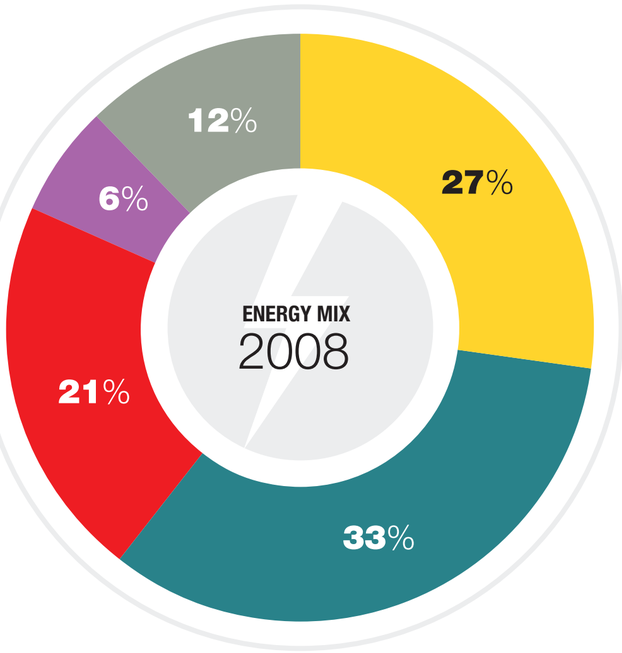
If we had had our flash forward in 2008, therefore, it is highly likely that we would have worn dark glasses: we would have foreseen very high oil prices at 200 dollars or more and coal as the main source of energy to fuel the Chinese "factory of the world." We would have expected a growing battle for access to resources and, consequently, tensions in the Middle East, the geopolitical equivalent of the fog in the Po Valley. And in 2008 there were certainly premonitions for a dystopian future: the price of oil reached a historic high of 149 dollars a barrel, the price of gas in the U.S. was close to 13 dollars per one million BTUs (MBTU), again a record, and the world awaited completion of the big LNG importation terminals that would guarantee continuity of supply in a market where supplies were gradually dwindling. Coal was the fastest growing energy source for the sixth year in a row, while China was the most voracious consumer in the energy sector, accounting for more than 50 percent of the growth in the demand for fossil fuels. Re-

TEN YEARS OF ENERGY

In the past ten years, replacing coal with gas and renewable energy has contributed to reducing the carbon footprint, despite the significant increase in energy consumption.



Source: Eni elaboration on IEA-Enerdata



newables? Not available. With an installed solar and wind capacity that globally amounted to 140 Giga Watt (GW) and annual increases of a few tens of GW no one could foresee any significant change in the sluggish trend of recent decades. Unsurprisingly, therefore, the first issue of *Oil* was dominated by a Malthusian theme: the oil price peak and the great uncertainty about the discovery of new resources. The title of the magazine "For how much longer?" might also have led Jules Verne's publisher to hide the manuscript of *Oil* for a century.

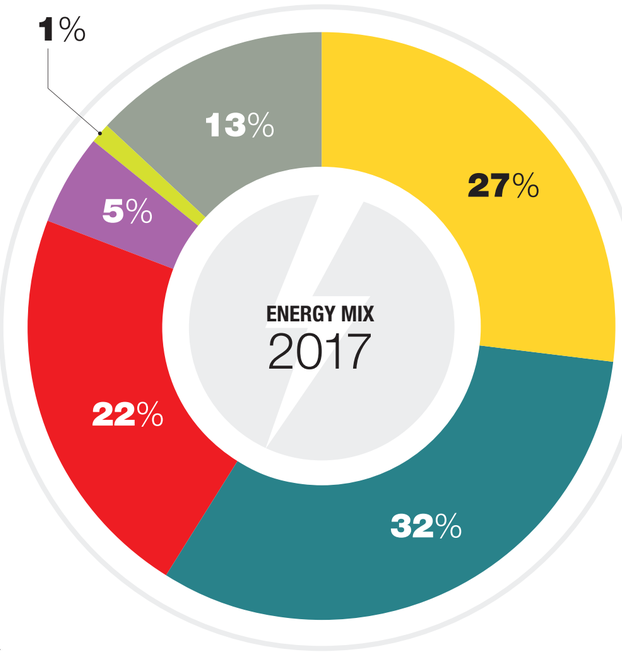
But everything has changed since then. The world of energy is cleaner, safer, more economical and diversified. Over a couple of months, the price of oil plummeted to 35 dollars, then climbed back up to 120 during 2011-2014 and fell again. It currently stands at around 75 dollars, but no one is wondering "for how much longer" any more. Similarly, gas in the U.S. has been priced at between 2 and 3 dollars per MBTU for a decade, a good 10 dollars less than in 2008. The U.S. no longer needs to import LNG as it is now exporting it along with gasoline, light oil and coal. U.S. domestic consumption of coal, despite the new Administration's attempt to relaunch it, has fallen by 40 percent. Thanks to the use of gas and renewables, CO_2 emissions in the U.S. have fallen to the levels recorded in 1992, the year of the first, fruitless attempts at a climate agreement. In Britain, coal use has returned to the level it was at the time of Wells' futuristic novels. China has also enacted a profound transformation of its industrial and energy model. Gas is the preferred source with growth rates of more than 10 percent, and defending air quality in cities is an absolute priority. Coal remains the dominant fuel in electricity production but its use, even in China, has been falling for 5 years. Globally too, the growth in the demand for coal has almost stopped, while solar and wind power are the fastest-growing sources, having reached an electricity generation capacity of 1100 GW, 10 times the level 10 years ago.

A small but significant technological revolution

But what has led to this radical change in prospects?

The answer is technological and relates to the transformation of two marginal sources into mainstream ones: the production of oil and gas from impermeable rocks, tight oil and shale gas, through hydraulic fracturing and the production of wind and solar energy through the widespread creation of new plants. After years of accumulating experience, these two developments have achieved a sudden breakthrough which has fostered massive and rapid operational scalability: the simplification of operations has in fact made production of energy from these sources as routine an activity as manufacturing. The implications are considerable: the small financial outlay—a well or a wind turbine cost a few million dollars—and the extensive availability of credit—with cash flow ensured by subsidized rates for renewables or hedging for Oil & Gas production—have greatly reduced the barriers to entry of new operators and allowed a rapid evolution of the learning curve. In the U.S., nearly 10,000 wells are drilled every year by hydraulic fracturing and there are thousands of turbine or photovoltaic installations. If Gladwell's rule about 10,000 hours of practice being needed to become a champion also applied to energy, we would be beating new records every year.

And the transition from Malthus to the exponential increases of Moore has been a short one: in 2008 the world consumed energy equivalent to 245 million barrels of oil a day. 200 million of these, over 80 percent, were fossil fuels, only 1 million of which were shale gas/tight oil, and 0.6 were solar and wind power. The rest was split between hydroelectricity at 2 percent, nuclear at 5 percent and biomass at 9 percent. The world currently consumes 270 million barrels, but the tight oil/shale gas component is 14 million barrels/day and 3 million bbl/day come from solar and wind power. In other words, 2/3 of the world's increased consumption over the decade has been covered by sources that in 2008 were totally marginal and have now suddenly become competitive. One further and unforeseeable benefit of the new technologies is the improvement in the carbon content of the energy mix. More gas, more renewables and less carbon equals less CO_2 per unit of energy. Despite the 15 percent increase in the demand for energy over the decade, emissions have increased by "only" 10 percent. Today the world emits 2.3 tons of carbon per million tons of energy consumed. Fossil fuels are still dominant, with 228 mil-



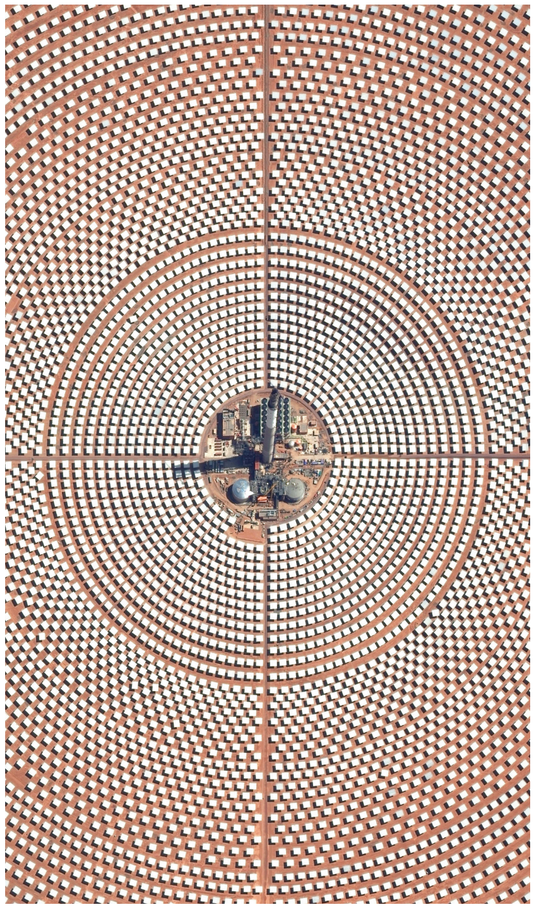
lion, their share of the total has remained substantially unchanged, but their contribution to the growth of individual sources has not been uniform. While gas has grown by 12 million barrels, carbon has only grown by 8 and has remained stable for a few years. And this has a positive effect on the weight of carbon in the mix.
And finally, energy production today is more diversified and secure. The U.S., third in 2008, is now the top oil producer and the top gas producer as well from second ten years ago. OECD countries generate 30 percent of their energy in-house, a level that has remained stable over the last 10 years. This is an excellent result considering the lower energy potential of these countries and the maturity of their oil production areas.
In short, we have written a much more positive novel that we had planned. Travelers in the days of Verne and Wells were right about a world without poetry and dominated by dehumanizing technology. But it's a freer, fairer and more peaceful world than they inhabited or had ever imagined. And that we could have imagined even ten years ago.

A U-turn?

Then all is well? If our traveler were to jump forward ten years, what kind of world would he find? Have the dynamics of recent years set a virtuous trajectory? Nothing can be taken for granted and everything could be quickly overturned. In fact, the last few years have been characterized by a new phenomenon which could have serious consequences for human development and for an effective fight against climate change: the growing aversion to investments in fossil fuels. This process undermines the foundations of the energy system, which requires constantly available, high-density energy sources.
Dense and constant energy is guaranteed today by fossil fuels, hydroelectricity and nuclear energy, which cover 99 percent of requirements. Fossil fuels provide the majority, covering more than 80 percent of consumption, and can only be replaced with intermittent forms of energy (such as solar and wind power) for certain kinds of use, e.g., the production of electricity during the 4 to 5 hours daily of maximum sunshine and wind strength. There is no actual substitute for the remaining 20 hours of electricity generation to allow the production of chemical materials, to fuel the most energy-intensive industries such as cement, steel, air, sea and heavy goods transport. Also limited, despite the emphasis, is the degree of substitution in automotive transport, considering the high cost of batteries, which in poor countries exceeds the cost of the entire car, reduced vehicle autonomy and charging times.
The limitations presented by new renewables derive structurally from their low energy density, which requires vast expanses of panels or rotors to produce the amount of energy required, from intermittent generation and low efficiency of batteries that are expensive and also characterized by low density energy. New materials or original technological solutions are needed to improve their performance and make them effective alternatives to fossils.
Just as technology has allowed us to reverse the trends expected in the last decade, it also prevents us from exceeding a certain dimension and speed of replacement. Rather than an actual substitution, what we are seeing today is the development of a model of solar and wind power integration with the primary energy produced by continuous sources. This is why the general aversion to fossil fuels is extremely dangerous: if these were no longer available, the entire energy system would lose continuity, reliability and collapse, with knock-on effects on the production of all other sources such as the functionality and stability of the electricity grid which is ensured by the availability of continuous sources as are the production and transport of materials used for renewable sources. For poor countries it would be impossible to continue developing as they have done over the last thirty years, this despite the fact that a billion people still have no access to electricity and a further billion have limited and intermittent availability. Finally, the energy potential needed to fuel research into new technologies would also be lost.

Conclusion

The history of the last ten years has taught us that technology, and therefore human ingenuity, are the most effective tools at our disposal to escape a nefarious future.
And that CO_2 emissions can be reduced massively and easily by replacing coal with hydrocarbon gases very quickly.
Aversion to the fossil fuels that feed 4/5 of the global energy system could lead to a convergence of instability, high energy prices and higher emissions, taking us back to the negative conditions we feared a decade ago and (paradoxically) slowing down the process of change.
Our brain uses 20 percent of the energy while weighing just 3 percent of the body. It requires constant, reliable and efficient energy. Our economic system also requires a lot of constant and efficient energy. A necessary premise to give birth to new ideas and continue moving towards a cleaner, more beneficial and richer world. For everyone.



TRULY ALTERNATIVE
The limitation of renewable sources lies in their very low energy density (which relies on large numbers of panels and wind turbines to produce energy), and their intermittent and low efficiency batteries. In the future, we will need new technologies to provide real alternatives to fossil energy sources.
Left, a satellite image of the Ouarzazate solar power station in Morocco.

Analysis/Opportunities and obstacles in the circular economy

A Good Idea in need of Global Champions

Awareness of the need to combat pollution created by waste is slow-spreading and companies still lack the incentives to replace their use-and-discard models in favor of use-recycle-and-reuse ones. Large-scale, adequately incentivized and state-supported attempts to drastically alter the way we currently create and dispose of waste are still few and far between →



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.*

From Starbucks to Alaska Airlines, from Taiwan to Scotland and from William Shatner to Jane Goodall, corporations and individuals from all over the world are becoming engaged in a crusade to eliminate plastic straws. Why? This product does not belong in a circular economy.

While there is slow but growing global awareness of the effects of fossil fuels on climate, the need to tackle the pollution created by waste has received far less attention. The idea is to complement (and eventually replace) the so called "linear economy" (produce, use and discard) with a "circular" one in which products are used and instead of discarded are recycled. The circular economy seeks to retain the value remaining in the products after they are used while also curbing the waste and pollution created by discarded products.

Hitherto, efforts to champion a circular economy have been largely regional in scope and mostly led by the private sector and non-governmental organizations. Approximately 62 percent of the initiatives promoting a circular economy are based in Europe and only 13 percent in North America, while the remaining 25 percent is broadly distributed in Asia, Latin America and Africa. Over 70 percent of the initiatives have been started by the private sector, although member countries of the European Union agreed last May to approve a set of waste management regulations that will lead to 65 percent of municipal waste being reused and recycled by 2035, as compared to some 50 percent in 2010.

The *Circularity Gap Report* (see page 20) points out that of the 92,8 billion tons of materials placed in the economic cycle, only 8.4 billion or 9.1 percent is recycled, while the remainder is incinerated, dumped in landfills or spread into the environment. At the same time, utilization of natural resources has tripled since the 1970s, from 26.7 billion tons to 84.4 billion tons in 2015, while forecasts point to the utilization of a whopping 175 billion tons by 2050. Clearly, more and better policies that incentivize the use of the circular economy and more effective technologies that facilitate the reuse and recycling of used products are urgently needed.

Multiple definitions and diverse initiatives

In a recent article in the journal *Science*, Dutch Professor Julian Kirchherr and his colleagues identified and reviewed 114 definitions of circular economy. They concluded that a "Variety of understandings can result in the circular economy concept eventually collapsing or ending up in conceptual deadlock." This tower-of-Babel situation makes it harder for governments to adopt common standards which, in turn, would stimulate companies that operate in multiple jurisdictions to abide by them and thus scale up their "circular" efforts.

The need for a deeper, more comprehensive and more systematic connection between efforts to promote the circular economy and those aimed at nurturing more sustainable practices is very clear.

At the same time, a review of the scant but intense global conversation about the importance of fostering the circular economy shows that the concept is still at a relatively early stage of conceptual development.

With some exceptions, most current efforts aimed at building a circular economy tend to be quite narrowly defined and are primarily centered on increasing specific economic benefits, by cutting costs for example. There are few large-scale, well endowed, public policy-backed and global efforts that try to drastically alter the ways in which humanity now creates and disposes the waste of "the linear economy." One of these more comprehensive and ambitious initiatives is the *Platform for Accelerating the Circular Economy* (PACE), launched in 2017 as a public-private collaboration supported by the *MacArthur Foundation*, *the International Resource Panel*, *Circle Economy* and *Accenture* and hosted by the *World Economic Forum*. Other examples of important initiatives include *The Circular Economy Club* (CEC), a nonprofit international network active in more than 60 countries with over 2,600 circular economy professionals engaged in the creation of a Global Data Base on circular economy-related initiatives.

The gains from circularity

These initiatives are illustrative examples of the growing interest and support for the circular economy. A 2016 report by the consulting firm McKinsey and Co. describes how the concept is moving from theory into practice and points to a transition already taking place as more companies are adopting circular economy concepts. In Europe, notes the report, the adoption of circular economy practices could generate a net economic gain of almost two trillion euros per year by 2030. The report analyzes three main European sectors: mobility, food and shelter under a circular scenario and concludes that by 2050, savings could reduce mobility costs for the average European household by 60 to 80 percent, food costs by 25 to 40 percent and housing costs by 25 to 35 percent. These improvements would grow the size of European economy by 7 percent above what is now the consensus economic forecast. The McKinsey report recommends a six-point action plan for Europe to transform from a linear to a circular economy—its recommendations include shifting to renewable energy and materials, maximizing utilization of products through peer-to-peer sharing of privately owned products or public sharing of pools of products, improving the performance and efficiency of products, keeping components and materials in closed loops through recycling, emphasizing virtual delivery of utilities and replacing old materials with renewable ones. Perhaps the most important point to keep in mind is that once the incentives are in place, new technologies and business models are bound to create many more circular economy possibilities than are now imaginable.

The obstacles

The Copernicus Institute of Sustainable Development, *Utrecht University*, *Deloitte and the Dutch government* have jointly carried out research on the obstacles to the widespread adoption of the Circular Economy (CE) in the European Union. A survey of business executives of large corporations, government officials and leaders on the circular economy in businesses, government, academia and NGOs asked them to identify the main barriers. Cultural barriers appear to be the most important, including the lack of consumer interest and awareness and the strong reluctance of corporations to abandon their linear ways. Market barriers include the relatively low prices of virgin material and the high upfront investments required to convert business, governments and households from a linear to circular economy. Regulatory barriers are also hindering circular economy efforts. Not surprisingly, technological barriers were not found to pose very important impediments. However, a 2017 report by the *Wuppertal Institute for Climate*, *Environment*, *and Energy* suggests that the attainment of a circular economy is a rather utopian aspiration, since it would require the use of energy in sufficient quantity to become incompatible with climate control targets, a difficult dilemma that needs more research and clarification.

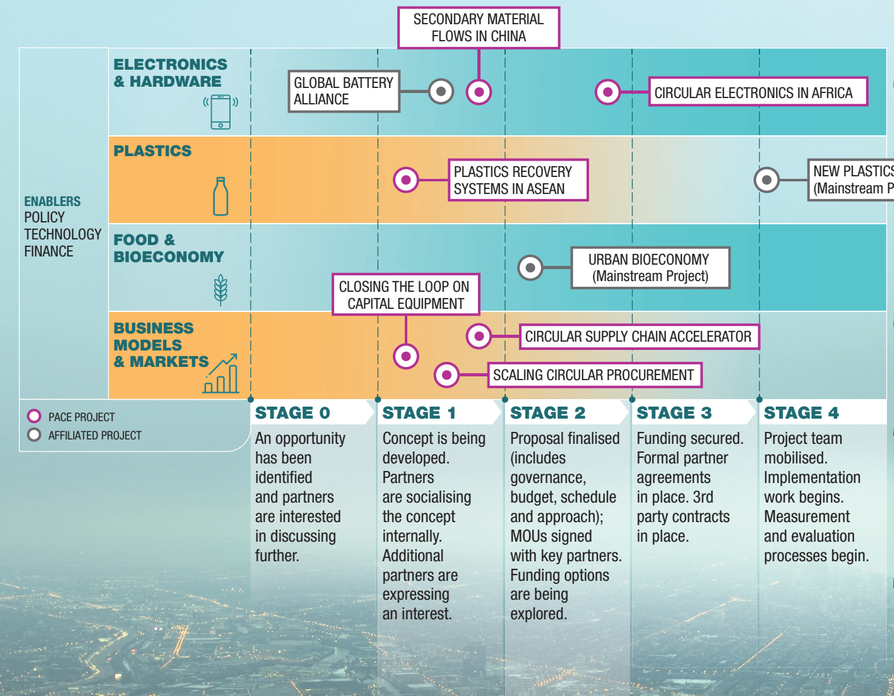
The circular economy: what is next?

Joss Bleriot, of the McArthur Foundation, persuasively argues that the European Commission is the world's leading force pushing towards the large-scale adoption of the circular economy. The reasons are many: There is a greater sense of urgency in Europe about this issue because the Continent is poorer in natural resources than other areas of the world and has much less territory to accommodate waste. In 2015, the Commission agreed on a circular economy package and announced the development of a monitoring framework. The resulting package aims to contribute to broad political priorities by tackling climate change and the environment while boosting job creation, economic growth, investment and social fairness. The monitoring framework includes a set of 10 indicators to cover the different phases of the circular economy and is a key tool to measure progress. The specific targets of the Plan include halving food waste by 2030 and the reduction of marine litter, while establishing a strategy for recyclability of plastics and a revised regulation for fertilizers.

There is little doubt that the example set by Europe should become a global effort. The need for the United States, China and India as well as other large developing countries to join this effort is evident. Professor Seeram Ramakrishna of the National University of Singapore notes that during the last five decades man has consumed more natural resources than in the previous 30,000 years and generated more waste than in all of past history, while consumption of food and goods keeps increasing. In his view the circular economy, with its emphasis on extracting maximum value from resources, and recovering and recycling materials used, offers the best chance for a more sustainable future. It is hard to disagree with the professor.

PACE projects

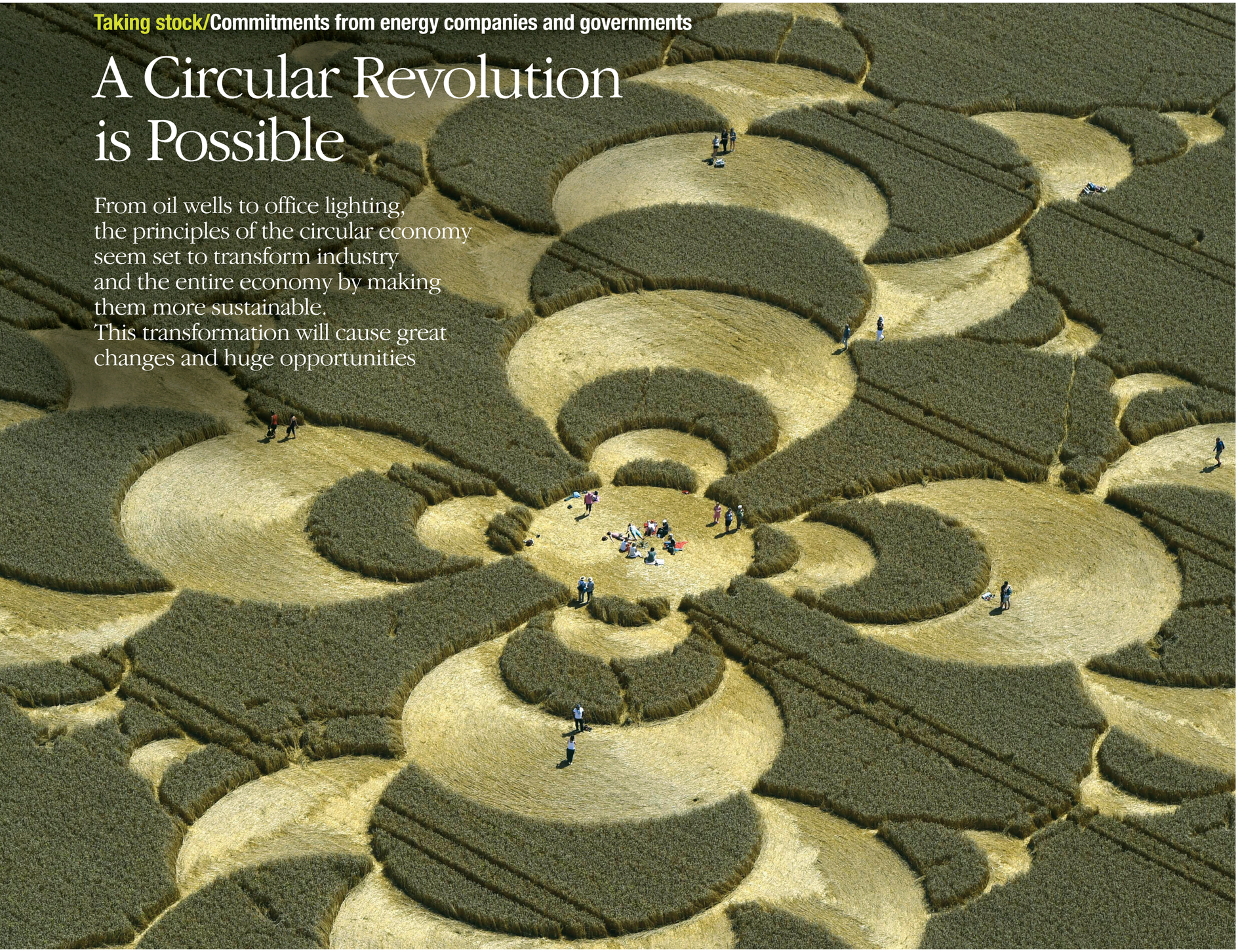
The Platform for Accelerating the Circular Economy (PACE) program was launched in 2017 within the framework of the World Economic Forum, as a synergistic public-private collaboration. It is financed by the Ellen MacArthur Foundation, the International Resource Panel, Circle Economy and Accenture. Its focus areas include plastics, electronics, food and the bioeconomy as well as a business model and market transformation for China, ASEAN, Europe and Africa.



Taking stock/Commitments from energy companies and governments

A Circular Revolution is Possible

From oil wells to office lighting, the principles of the circular economy seem set to transform industry and the entire economy by making them more sustainable.
This transformation will cause great changes and huge opportunities





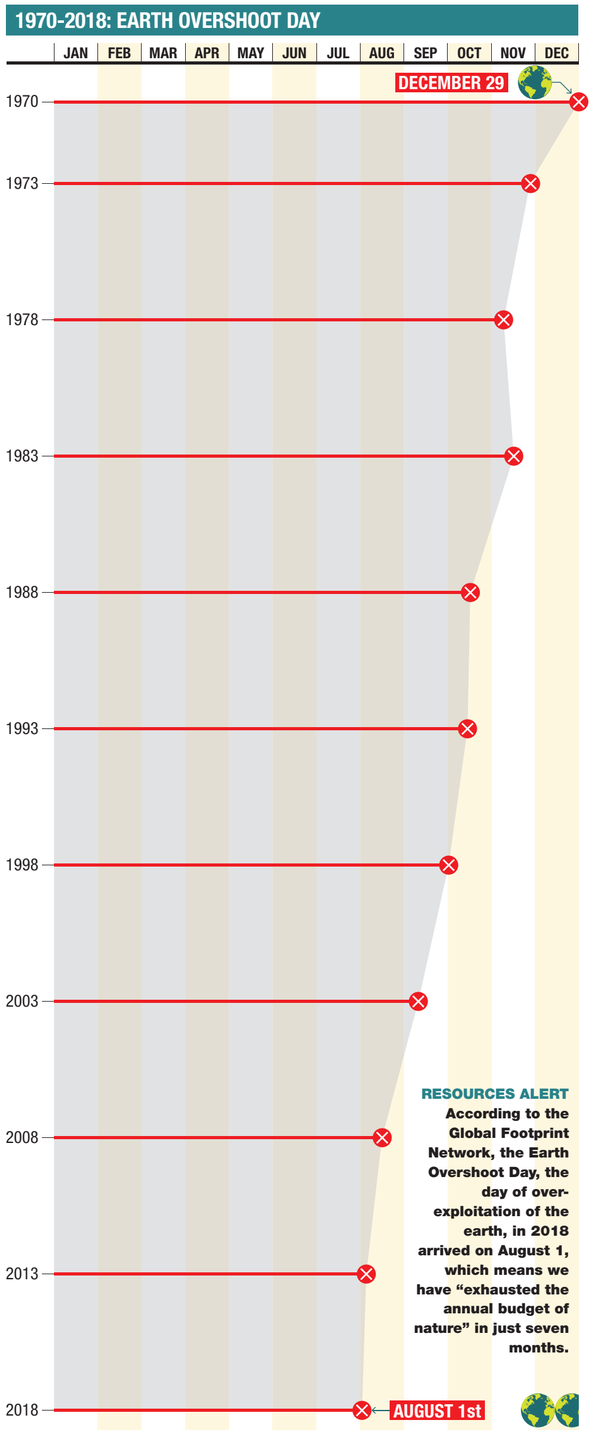
MIKE SCOTT

As a freelance journalist Mike Scott has written for a range of titles including the *FT*, *Bloomberg New Energy Finance*, *The Guardian*, *The Daily Telegraph* as well as for think tanks such as Friends of Europe and corporate clients including Siemens, Rabobank, PwC, Deloitte and AkzoNobel.

Since the start of the Industrial Revolution, the global economy has been based on a specific economic model, one so pervasive that we often don't even realize it is there—this is the model of the linear economy, which can be summed up as a "take, make, use, dispose" chain of activity.
We take raw materials, process them to make them into products, which are then sold to consumers who use them until they no longer need them and then dispose of them. This model applies to everything we consume, from petrol to pasta to the plastic packaging the pasta comes in and the cars that use the petrol.
And underpinning it all is a set of invisible assumptions—the first is that there is an unlimited supply of raw materials that can be mined, along with the other inputs used to make the products we use, including energy, water, and skilled labor on top of resources such as steel, copper and aluminium. The second is that the key to future prosperity is unending economic growth and the corresponding consumption of resources that implies. And finally, it is assumed that the planet can cope with all of the waste that we produce at every stage of this process.
However, it is becoming increasingly clear that these assumptions no longer hold true. There is no doubt that two and a half centuries of untrammelled growth have drastically improved the quality of life of billions of people, but this growth has created immense problems too, and it is clear that we are approaching the limits of the earth's ability to support us.

Earth Overshoot Day is coming earlier and earlier

The Global Footprint Network calculates the day each year when we have used up that year's store of the earth's resources, which it calls Earth Overshoot Day. We first went into overshoot in 1971, the group says, and the day at which overshoot arrives has been getting earlier every year. In 2018, that day arrived on August 1, meaning that we "exhausted nature's budget for the year" in just seven months.
We can see the effects of this overconsumption all around us—in the mountains of plastic waste polluting our oceans and killing marine animals, the thousands of deaths caused by pollution from cars and factories around the world and in the steadily rising temperatures that are causing our climate to change drastically, bringing with it problems ranging from extreme droughts and floods to rising sea levels.
Nowhere is this overuse of the planet's resources more obvious than in the energy sector. Our reliance on energy is one of the main challenges we →



Source: Global Footprint Network National Footprint Accounts 2018



face as a result of our pursuit of growth through the linear economy. Energy has been the driver of our economies' development, and until recently almost all of that energy came from burning fossil fuels—coal, oil and gas. We now know that these fuels, while they are fantastically efficient stores of energy, come with side effects. The pollutants they release are harmful to human, animal and plant life at a local level, while on a global scale the greenhouse gases (GHGs) they release are causing climate change that is starting to have profound effects on people around the world—flooding them out of their homes, ruining crops and driving people out of their homes.

In order to leave a planet fit for future generations, we have to change the way we do things—we need to decouple economic growth from resource use and GHG emissions. In the language of the linear economy, we need to take less, make less, use less and waste less. We also need to pollute less. In order for that to happen, everyone needs to become smarter about how they use energy. The most obvious step—on a global scale—is to switch from fossil fuels to using renewable energy to produce power and heat, and to replace petrol and diesel in vehicles. This is happening all over the world as wind and solar power become more affordable, while electric vehicles are also rapidly moving into the mainstream. Bloomberg New Energy Finance reports that from 2009 to 2018, the global benchmark levelized cost of energy (LCOE) for solar PV has tumbled by 77 percent, and that for onshore wind by 38 percent, while the cost of lithium-ion batteries fell from $1,000 per kWh in 2010 to $209 per kWh in 2017. Meanwhile, the total number of electric vehicles (EVs) hit 4 million in August 2018 and sales are accelerating fast. It took five years for EV sales to hit 1 million, while the fourth million took just six months.

But beyond the straightforward replacement of fossil fuels with renewable sources of energy, there is a path that all businesses can take that will help to create a more sustainable world without plunging the world back into poverty—by implementing circular economy principles. The circular economy model focuses on creating closed loop systems that minimise waste and resource use by recycling and reusing materials and products once they have reached the end of their useful lives. In some instances, this is just about making small, even obvious changes, such as reducing waste. In other cases, it requires companies to completely change their mindset and the way they do business, and consumers to make major behavioral changes as well.

Projects for clean energy

Even as the world moves towards a more renewable energy system, there is much that energy companies can do, both in their day-to-day operations and at a more strategic level. In a recent report, *Circular Economy in the Energy Industry*, Deloitte Finland said that "energy is an essential part of a sustainable economic system, as it enables the re-use of materials. Circular economy in the energy industry is promoted by cooperation between industries and companies, as well as by services that decrease the overall consumption of energy."

Applying circular economy principles in the energy system will "maximize the efficient use of natural resources for energy production, end use of energy, excess energy and side streams," it added. This can start at the point of production with initiatives such as increasing the use of renewable energy in the production process—for example, Norway's Equinor, formerly Statoil, is looking at building a new floating wind farm to supply power to some of its North Sea oil and gas fields, while Glasspoint has pioneered the use of solar power to produce steam for enhanced oil recovery (EOR) in heavy oil fields, cutting the use of natural gas and reducing emis- →

PLASTIC ARMY

Every year, between 4 and 12 million tons of plastic end up in the world's oceans, accounting for 80% of global marine pollution. The image shows "Plastic Army", an artistic installation in front of the beach of Ses Covetes, in Mallorca, Spain. By T. Siepmann/TAS (idea) and Dirk Kruell (installation).

sions. There is also an industry-wide initiative to reduce gas flaring, under the aegis of the World Bank, which points out that oil production sites around the globe flare billions of cubic meters of natural gas annually. "Flaring gas wastes a valuable energy resource that could be used to support economic growth and progress. It also contributes to climate change by releasing millions of tons of CO_2 to the atmosphere," the Bank says. In a classic example of turning a waste into a resource, the World Bank's Global Gas Flaring Reduction Partnership (GGFR) is working to reduce natural gas wastage through flaring, and it is starting to have an impact. The partnership's Zero Routine Flaring by 2030 Initiative, whose signatories include governments ranging from the U.S. to Kazakhstan and Nigeria as well as companies such as Eni, BP, ExxonMobil and Total, have committed to limit routine flaring in new oil field developments and to find ways to end it at existing sites by 2030 at the latest. The initiative has been endorsed by 27 governments, 35 oil companies and 15 development institutions. New satellite data shows that gas flaring at oil production sites around the world fell by 5 percent in 2017, even though oil production rose by 0.5 percent, with the largest declines seen in Russia, Venezuela and Mexico.

Further up the value chain, the huge amount of heat produced by thermal power plants (both fossil-fuelled and nuclear) can be recovered and used either to improve the efficiency of the power plant itself or to provide energy for other uses such as heating swimming pools, hospitals, schools or even entire districts, as happens with Scandinavia's district heating schemes. Power plants can also make use of the waste produced by other parts of the economy, such as agriculture and industry—materials such as crop residues, wood chippings and bagasse from the sugar production industry can all be burnt to produce electricity or processed and turned into biofuels. This not only helps reduce waste in other sectors but increases the efficiency and cleanliness of power production. Power generators and waste companies can also co-operate in developing dedicated waste-to-energy plants that use household waste as a feedstock, helping to reduce the need for landfill.

And alongside the rapid development of the renewable energy sector, energy storage is expanding at a similar pace, allowing generators to use energy that otherwise would be wasted, at a time of their choosing.

There are also a number of projects that capture the carbon emissions from power stations (and other industrial facilities) and use them to make new products, in a process known as carbon capture and utilisation. These products include hydrogen, syngas, methane and methanol, as well as construction materials, polymers, carbonates and urea, a key ingredient in fertilisers, says a report from the European Union's group of chief scientific advisers.

Sharing, services and zero waste

But the true value of the circular economy—and the consultancy Accenture has calculated that it could unlock $4.5 trillion of economic growth—will come from its application throughout the economy as a whole. There are three key trends that are driving the adoption of the circular economy model—the sharing economy, product-as-a-service and a focus on driving out waste from production processes.

The sharing economy has given rise to entirely new economic sectors as people rent out their spare rooms, turn their cars into taxis and sell the energy they generate from solar panels to their neighbors. It has also helped create new competitors to traditional industries, such as Airbnb (hotels), Uber and Lyft (taxis). As CoinTelegraph explains, the concept can be applied to almost every aspect of the economy. "You can share someone's garden if you live in a bustling city, strike up job shares, team up with other travellers to share a tour, swap books, and even take someone's dog out for the day," it explains. The services offered in JustPark's Sharing Economy Index start with "I can lend you some money" and include everything from "You can borrow my parachute" to "You can dock your boat at my marina."

Closely related to this, but at a business level rather than a personal one, as-a-service models give people access to goods and services that in the past they might have bought but on a rental basis. As-a-service models have emerged across the economy, in businesses including software, lighting, medical scanners, carpet tiles, jeans and aircraft engines. The company offering the product retains ownership and control of it, and in return provides all the necessary maintenance and upgrades. This enables companies to take back products and ensure that they are properly reused, remanufactured or recycled, improving resource efficiency and reducing waste.

This focus on waste is another key theme of the circular economy. Companies such as GM, the U.S. carmaker, are looking to send no waste at all to landfill. This has required a considerable change in how employees think about waste and having to adopt what the company calls a "zero mindset." "To us, waste is simply a resource out of place," says John Bradburn, General Motors Global Waste Reduction manager.

Commitments from governments

To date, most circular economy efforts have been driven by individual companies and NGOs, but the concept is starting to find its way into the regulatory sphere as well. The European Union this year introduced a Circular Economy Package that sets stricter targets for recycling and cutting the amount of waste sent to landfill. It also puts the onus on producers to contribute to the cost of recovering materials at the end of a product's life and encourages new business models that design out waste, increase product lifespans and promote reuse. This will be bolstered by specific legislation to tackle plastics waste, the E.U. Plastics Strategy.

The E.U. has signed a memorandum of understanding with China, which has had its own circular economy regulation, the Circular Economy Promotion Law, in place for 10 years. The MoU could see the two economies aligning circular economy mechanisms, paving the way for them to develop common policies and product standards. Given the size of the two economies, this could have a global impact.

Japan, because of its relative resource scarcity, has long had a focus on circular economy and resource efficiency. "Devised around the concept of 'establishing a sound materials-cycle society,' Japan's system of policies focuses on waste management and resource depletion," according to the World Economic Forum. Examples include the Law for the Promotion of Efficient Utilization of Resources, ratified in 2000 and the Law on Re-utilization of End of Life Automobiles, which came into force in 2002.

In North America, Canada's Waste Free Ontario Act includes a section on Resource Recovery and Circular Economy, and while the U.S., as the European Circular Construction Alliance notes, "has not been a trend setter in the circular economy field", the U.S. chapter of the Ellen MacArthur Foundation's Circular Economy 100 (CE100) program includes brands such as Google, Cisco, Coca-Cola, eBay, Apple, Novelis and IBM.

Many countries in the developing world have in the past prioritised economic growth over sustainability concerns because of the need to move people out of poverty, but there is a growing realization that unconstrained growth causes serious problems including resource scarcity, air and water pollution and climate change. The circular economy, however, can help to tackle many of these problems at the same time as lifting people out of poverty. As a result, "there is growing optimism about the potential of the circular economy (CE) as a new model for sustainable growth in developing countries," says the think tank Chatham House.

Governments in Rwanda, Nigeria and South Africa, for instance, are working with the World Economic Forum and the E.U. and have recently launched the African Alliance on Circular Economy. Multilateral development banks are exploring the potential of CE approaches with Colombia and Turkey, it adds, while the Indian Resource Panel recently unveiled an action agenda on resource efficiency highlighting the CE. "This reflects increasing optimism about the potential for the CE to help lower-income countries 'leapfrog' to more sustainable development pathways," the think tank says.

As the circular economy gathers momentum around the world, the energy sector will be both a key target of changing business models and a key enabler of the transformation of the rest of the economy.

The advent of renewable electricity and storage, in tandem with technologies such as the internet of things, machine learning and big data analytics. help to make customers producers of energy as well as consumers. The new energy system will be decentralised, distributed and multi-directional. Energy companies will need to respond by introducing energy-as-a-service (EaaS) business models, where energy companies will take responsibility for a building's future energy costs and then introduce various efficiency measures to reduce the amount of power needed to run them.

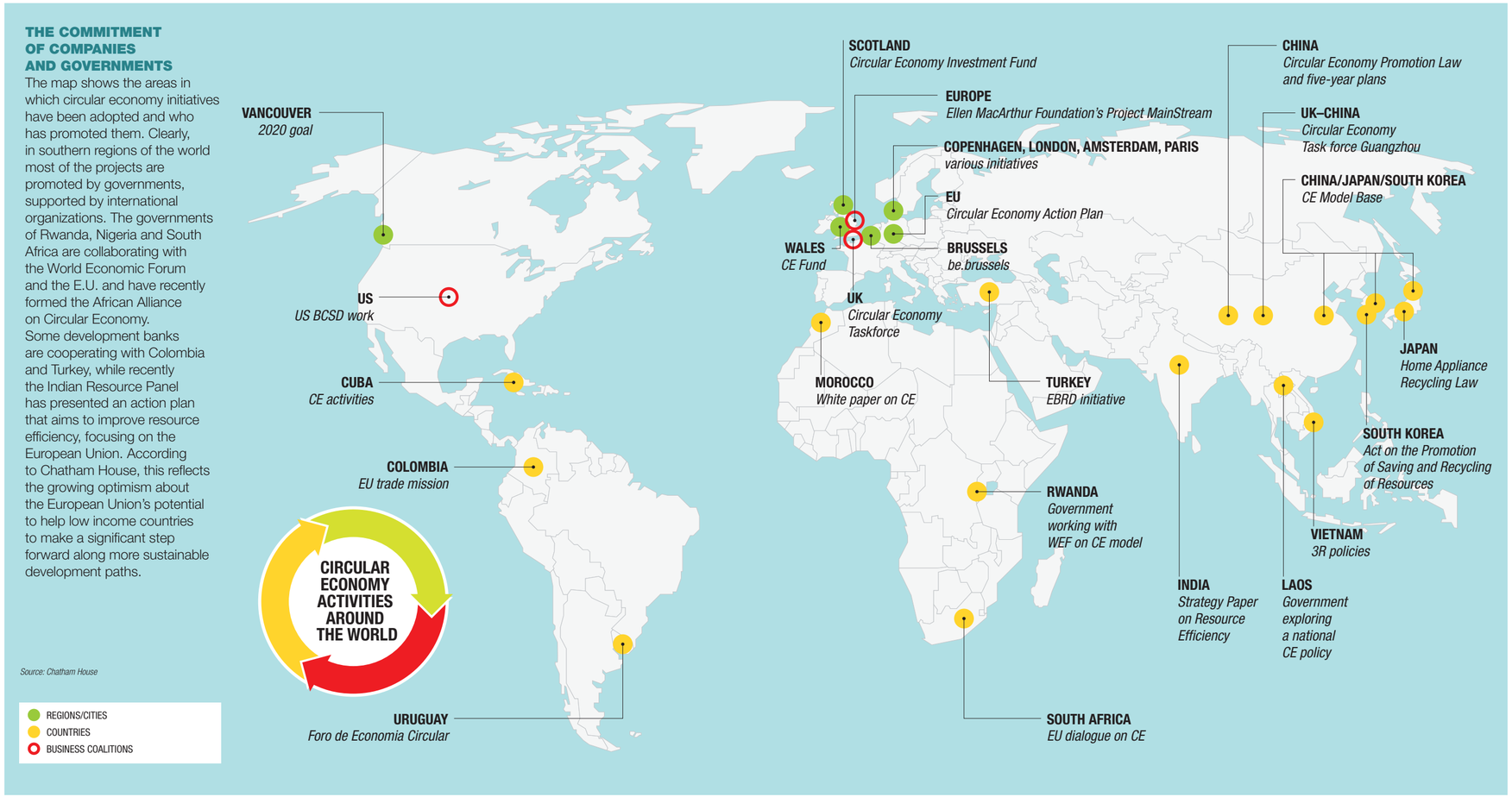
A comprehensive EaaS approach "will include a combination of saving energy, producing energy, and storing energy, in addition to the conventional buying and using of energy with such entities as solar and/or wind power procurement, onsite or remote; onsite generation such as combined heat and power (CHP) or fuel cells; microgrids and storage; retro-commissioning and energy retrofits; time-of-day demand peak shaving; demand response; fuel-switching; and fossil fuel and electricity procurement," according to CX Associates' Building Energy Resilience blog.

From the oil field to office lighting, circular economy principles look set to transform the energy sector and the wider economy, making them more sustainable in the process. This circular revolution will cause a major upheaval in the industry, but there are huge opportunities, too, for companies that accept the challenge.

THE COMMITMENT OF COMPANIES AND GOVERNMENTS

The map shows the areas in which circular economy initiatives have been adopted and who has promoted them. Clearly, in southern regions of the world most of the projects are promoted by governments, supported by international organizations. The governments of Rwanda, Nigeria and South Africa are collaborating with the World Economic Forum and the E.U. and have recently formed the African Alliance on Circular Economy.

Some development banks are cooperating with Colombia and Turkey, while recently the Indian Resource Panel has presented an action plan that aims to improve resource efficiency, focusing on the European Union. According to Chatham House, this reflects the growing optimism about the European Union's potential to help low income countries to make a significant step forward along more sustainable development paths.



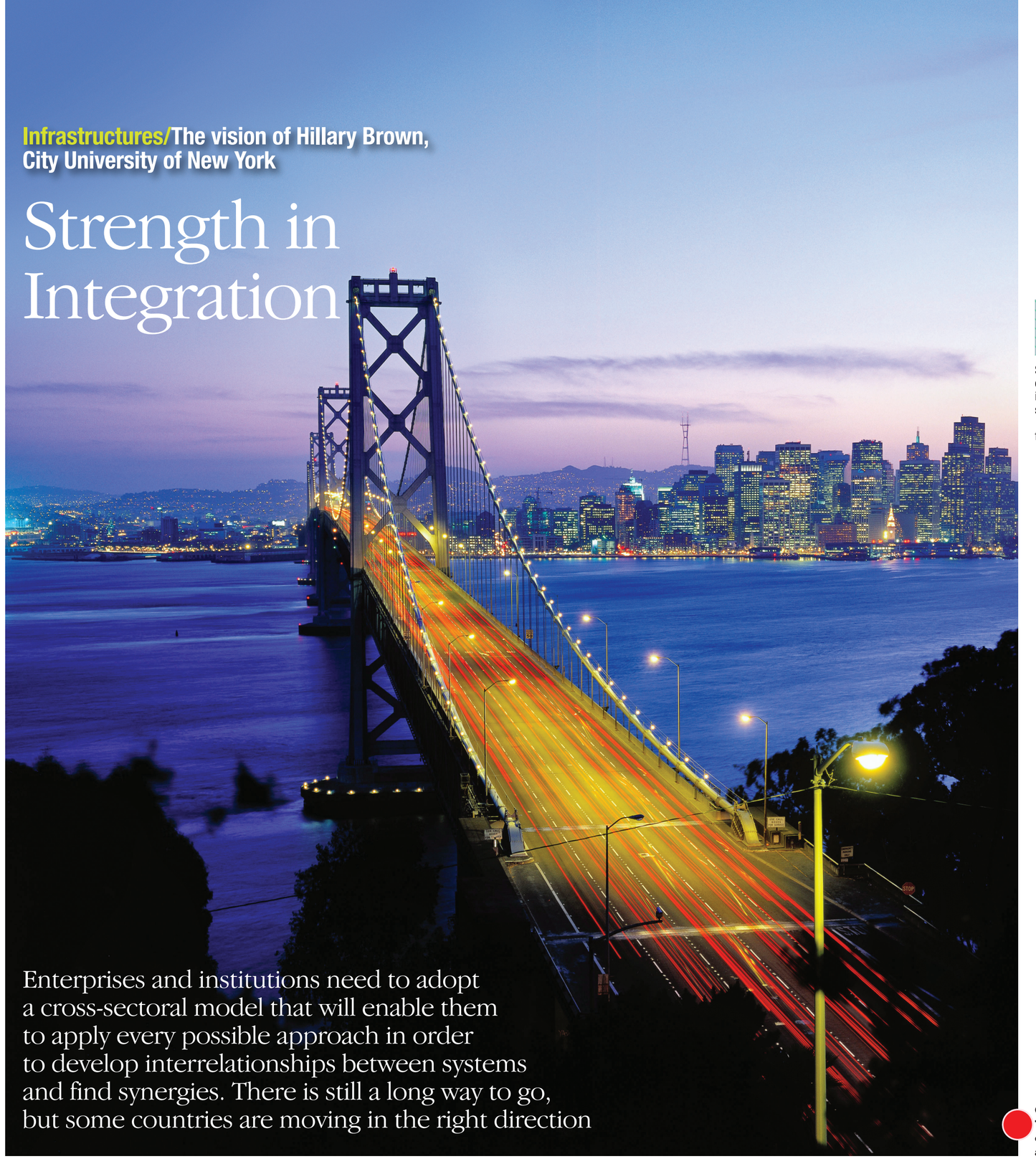


Hillary Brown

A Fellow of the American Institute of Architects, she is the author of the books *Infrastructural Ecologies: Alternative Development Models for Emerging Economies* and *Next Generation Infrastructure: Principles for Post-Industrial Public Works*. At City College, City University of New York, she is Professor and Director of the M.S. Program: Sustainability in the Urban Environment.

Infrastructures/The vision of Hillary Brown, City University of New York

Strength in Integration



Enterprises and institutions need to adopt a cross-sectoral model that will enable them to apply every possible approach in order to develop interrelationships between systems and find synergies. There is still a long way to go, but some countries are moving in the right direction

Oakland, United States. The Bay Bridge, connecting Oakland and San Francisco.



MOLLY MOORE

She is a Senior Vice President of Sanderson Strategies Group in Washington D.C., a media strategies firm, and a former *Washington Post* foreign correspondent.

ntegration" of economic and infrastructural resources, "reciprocity" and "exchange." These are the keywords that define the circular economy, according to Hillary Brown, one of the most authoritative American commentators on sustainability and urban environments. The drivers for this integration must come from both the public and the corporate sectors. According to Brown, companies can retool by reconfiguring their supply, production and dismantling processes in order to move beyond an economic model based on a high growth consumption rate. Local and national institutions need to adopt a cross-sectoral approach that will give them a system-wide vision.

What is the circular economy and to what extent are countries and corporations embracing it?

It's an idealized concept. We understand the potential to retool our economy to resemble nature's closed cycles, but I don't think it's a mature concept and it's not uniformly organized. It still seems to be a collection of separate fields and some even semi-scientific concepts.

I describe it as a high level of integration along multi-dimensional resources—economic and infrastructural, and it entails reciprocity and exchange among systems. That is my own broader definition rather than the one that focuses on sharing or recycling.

We've accepted recycling, yet things like remanufacturing will require more aggressive changes to the manufacturing process. Like it or not we seem to abide by the design for obsolescence, which is very hard to eradicate because that would run counter to the high growth consumption rate in our economy.

That's one of the barriers, but there are countries that are embracing this.

What is the most important step a company, country or local government can take to initiate this shift to a circular economy?

The action has to come from both the corporate and public sector. Companies can retool. It means reconfiguring their supply chains if they are going to recycle elements into new products. They have to create new processes for deconstruction. That is very difficult when you have hybridized materials and very few countries have the infrastructure for the product take-back. We are geared for a one–way transport system from factory to consumer. We need to have the extended manufacturer responsibility that they do very well in Germany and other parts of Europe.

Take for example obsolete or broken appliances. They should take them back at the end of their useful life, dismantle them and reutilized their parts. To a certain extent we extract some rare earths or important metals from computers but it's just not a robust industry. That's what I mean by take-back. In a full circular economy you lease or rent a product of service then it goes back for materials recovery and remanufacturing.

How should local governments approach this?

Local governments should look across several sectors at these resources. I call the system "infrastructural ecology," a concept I describe in both of my books. Administrators can look at the interrelationships between water, energy, sanitation and waste management to find synergies.

Here's a very simple example of the idea of looking to co-locate different facilities. Take a system of highway noise barriers on highways that go through urban areas. In much of Europe, those barriers are not only noise barriers but they can also be retrofitted with photovoltaic panels. So you have a system of energy production at the same time you have noise reduction. That's a very simple example of what I mean by hybridized systems.

Another similar system is using bodies of water—a reservoir or a canal—as a surface upon which you can float solar panels. This is being done widely in India across irrigation canals in the dry zones of Gujarat. The synergy here is that the shad- →

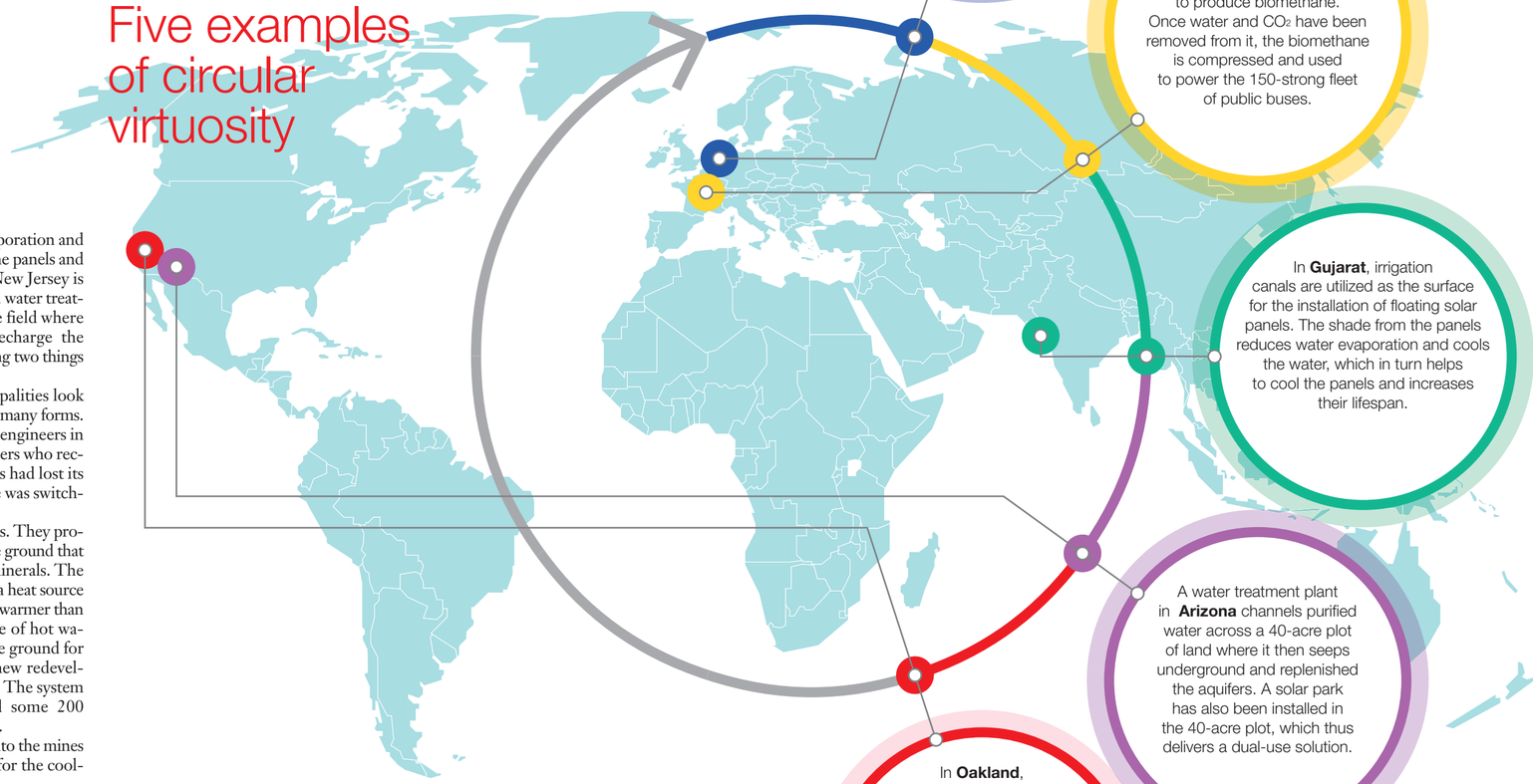


Amsterdam, The Netherlands. Herengracht Canal and the old Lutheran Church.



Arizona, United States. View of the Grand Canyon.

Five examples of circular virtuosity



ing from the solar panels reduces the water's evaporation and the temperature of the shaded water helps cool the panels and extends their lives. A water treatment plant in New Jersey is using its reservoir to float panels and in Arizona a water treatment plant sends its treated water into a 40-acre field where the water is put back into the ground to recharge the aquifers. On those 40 acres is a solar farm. It's doing two things with a single solution.

The other proposition is simply to have municipalities look at local natural resources, and that can take many, many forms. A case study in my book talks about two women engineers in Heerlen, Holland. The women were civil engineers who recognized that the town in the late 70s or early 80s had lost its economy—which was coal mining—as everyone was switching to cheaper natural gas.

Under the town were decommissioned coal mines. They produced something called mine water—water in the ground that becomes a bit contaminated by chemicals and minerals. The water fills up the mine over time, and it becomes a heat source because the thermal gradient of the earth is much warmer than the air. If you go deep enough, you get a source of hot water. They actually tapped that resource under the ground for heat, and it supplied enough heat for a whole new redevelopment of the town and its municipal buildings. The system heats the civic center, public buildings and some 200 dwellings, much of which is affordable housing.

In summer, you can also put the hot water back into the mines as a heat sink so you can use the same resource for the cooling of homes.

There are something like a million disused mines worldwide, and this could be a source of renewable energy. It's been done in Germany, and a study in the U.S. showed that an area in the coal regions of Pennsylvania could heat 20 houses from just 4 percent of the mine water from a single coal mine.

In the areas of energy, where are the greatest strides being made today? Could you offer some specific examples of existing projects you consider among the most successful?

An initiative in the town of Lille, France is a good example of a top-down initiative where the mayor looked across three different departments to reduce carbon emissions. It started with a wastewater treatment plant that was using a anaerobic bio digestion as a way of treating water, one of the most common water treatment processes. Organic matter decomposes into methane, CO_2 and water in the presence of bacteria, a process done anaerobically, meaning without oxygen. The byproduct of the bio digestion is bio methane and sludge, which is full of nutrients. You can use that sludge for fertilizer.

This town did a pilot study, where they took the biomethene, they cleaned it, they removed some of the water and CO_2 and compressed it and it became a gas for the city buses. This was so successful that they needed to find another source of organic material. At the same time they had problems with their incineration plant which they had to shut down. They decided to build an organic waste recovery facility—which any town can and should do. That organic waste recovery facility takes waste from restaurants, food processing, domestic organic waste, which people sort and agricultural waste. You can bio digest that waste and produce the methane or biogas, which can be used to generate energy.

In the case of Lille, they used it for powering 150 public buses. That is renewable energy.

Are systems like these cost-effective? Do they pay for themselves?

This is the million-dollar question. It depends. They were able to run all their buses on renewable energy so that displaced the need to buy something like 5 million gallons of diesel oil. The system cost is expensive, but if you can monetize it several ways you can utilize the fertilizer from the sludge and that can be sold back to the agriculture sector. And you can use that gas in many different ways—you can sell it to the grid.

The question you asked is the important one because today with the very, very low cost of natural gas the payback period on this is fairly long. The fact is that we subsidize our natural gas, our drilling, etc., when instead we have the resource of natural gas from the closed loop. If we corrected the subsidies, it would pay for itself in no time.

It's the dilemma, but let me give you a couple of examples of where it's done quite economically. One is in the East Bay municipal utility district in Oakland, California. They are processing restaurant waste, agricultural waste and waste from wineries along with sewage sludge and they are able to generate enough biogas to run their facility and sell some of that gas back to the grid at a profit. They've done it right. They have the right mix of biological waste products that makes the process economical. They save something like USD 500,000 a year in electricity that they don't need to run their plant. Yes, this can be done. It's an investment many municipalities think they can't afford because natural gas is so cheap.

Which country is doing the most to incorporate the circular economy into its planning and development and what has been the major driving force for it? What have been their greatest successes?

If you look at countries that are really taking the circular economy most seriously, we would have to say the Netherlands. For example, in Amsterdam they've taken the circular economy seriously in terms of doing anaerobic bio digestion, and they are producing a lot of their energy renewably. Buiksloterhan, a neighborhood in Amsterdam North, is a kind of living lab where they are testing circular solutions at the urban scale. It's a post industrial district so they are reusing some of the buildings as housing and offices and creative maker spaces. All of these are built to the highest standard of sustainability and circularity using used water and gray water. They save about 30 percent of their energy, and they are also doing things like promoting home batteries so people can become somewhat energy independent.

So what is the driving force for a country like the Netherlands to embrace the circular economy more than others?

It's political and the Netherlands has been so far ahead of the curve in many respects—most important in the area of resiliency. They developed so many technologies because they have to constantly pump water from the land, which requires →



**Gujarat, India.
Modhera Sun Temple, dedicated to Surya, Hindu Sun god.
The temple complex was built by Bhimdev I in 1027 A.D.**

a lot of energy because much of the land is below sea level. They use the tidal energy that is produced in the dikes as a source of energy, but the dike is also there to reduce a storm water surge. Their mentality is how do we create multiple services with single solutions? It's part of a civic survival skill that has really driven this.
A lot of thought leadership is also coming out of the UK.

Where does that leave the developing world?

That's the subject of my second book, which is called *Infrastructural Ecologies*. I asked myself the question: How does this theory of interconnected, synergistic infrastructure apply to the developing world? Is it possible to do in the developing world? I will share with you three really outstanding examples of out-of-the -box thinking.
In India, the rural areas are energy poor. There is no energy access. One really interesting innovation allowed for enabling the rural poor to have basic energy services. Throughout India there are something like 400,000 cell phone towers that are off the grid. In India's initiative to move towards renewable energy, they were trying to get the telecommunication towers onto renewable energy. So a company named Omnigrid Micropower created a distributive energy model that we could call a micro solar power plant. It was based on the economic model of having the telecommunications tower be the primary customer that would buy the energy produced from this solar power plant.
They could also take the excess and put it on a mini- grid or a micro-grid and that micro-grid could then power LED lamps and small battery boxes that could be sold to the communities in the area around the cell phone towers. They had a circular service and they had what they called "light wallahs" who would distribute the recharged lanterns to customers throughout the villages who would pay for them as a prepaid service. They would collect them in the morning and recharge them.
They spun that into a little industry. They had these battery power boxes people could lease that would run equipment designed for the mini-grid—like refrigerators, irrigation pumps or fans. They didn't have to wire the whole town but they could provide all the services that the townspeople needed without wires. It's really, really brilliant. They proved that this is a really disruptive innovation by linking the needs of these two sectors, the telecom and the electricity sectors.
They found that more than 50 percent of the revenue for these power plants came from the local residents and that contradicted the notion that the poor could not be a source of bankable revenue for electricity. Moreover they created jobs. For every power plant they would create 10 to 15 jobs. The model has been widely replicated. They've won all sorts of awards.
I want to share another one, which shows the reciprocity between water and energy. This one is in Brazil. There's an organization called ITaipu Binacional [IB], which is the largest producer of hydroelectric energy, possibly in the world, from the rivers that divide Paraguay and Brazil. They built this enormous dam, but like many hydropower companies they had a troublesome start. They had to displace some 59,000 residences of the Piranhas River from their homes. Because this area was in very rich agricultural and animal husbandry land, a lot of the runoff from agriculture and from dairy began to pollute the reservoir and it grew algae. That jeopardized the power production.
IB determined that the solution to this would be to work *with* the farming communities to curb their pollution. They could do that if they cleaned up a lot of the animal waste and the fertilized agricultural waste.



**Lille, France.
View of the theater entrance with the bell tower in the background.**

What is it going to make these kinds of efforts more widespread?

That's why I wrote the book. There's opportunity out here. It may not be the only answer to carbon and gas reductions, but it is one that looks at large sectorial productions of greenhouse gasses. Cities are implementing these in single sector solutions and they are just not looking broadly at their assets as a potential source of renewable energy.
The mayor of Lille, France had a vision for carbon emission reduction, and he really cross—examined his engineering teams and said, "What are other ways we could power our buses?" And that's when they started looking at wastewater and organic waste. We need to be doing that.
New York City has all of this organic waste. We do a small amount of composting, but composting is not necessarily the best use of organic waste, which is to produce energy. It's a frustration of mine that we are locked very deeply into these sectorial regimes that don't look at opportunities. I wrote the book to show all of these ways we could connect the systems.

Do you think there will ever be the day when we become fossil fuel free?

There are so many variables involved. We could be fossil fuel free. Twenty years ago if we opted to invest in renewables and reduce subsidies to fossil fuel energies we could have been by now. We have to use all kinds of transitional technologies, one of which is waste-to-energy, which we don't use in America. All over Western Europe and Japan there are waste-to-energy or energy-from-waste plants that utilize municipal solid waste as a source of energy production.
In the United States we are very reluctant to do that. There is this lingering fear of dioxin emissions. Well that's been largely taken care of—99.9 percent. The other push back against it comes from the environmental community that says we shouldn't be burning our waste, because burning our waste is an incentive to produce more waste. But I look at it as a transitional solution that will buy time while we're ramping up full renewable energy.
There are many variables and most of those variables are political. The transition to renewable energy is hypothetically doable if we take certain measures as well as eliminate the gas subsidies and motivate and mobilize municipalities to utilize the energy from their wastewater treatment plants. If we were to do that tomorrow, we would be a long way down the line.

They gave bio-digesters to 33 small-scale farms. It was called the Agro Energy Condominium for Family Agriculture. The biogas from the farms was transported by pipeline to a small centrally located power plant where it produced electricity and heat. That heat was then used by the farmers to dry their grain and that saved them huge expense.
The surplus biogas was sold to the state's energy distributor, which provided another source of revenue for the farmers. That eliminated this entire amazing amount of methane as well as carbon emissions and provided electricity to rural farmers who had no electricity. At the same time it restored the water quality in the water basins—a solution that solved multiple problems.

What are the greatest obstacles for companies and governments in moving toward a circular economy and initiating its principles?

They have to look across all the different sectors. The energy water and waste sectors are almost like three different tribes. All of the engineering disciplines involved in each of those sectors are very siloed. They don't really recognize that the waste from a waste treatment or a water treatment plant is a source of energy. We are very sector specific and isolated.
I'm an architect; I'm not an engineer. As I started to research this, I realized that my insight as an architect was looking at the interrelationships across different sectors, and I've learned to think horizontally across those sectors. Municipalities don't do this as a rule. They are starting to, but it really needs to be much more widely adopted as a strategy particularly in developing nations, which are putting in place their infrastructure systems for the first time. They can basically leapfrog over our fossil fuel—powered systems and go directly to renewable energy.

E.U./The Circular Economy Action Plan grows up

Europe Goes Circular

It's been three years since the E.U. instituted its circular economy strategy, and the concept has gone from being a fringe topic to mainstream thinking. But it isn't being applied to the energy sphere



DAVE KEATING

Former editor of EuropeanVoice.com, is an American journalist based in Brussels. He covers E.U. politics and policy, focusing on energy and environment issues.

In 2015, when the European Commission first put forward its Circular Economy Action Plan, the concept was so unknown that Commission Vice President Frans Timmermans had to explain it to a befuddled press corp. "Our planet and our economy cannot survive if we continue with the 'take, make, use and throw away' approach," he said as he unveiled the package. "We need to retain precious resources and fully exploit all the economic value within them."

The idea is to transition from the "throw-away economy," where we use something once and then dispose of it, to a circular economy, where everything is reused. The system regenerates, and energy and material loops are closed. The main tools to achieve this are recycling, reuse and refurbishing, as well as the use of renewable energy.

A painless revolution

Over the past three years the concept, once obscure, has turned into one of Europe's hottest buzzwords. Its particular promise to businesses, consumers and policymakers alike is that it can enable a sustainable transition without a significant change to quality of life or revenue. In fact, the system's ability to save resources and eliminate waste can result in serious profit.

"When I started working on plastics five years ago, I thought it was a bit of an ugly topic and nobody wanted to talk about it," says Jean-Pierre Schweitzer, a product policy and circular economy officer at the European Environment Bureau. "But now there's been a huge take-up of the topic, and it seems like there are constantly events in Brussels and across Europe on the circular economy. So in terms of supporting the concept, and bringing resource productivity onto the agenda, it's been a real success."

The Commission has said implementation of their circular economy strategy could create 170,000 jobs and bring a net savings of €600 billion for businesses in the E.U. According to the consultancy McKinsey, the policy could deliver a net economy benefit of €1.8 trillion by 2030. That value is generated in all parts of the circle, from production to waste.

The strategy also looks anew at some materials which many have come to view as old-fashioned. Traditional industrial products like steel, glass and aluminium are usually not considered environmentally-friendly. But because they lend themselves so easily to reuse, these materials are going to be much better for the environment and climate than newer, harder-to-reuse materials like plastics.

The legislative proposals in the package will also create new design requirements for producers, ones that will make their products more easily reusable and recyclable. Though some European producers have bristled at these new requirements, the Commission says the new design requirements create a market opening for new production technologies and materials, changes which can give European companies an edge. Making products easier to disassemble will also make it easier for manufacturers to retrieve and reuse them, saving money.

The strategy also set out new recycling requirements, setting a common E.U. recycling target of 60 percent of municipal waste by 2030, and 70 percent of packaging waste by 2030. Today only around 40 percent of the waste produced by E.U. households is recycled.

New proposals

Earlier this year the Commission came out with new proposals as part of the strategy, mostly targeting plastic waste. They proposed to ban single-use plastics like drinking straws and cups by 2021 and to require that all plastic be recyclable by 2030. On 24 October, the European Parliament →

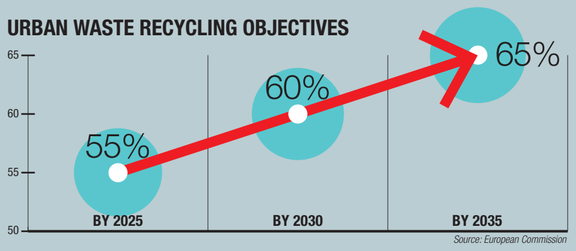


THE PROTAGONIST
Frans Timmermans, currently the first vice-president of the European Commission, in 2015 was one of the main promoters of Europe's move toward a circular economy, which has become a reality now.

An example for the rest of the world

The set of rules adopted by the European Union with regard to a circular economy is the most modern waste management regulation in the world, a field in which Europe is showing a forward-thinking approach that should be taken as a model.
The new rules in detail:

URBAN WASTE RECYCLING OBJECTIVES

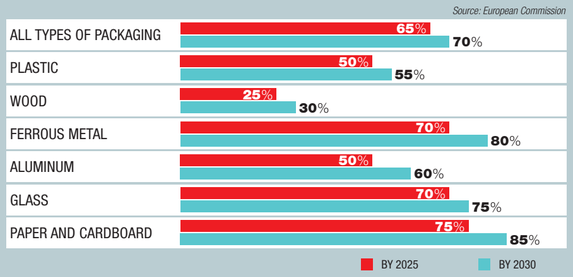


Source: European Commission

Stricter rules on recyclingrates will also spur monitoring of progress in creating a circular economy.

NEW RECYCLING TARGETS FOR PACKAGING WASTE

Source: European Commission



voted to strengthen this proposal, expanding the list of banned plastics and requiring E.U. countries to recycle 90 percent of plastic bottles by 2025. National governments are now preparing their own vote on the proposal, and negotiations to craft the final version of the legislation will begin in the coming months.
The goal is to prevent these plastics from ending up in oceans as marine litter, as 70 percent of such litter is made up of plastics. Separately, the Commission has proposed a reform of rules for port reception facilities, to reduce the leakage of plastics into the environment. Every year, Europeans generate 25 million tons of plastic waste, but less than 30 percent is collected for recycling. This waste is entering the atmosphere, and its effect on human health is not fully understood.
"With our plastic strategy we are laying the foundations for a new circular plastics economy and driving investment towards it," says Jyrki Katainen, the commissioner responsible for jobs, growth, investment and competitiveness. "This is a great opportunity for European industry to attain global leadership in new technology and materials."
The Commission has also proposed a new monitoring framework on progress towards the circular economy at the E.U. and national level, a framework composed of a set of ten key indicators which cover each phase—production, consumption, waste management and secondary raw materials—as well as economic aspects and innovation.
Finally, the Commission published a report on critical raw materials, highlighting the potential to make use of the 27 critical materials floating around the European economy. The report calls for strengthening Europe's waste legislation, known as Waste Electrical and Electronic Equipment (WEEE), in order to increase take-back schemes.
This last report is of particular interest to the appliance sector, which has been working to try to improve recovery of the valuable metals and materials in their products. Paolo Falcioni, director general of the European appliances manufacturers association APPLiA, says that until recently these waste laws were not considered part of a larger circular system.
"We can reach a circular economy only if we consider it part of a wider circular society where each actor has a role to play," he says. "We as an industry started to deal with this long before this strategy, and WEEE pushed to have the sector deal with waste. But the sector can't succeed by itself, and we need the cooperation of citizens. Today, 17 percent of appliances end in the waste bin, with a loss of valuable raw materials. Two-thirds are not traced, so we don't know how they are treated. We need the authorities to help us to understand where the heck they go."

Circular Economy 2.0

As the 2018 proposals work their way through the legislative process, people are already talking about what comes next. The commission of Jean-Claude Juncker will finish its five-year term next year, and it is unclear whether his successor will promote the circular economy concept as enthusiastically. But civil servants within the Commission assume that the next Commission will continue the work, and there are still many uncertainties for various stakeholders. Because even with the new legislation of the past three years, there are still significant unanswered questions.
"There have been some areas where the progress has been very slow and it's not clear what the vision is," says Schweitzer. "On eco-design, promoting repair and reuse, the commission has made a statement about where they want to go but not much has happened. There have been other issues like food waste that have been stated as important in the circular economy but we haven't seen any action."
But he says that more than producing specific proposals, the Commission needs to lay out a clearer overall vision of where it's going. "It's a bit like the terms 'sustainability' and 'circular economy' can also be interpreted in many different ways by different actors. My personal perspective is that it should really be about reducing the use of materials. If that's the case, is that really where we're going in Europe?"
"The question is, on a very macro level, what's the real objective for the circular economy and where do we want it to go? Recycling targets are valuable, but are they linked to big picture issues like planetary boundaries?"
Falcioni agrees that the new commission would be well advised to revisit the big picture when it takes office next year, and to broaden the approach to all parts of the waste value chain. "It's important to us that the same environmental standards are followed consistently by everybody who touches waste, and that is not the case today," he says. "We need help in making sure that environmental standards are followed consistently, and that is not the case today. Unfortunately too often here we are falling between the cracks."

Circular energy

So far, the E.U.'s circular economy approach has revolved around materials, resources and waste. But it has largely steered clear of the energy sector. Emissions reductions have been dealt with as a separate area of legislation, and Schweitzer believes this is a mistake.
"Renewable energy is really the basis of a circular economy, and I don't think there's any discussion of that," he says. "Everyone is agreed that we need to transition to renewable sources as quickly as possible. What I don't think has happened so well is the connection of the agenda on the circular economy and the agenda on climate change. These two topics could be very nicely coupled."
"When the IPCC called for system transition on an unprecedented scale, that really calls for a circular economy. But a lot of work on the circular economy ignores the climate aspect, the emissions you could save. And lots of the work done on the circular economy ignores the fact that you can save a lot of emissions by reducing the consumption of resources."
In the E.U., roadmaps toward emissions reduction have focused mainly on increasing energy efficiency and deploying low-carbon energy sources. But when it comes to industrial emissions, these measures would only offer a partial solution.
A recent report on the circular economy released by the Stockholm-based consultancy Material Economics concluded that a more circular economy could make deep cuts in emissions from heavy industry. In an ambitious scenario, as much as 296 million tons of CO_2 per year in the E.U. by 2050, out of 530 in total, and some 3.6 billion tons per year globally, could be avoided.



A MORE RENEWABLES-FOCUSED STRATEGY
So far, the E.U.'s circular economy approach has revolved around materials, resources and waste. But it has largely steered clear of the energy sector. Linking E.U. energy policy more closely to the circular economy would result in a more renewables-focused strategy.

Demand-side measures alone, the report concludes, could get Europe more than halfway to net-zero emissions from E.U. industry, holding as much promise as those on the supply side. At the same time, the measures are economically attractive as they produce more efficiency and greater profit.
Despite this opportunity, most discussions about industry emissions have focussed on the supply side, the reduction of emissions from the production of things like steel, cement and chemicals. If the E.U. could make better use of the materials already produced, it would reduce the need for the new production which causes emissions.
In fact, the report concludes, it is unlikely that the goal of the Paris Agreement—keeping global temperature rise to less than two degrees Celsius by 2050—can be met without transitioning to a circular economy. The IPCC has estimated a remaining "carbon budget" for this century of around 800 billion tons (Gt) CO_2. The report concludes that based on current trends, materials production alone would result in more than 900 Gt of emissions. Energy efficiency and low carbon energy will help, but do not resolve this dilemma: emissions add up to 650 Gt even with rapid adoption of these changes, as much carbon is either built into the products themselves and then released at their end of life, as is the case for plastics, or is used in the process of production.
But a lack of circular thinking is holding back these solutions, even though these abatement opportunities are low-cost or even profitable, the report says. Product manufacturers lack incentives to enable high-value recycling several steps later in the value chain, and many externality advantages of sharing business models are not accounted for. A higher carbon price would help, they conclude, but capturing a large share of the opportunities will require addressing those barriers directly.

The role of renewables

Schweitzer wants to see the lessons of the report taken up by the Commission, and he believes this should include incorporating the E.U.'s Renewable Energy Directive into the strategy. This would involve linking reducing material use to reducing energy use, and seeing both as part of an overall system of reuse. Fossil fuels are, after all, materials themselves, and in the long term, these materials will be far more damaging than plastic straws.
But such a rethink could put some of the E.U.'s energy strategies at risk. For instance, it's hard to see how carbon capture and storage (CCS), an unproven technology which would capture the carbon emissions from fossil fuel power plants and factories and store it underground, would fit in with a strategy to use less and reuse more. Fossil fuels, in the case of CCS, are still just being used once. This is why linking E.U. energy policy more closely to the circular economy, Schweitzer says, would result in a more renewables-focused strategy.
The United Nations Framework Convention on Climate Change, which administers the Paris Agreement, has already begun looking at the circular economy as a way to reduce emissions. Last year's annual climate summit in Bonn saw some sessions devoted to the topic, and even more are planned for this year's summit in Poland. As the new Commission takes shape next year, various stakeholders will be waiting in line to impress upon the new commissioners their vision for the Circular Economy 2.0. As the strategy broadens beyond just plastics and waste, it could result in a fundamental shake-up of how Europe operates in many sectors.

The "Circularity Gap" and Strategies to Close It

Only nine percent of the global economy is circular. To promote the transition from a "depletive" to a "regenerative" use of resources, we need to reduce the input of virgin materials, improve the use of existing resources and limit the output of harmful waste



JELMER HOOGZAAD & MARC DE WIT

Jelmer Hoogzaad is founder and Senior Advisor at Shifting Paradigms. Before founding Shifting Paradigms, he worked with Climate Focus to support international cooperation on low-carbon development. Before that, he managed the emission offset portfolio of the Dutch government in Russia, Ukraine and Bulgaria.

Marc De Wit leads Circle Economy's strategic partnerships and consulting and is the main author of the Circularity Gap Report. He is an experienced strategy consultant with 10 years of experience in advising companies and governments in developing sustainable strategies. Since joining Circle Economy in 2012 he has initiated and led over 25 projects.

The circular economy is a business opportunity that combines the transition from a linear economy with a reduction in our carbon footprint. The benefits of a circular economy go beyond mitigation action alone, as it aims to make vital services like mobility, shelter and nutrition available to more people at lower cost in financial, environmental and social terms. By closing material cycles, extending the responsibility of producers beyond the point of sale, adjusting our tax systems and adjusting the way we identify greenhouse gas mitigation options, the circular economy can target emissions at their root causes. As such, it offers a promising pathway to a low-carbon society, a pathway that has enabled progress on a broad range of Sustainable Development Goals (SDGs).

This article explains how global resource use is tied to greenhouse gas emissions. It provides a preview of the second Global Circularity Gap report, which will be published in January 2019. The second edition of the Global Circularity Gap report will go into more depth on the mass-value-carbon nexus, by connecting these three dimensions to identify global leverage points for a transition to a circular economy. From there it goes into more detail about circular economy opportunities in the built environment, capital goods and global efforts to mitigate climate change.

The world is 9.1 percent circular

Our world economy is only 9.1 percent circular, leaving a massive "Circularity Gap." This alarming statistic is the main output of this first Circularity Gap Report, which launched a metric for the circular state of the planet.

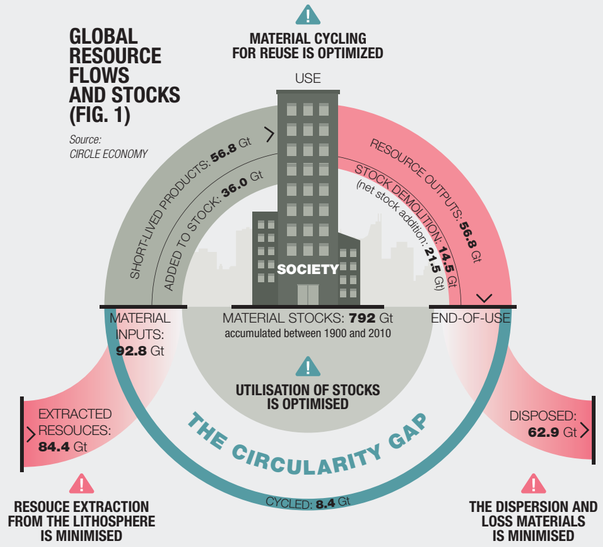
The consequences of a mostly linear economy

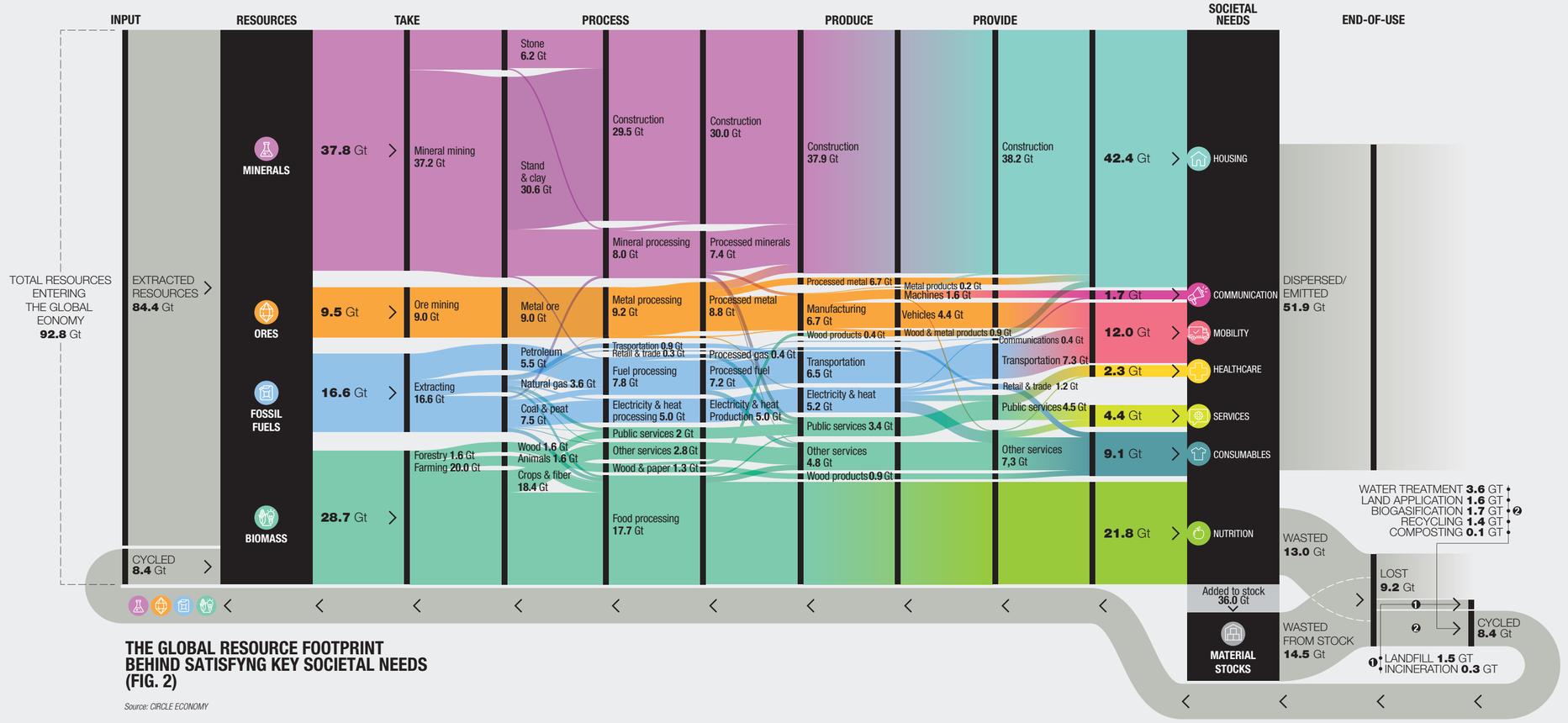
Only nine percent of all materials in use are recovered and reused (figure 1). The remainder is added to long-term stock in buildings and infrastructure (21.5 billion tons) or dispersed. The disposal of an annual 62.9 billion tons creates gross environmental consequences like climate change, biodiversity loss, ocean acidification, disrupted nitrogen and phosphorous cycles, soil degradation and freshwater overexploitation.

As such, the linear, take-make-waste economic model prevents progress on a range of SDGs. Several SDGs are related to the production of waste or excessive use of natural resources, whether they involve air quality in cities, food waste, access to clean water, the health consequences of exposure to hazardous emissions, or whether they relate to the wider goals like living in harmony with nature, or global resource efficiency in consumption and production.



Resources worth protecting





THE GLOBAL RESOURCE FOOTPRINT BEHIND SATISFYNG KEY SOCIETAL NEEDS (FIG. 2)

Source: CIRCLE ECONOMY

The natural resources extracted and used by the global economy total 84.4 billion tons (Gt). The majority of these materials are used in three sectors: residential and infrastructure construction, food and transport. The construction sector alone uses almost half of global resources (especially minerals, steal and wood). Between 1900 and 2010, the materials used for construction and infrastructure amounted to 792 billion tons.

In a circular economy the amount of extracted resources, and the amount of materials dispersed and emitted should be minimized. There are two underlying principles to achieve this (figure 1):

1 | The utilization of stocks is optimized so that current stocks-in-use such as buildings and machinery are used to their full potential, limiting the stocks which are temporarily not in use (hibernating) or mobilizing materials to re-enter the economy (urban mining);

2 | Material cycling for reuse is optimized, a position that requires new product design, wide-scale adoption of best available technologies and improved collection infrastructure for the processing of resources to optimize reuse.

The global metabolism: flows and stocks

Identifying circular economy opportunities requires an understanding of how materials are used to satisfy societal needs. This calls for a metabolic approach (figure 2). In a metabolic analysis all resource flows, stocks, conversions, imports, exports and energy use are examined as a system, rather than a set of individual elements. Looking at a jurisdiction or industrial cluster as a metabolism opens development perspectives which cut across sectors and industries and has impact beyond administrative borders or factory gates.

About half of the materials we use—fossil fuels, food, fodder and fuel wood—provide energy and nutrition. The other half—metals, minerals, timber, asphalt and plastics—are used in long-term applications, to build up, maintain and replenish physical stocks and assets. These stocks are the buildings, infrastructure and consumer products that provide shelter, mobility, communication and other valuable services to society.

In the years from 1900 to 2010, global material stocks increased to 792 billion tons in 2010. Most of the stocks in use today are relatively new, with 82 percent of current stocks less than 30 years old. In some developed countries, stock levels have stabilized and in some cases they have even started to decrease. Developing and emerging economies, however, are rapidly building up their stocks. For example, China's share of global stocks has more than doubled, from 10 percent to 22 percent, since 1990, and the country's net additions to stock have surpassed those of industrial economies.

All these resources are used to respond to the needs of society. The three societal needs which require the most materials are housing and infrastructure, nutrition, and mobility. Housing and infrastructure, or the construction sector, uses close to half of all global resources, which are primarily minerals (the sand, gravel and limestone in concrete production), steel, and wood. These construction materials are mostly locked into material stocks for a long time. This resource flow is particularly prominent in emerging and developing countries that are building their infrastructures. Construction materials can only be recovered when structures reach the end of their service time. The amount of concrete from demolished stocks is estimated to be half of the total 14.5 tons of annually discarded stocks.

Nutrition has the second highest need, which is met with organic materials, typically food. Considerable amounts of food products and animal feedstock travel large distances to their consumers. Although nutrients can be recovered, the large distance between production and consumption complicates the closure of nutrient cycles.

Mobility is the third highest, where materials use consists of the metals in vehicles and the fossil fuels used to propel them. Fossil fuels are an estimated 20 percent of the resources we extract. They have an inherently linear character as these fuels are mostly used to provide energy and have no material value to society after combustion. In terms of recovery of vehicle components and materials, the transport sector is performing relatively well.

Strategies to close the circularity gap

Seven circular economy strategies can decouple economic growth from resource use, making material use regenerative, rather than depletive. It does that by proposing strategies which reduce the input of virgin materials, improve the use of existing assets and reduce the output of harmful waste.

1 | Recovery and Reuse: Recovering and treating waste and by-products as inputs for other uses.

2 | Use regenerative material sources: Avoiding the use of materials that create harmful waste and optimize the use of regenerative sources of materials.

3 | Lifetime Extension: Extending the lifetime of products and assets through a greater focus on the design and use phase of maintenance, upgrade, and repair, as well as reverse logistics, product take-back, and remanufacturing.

4 | Sharing and Service Models: Offering products as a service through pay-per-use models and employing sharing and leasing platforms to maximize the use of products and assets.

5 | Digitization: Dematerializing by replacing physical products with online equivalents or services.

6 | Circular Design: Designing products and assets with minimized resource use throughout the lifecycle is an enabling strategy which supports the above strategies.

Circular mitigation action

Circular economy strategies can also be used to specifically target greenhouse gas emissions. There are five main levers through which the circular economy reduces greenhouse gas emissions.

1 | Prioritizing secondary over primary materials: Recycling reduces greenhouse gas emissions. An analysis of a range of products and materials showed that products produced from secondary or recycled materials have a smaller carbon footprint than products from primary materials. The difference is around 1.4 ton CO_2 equivalent per ton product. This makes recycling a strong mitigation lever.

2 | Prioritizing low-carbon materials: The investment choices we make now will determine our greenhouse gas emissions for many decades. For example should we invest in improving the efficiency of existing carbon intensive industries or invest in inherently low-carbon alternatives for the services which they provide society. The unprecedented growth of renewable energy capacity shows that for the energy sector we have chosen to prioritize regenerative sources over fossil. For materials we will have to do the same.

3 | Closing nutrient cycles: A third lever targets organic materials. It is the closure of nutrient cycles by combining source separation with anaerobic digestion of manure, organic waste and wastewater with nutrient recovery and application to land. Through land application technology can avoid soil degradation, but current digestion capacity is only sufficient to process 0.5 percent of global organic waste. Expanding this capacity is an opportunity that can build on existing agricultural and environmental experience and initiatives in both developing and developed countries.

4 | Optimizing the use of active assets: Extracting more economic value or optimizing the service level that existing active assets can provide is another way in which the circular economy can have a lower carbon footprint than our current linear approach.

5 | Designing for the future: Finally, when properly designed, the reuse, remanufacturing and recycling prospect of products can be optimized. Examples are Fairphone, a modular phone where broken el- →

THE WIND TREE
A "wind tree" is a wind turbine built to look like a tree. Each "leaf" acts as a mini wind turbine. The structure was installed for the COP21, the United Nations Conference on Climate Change, which was held in Le Bourget, on the outskirts of Paris.



ements can easily be replaced at the level of its components, or the use of biodegradable materials.

Integrated approaches under the Paris Agreement

The national climate mitigation plans, which countries submitted to the United Nations Framework Convention on Climate Change (UNFCCC) ahead of signing the Paris Agreement, show that only a handful of countries are developing environmental policies which target greenhouse gasses and resource use in parallel. Even the European Union considers climate action in isolation of its resource efficiency ambitions. This contradicts scientific research and economic models, which conclude that the combination of circular economy with greening of energy systems delivers significantly higher environmental and economic benefits than targeting the energy system alone.

The Paris Agreement provides for a five-year cyclical mechanism to enhance the collective ambition of the signatory countries. Separating climate ambitions from efforts to avoid excessive resource use and pollution leaves a large mitigation opportunity untapped. That is where the potential lies for countries to increase the ambition of their initial mitigation pledges. From a circular economy perspective, there are several ways in which countries can elevate their mitigation ambition, while making optimal use of the new mechanisms for international cooperation under the Paris Agreement.

1 | Complement existing mitigation approaches which target the source, with approaches that target the cause of emissions. The historic focus on greenhouse gas emission sources has made possible immense greenhouse gas emission reductions in the industry and energy sectors. However, this focus has also drawn attention away from developing alternatives to carbon-intensive industries. In the energy sector, the rise of renewable energy has started to make fossil fuel assets obsolete. It is time to aim for a similar shift to low-carbon and regenerative materials by closing nutrient cycles to reduce dependence on chemical inputs from fossil origin and using building materials that have a net sequestration impact.

2 | Use metabolic approaches to identify mitigation options. International cooperation and capacity building should step away from a focus on the sources of emissions, to developing an understanding of how resources are used to deliver services to society. This requires a metabolic analysis, a mapping of the flows and stocks of materials and energy in a jurisdiction. Only then can countries aim to improve the system and the way it responds to societal needs rather than seeking incremental improvements of the existing system.

3 | Support countries with integrating circular economy and low-carbon policies. Examples of such policies are:

a | Tax reform, from labor to resource extraction. The Dutch NGO Ex'Tax calls for a tax reform where taxes and contributions to the social security system levied on labor are reduced and environmental taxes increased. They call for taxes on what we want less of, while incentivizing what we want more of. Such a tax reform can make it more attractive for companies to adopt circular business models, even if these are more labor intensive, for example, where they require redesign, reverse logistics, sorting or improved maintenance to extend a product's service life or recover products and materials at the end of their lifetime.

b | Extended Producer Responsibility schemes introduce life-cycle thinking in manufacturing by supporting the marketing of better products and promoting responsible interaction between producers and consumers. They have proven to be effective in the European Union and in leading edge countries such as France.

c | Incentives for green public and green private procurement help create demand for circular products and services.

4 | Identify new mitigation options with consumption-based accounting. In national carbon accounting we need a life-cycle approach to reveal and encourage mitigation actions in international value chains. This is important, as an estimated 20 to 30 percent of a nation's carbon footprint lies in the emissions embedded in the products crossing its borders. That mitigation potential will be left untapped if countries continue to demarcate their climate impact with their national borders. Cities, but also the Intergovernmental Panel on Climate Change (IPCC), have taken first steps to consider all upstream emissions as mitigation potential, even if these emissions take place outside national or city borders.

The new circular approach, with its potential for creativity, is tangibly influencing today's ways of thinking about the world around us. Public and private actors have shifted their focus from the direct object of their activities to the overall impact of their work on the environment, on all our lives and on the future. Professionals across diverse industries have joined forces and are striving to ensure that their projects last over time, designing their products' intended uses with a view to reusing the materials they are made from and dreaming of a time when nothing will be wasted and everything will be recycled. They are not imagining a better world, they are creating it.

A Circular World



MATERIALS / **U**PCYCLING / **R**EPURPOSING /
NEW **B**USINESS MODELS / NEW **S**OCIAL MODELS

Data and images have been revised on the base of the information contained in the sites and communication media of companies and institutions of reference

PRINCIPLE

1

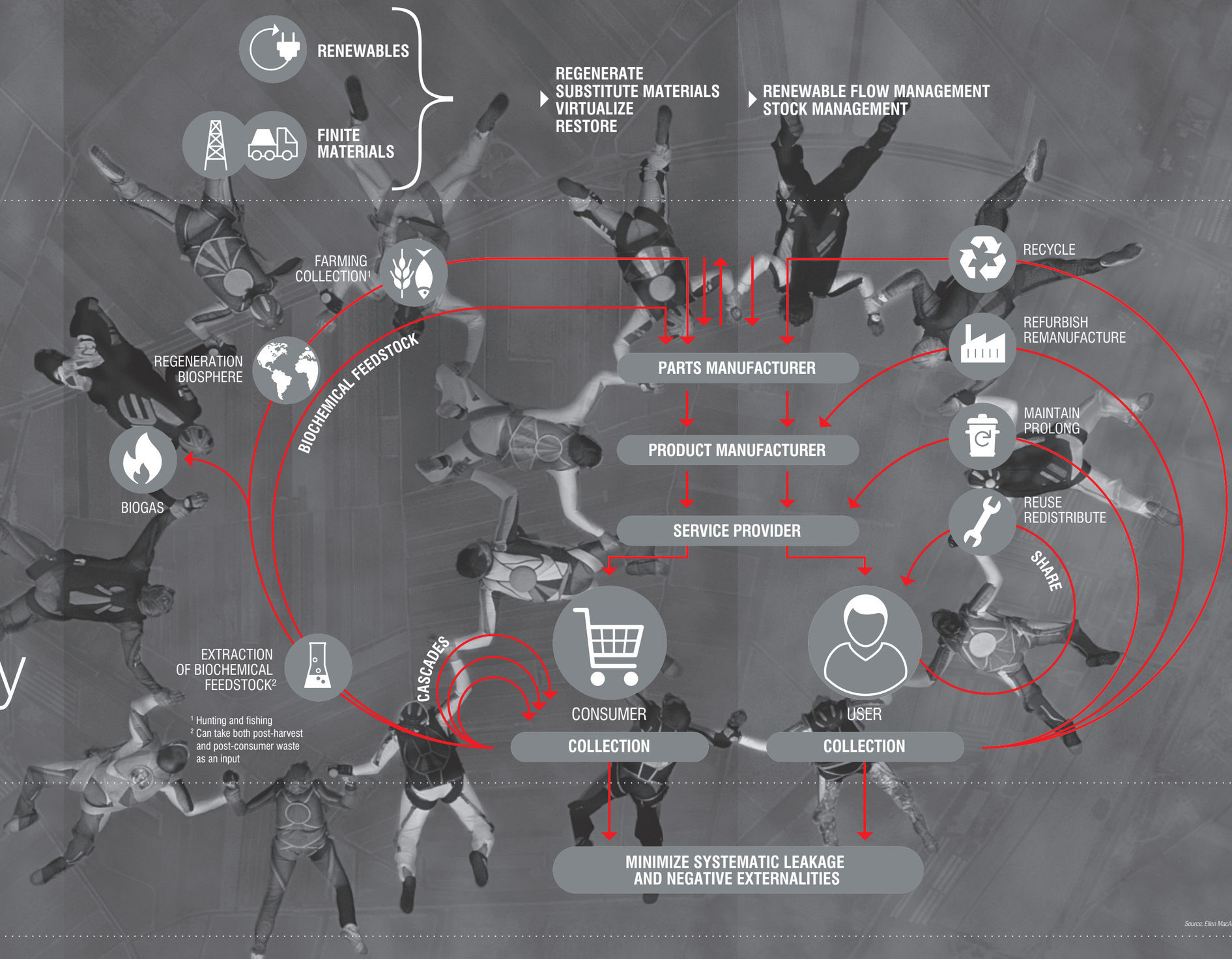
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.

PRINCIPLE

2

Optimize resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles.

Outline of a Circular Economy



[1] Hunting and fishing
[2] Can take both post-harvest and post-consumer waste as an input

PRINCIPLE

3

Foster system effectiveness by revealing and designing out negative externalities.

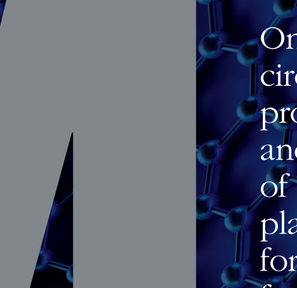
Source: Ellen MacArthur Foundation

M MATERIALS

One of the main objectives of the circular approach is to overcome the programmed obsolescence of products and to better address the problem of disposal: it is a matter of carefully planning the duration and providing for the recycling of the materials from the beginning.

Design for Today, Tomorrow and the Future

The design philosophy of the British company Orangebox involves using less material to create more durable objects that are easy to dismantle and recover for reprocessing. Its flagship product is the Ara, an office chair based on the cradle-to-cradle principle, allowing a closed-circuit production cycle to be achieved. 98 percent of the materials used to make the Ara are in fact recyclable. In the cradle-to-cradle approach, each chemical component in the raw materials is examined to ensure that it can be returned to the production cycle at the end of its life to create new high-end items. These materials must be free of toxins which, if released into the atmosphere, could be harmful to human health or the environment. To maximize the value of materials used in this chair and other products, Orangebox has set up a recycling facility at its plant in South Wales, offering its customers a used product collection service. The products are collected by the company itself and, if they can't be reused or refurbished, they are dismantled and sent for recycling.



CRADLE-TO-CRADLE
The "cradle to cradle" model provides for design and use of completely non-toxic and recyclable materials.



M



Don't Replace your Smartphone, Let It Evolve

Fairphone is a modular smartphone designed to last. The smartphone's components, which are assembled like Legos, can be updated or replaced. This allows the phone to be customized using prefabricated blocks that extend its life. Each block is connected to the base of the device to make it easier to swap parts. The idea is to create a phone that evolves in step with technology. The production materials used are environmentally and socially sustainable.

The Goals of the Project

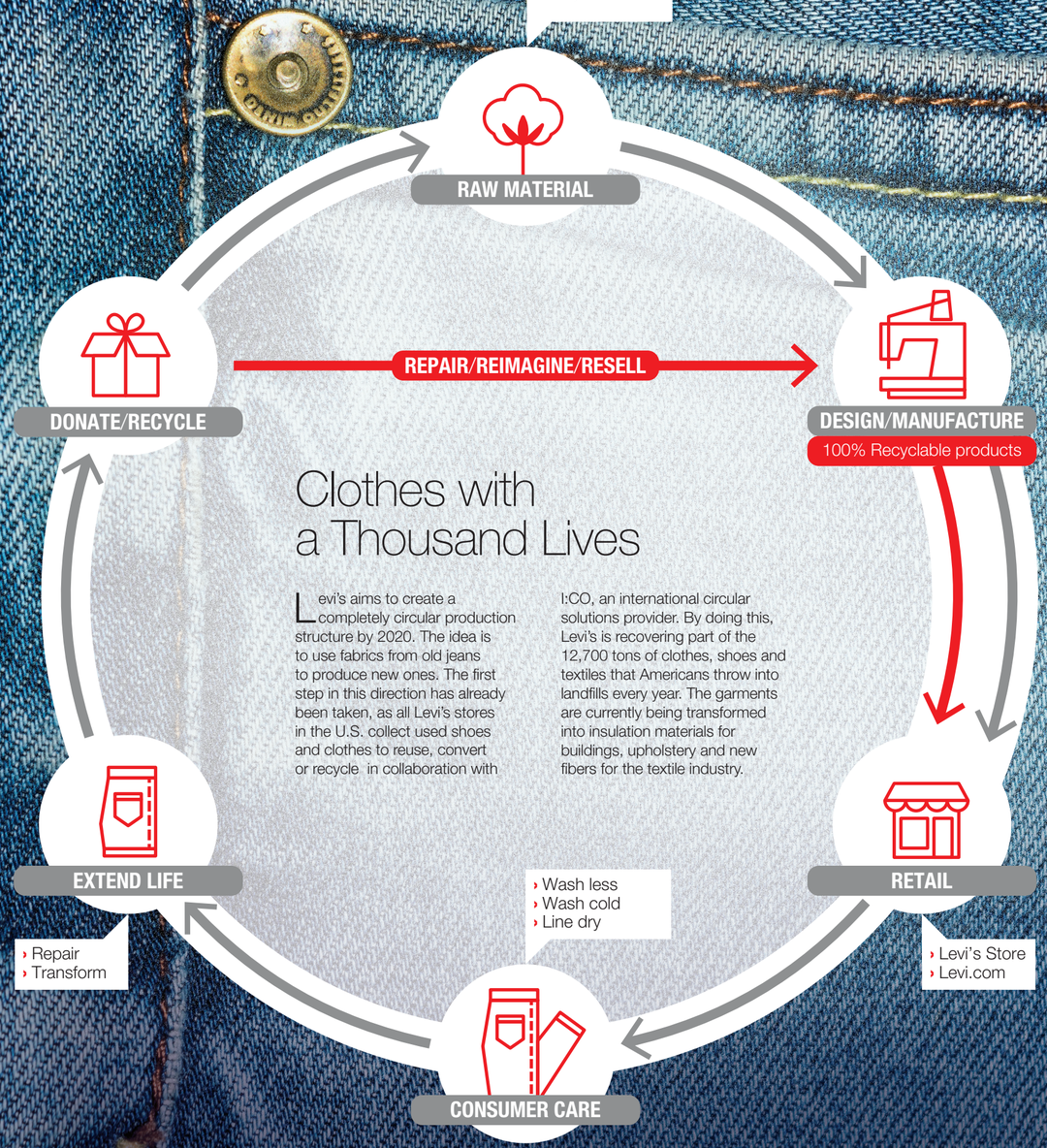
LONG-LASTING DESIGN. Consumer electronics often have an expiration date: they have to be replaced when something new arrives on the market. Phones are replaced on average every 18 months, which has a huge environmental impact. The Fairphone can easily be repaired to ensure long-term use: it takes less than a minute to replace the screen.

FAIR MATERIALS. The minerals and metals contained in the most widely used smartphones enter the supply chain from the mining sector, a challenging industry in terms of sustainability. The path taken by the components of Fairphone devices is monitored from the moment they are extracted from the ground.

GOOD WORKING CONDITIONS. Most smartphones are produced in China, where low costs and production speed often have repercussions on workers, Faiphone aims to improve working conditions in the heart of the electronics industry, including health and safety, workers' representatives and working hours.

REUSE AND RECYCLING. Fairphone aims to make the most of the materials used in consumer electronics, providing the user with spare parts and tutorials to repair the devices. It also supports recycling programs to ensure that precious materials are reused repeatedly.

M



Clothes with a Thousand Lives

Levi's aims to create a completely circular production structure by 2020. The idea is to use fabrics from old jeans to produce new ones. The first step in this direction has already been taken, as all Levi's stores in the U.S. collect used shoes and clothes to reuse, convert or recycle in collaboration with I:CO, an international circular solutions provider. By doing this, Levi's is recovering part of the 12,700 tons of clothes, shoes and textiles that Americans throw into landfills every year. The garments are currently being transformed into insulation materials for buildings, upholstery and new fibers for the textile industry.

12,700
tons of clothes, shoes and textiles are dumped in landfills in the US every year.

30.6 million
tons of CO_2 emissions a year would be avoided if every American recycled their used clothes instead of throwing them away.

69 bottles
Recycling a pair of jeans has the same impact as recycling 69 plastic bottles or 43.5 kg of garden weeds.

U

UPCYCLING

Can a product's second life be more fulfilling than the first? Circularity means reclaiming, and reusing means upgrading. With the end of landfills, certain materials regain sparkle and nobility in the form of objects of higher value, both symbolic and tangible.

The Ugly Duckling

Feathers from old cushions, duvets and mattresses that are no longer usable get a new lease on life in Patagonia down jackets. Regenerated goose and duck feathers are hypoallergenic and offer the same performance as virgin feathers. Taking some of the feathers used from products destined for waste collection reduces waste, contributes to developing and adding value to the recycling flow and creates a high-quality product without causing unnecessary harm to the environment.

100%

The Patagonia "100% Recycled Down collection" is made entirely of regenerated goose and duck feathers. The company's mission is to "build the best product, cause no unnecessary harm, and use business to inspire and implement solutions to the environmental crisis."





Sustainer Homes converts disused containers into self-sufficient and sustainable homes. The container homes can be transported anywhere in just two days and can be used as holiday accommodations or permanent dwellings. The homes are also furnished with as much recycled material as possible. The chairs, for example, are 3D printed using recycled plastic from fridges, and the sofas are upholstered with used denim.

The 100% Sustainable Container Home



24million

There are 24 million unused containers in the world.

10-15years

The average life of a shipping container is 10 to 15 years.

33%

One third of the world's CO_2 emissions comes from the construction of new buildings.



A project 24km long

The Track That Shines in the Night

From an abandoned railway to a pedestrian track that lights up at sunset, Singapore is testing a new asphalt that shines in the dark, thanks to the use of strontium aluminates mixed with bitumen. The new material, which has a greater luminosity and much longer persistence than other phosphorous compounds, absorbs ultraviolet light during the day and emits a greenish light at night. The test project will determine whether the material is strong enough and suitable to be used on other surfaces. The 100m long track is part of a wider project to upgrade an old 24km railway line, closed down in 2011, known as the Rail Corridor. The railway track, which once linked Singapore's city center with neighboring Malaysia, is currently being redeveloped into a park. It will be one of the longest parks in the world and will feature a mix of attractions, including leisure areas with sporting equipment, gardens with flowers and shrubs, suspended bridges over lakes and rivers, and special lighting effects. Once completed, the corridor will have 122 access points, each no more than 400 meters, or a 5-minute walk, away from the residential areas and offices situated along the railway route.

1
TOMATOES

2
TOMATO KETCHUP

3
TOMATO SKINS

4
FORD

5
LAB

6
STORAGE BINS

Future Car Components from Tomatoes

The U.S. car company Ford and the food industry giant Heinz are examining the feasibility of using tomato skins as a basis for new composite materials for vehicle components. Ford researchers are testing the strength of tomato fibers to generate bioplastics that could be used to make support brackets for electrical cables or small storage compartments.

The collaboration will allow Heinz to solve a recurring problem, that of finding new ways to recycle the skins, stalks and seeds generated from the 2 million tons of tomatoes used every year to produce its famous ketchup. While research is at an early stage, the conversion process based on this technology has already been validated.

The experiment is part of a broader initiative launched by Ford to develop lightweight plant-based and sustainable composite plastic materials to reduce the use of petrochemicals in its production process. Among the components made of biological materials, the U.S. manufacturer already boasts brackets for electrical cables made with rice husks, soya foam seats and cellulose fiber-reinforced parts for dashboards.

Oceans of Plastic

Parley, a movement that raises people's awareness of the dangers of ocean pollution, has partnered with Adidas to clean up plastic from the oceans, committing itself to reuse it by transforming it into sports clothing and high-performance footwear. This is possible due to Parley Ocean Plastic fabric, made entirely with plastic recovered from the oceans. An enormous amount of plastic ends up in our oceans every year, and ocean currents have formed five giant vortexes called "plastic islands" which slowly accumulate the debris. According to recent studies, at least 5,000 billion pieces of plastic are currently floating in the planet's oceans, weighing more than 250,000 tons. While most of this plastic debris sinks or remains in the vortexes, a significant proportion of it ends up on our shores every day.



"ARTIFICIAL" ISLANDS
Every year, an enormous amount of plastic ends up in our oceans. Ocean currents have formed five giant, slow-moving vortexes that scoop up the plastic. Sunlight degrades the plastic into tiny pieces, which fish and marine birds mistake for fragments of food and swallow.

5,000billion
pieces of plastic are currently floating in the planet's oceans.

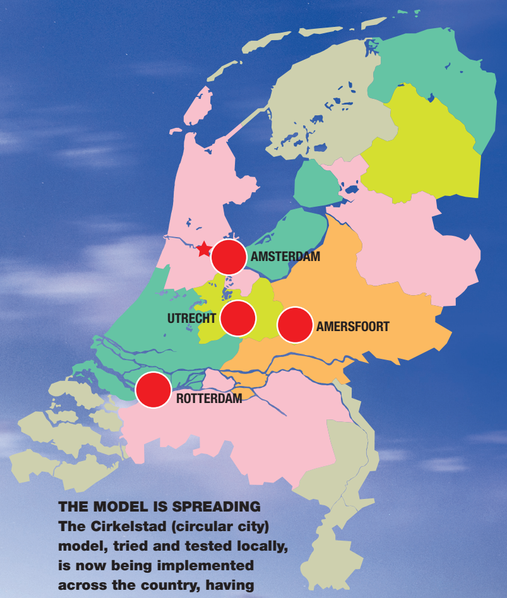
250,000
tons is the total weight of the plastic that is suffocating our seas.

135,000
Every year, between 57,000 and 135,000 whales, in addition to millions of birds, turtles, fish and other species, are estimated to become entangled in plastic debris in the sea.

R

REPURPOSING

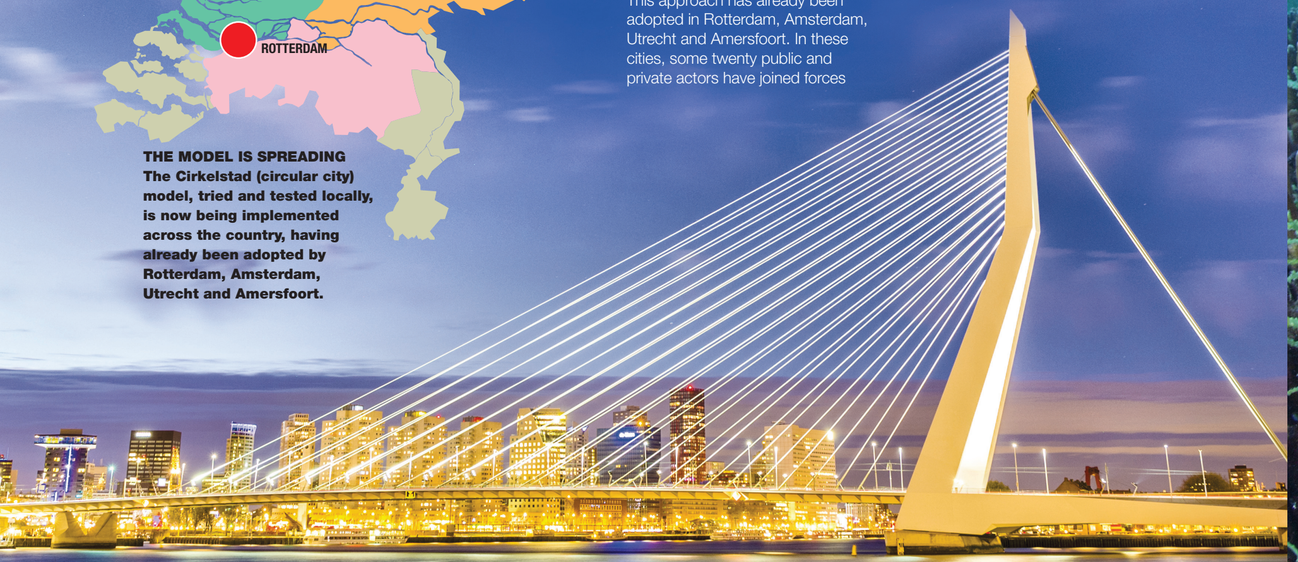
Materials once discarded as waste are now reliving, performing creative, innovative and unexpected functions. The concept of circularity becomes synonymous with valorization, and with restoring to the community places and objects that have supposedly reached their end of life.



THE MODEL IS SPREADING
The Cirkelstad (circular city) model, tried and tested locally, is now being implemented across the country, having already been adopted by Rotterdam, Amsterdam, Utrecht and Amersfoort.

Building with Rubble

Building without waste by using demolition debris as building material is not longer a mere dream. Rotterdam, in the Netherlands, has been using waste material for new construction and renovation projects since 2007. The initiative, known as Cirkelstad, is already been tested and consolidated locally and is currently being implemented across the country to promote waste-free construction.
This approach has already been adopted in Rotterdam, Amsterdam, Utrecht and Amersfoort. In these cities, some twenty public and private actors have joined forces to create a circular building sector in both architectural and engineering terms, and these projects are opening up job opportunities for people who would otherwise struggle to access the labor market. To get other cities involved, a so-called “Green Deal” has been signed with the central government, under which the parties undertake to close the construction and demolition cycle.





FROM 2012:

208
tons of fishing nets collected and recycled.

2,200
families have access to micro-credit.

64,000
people can enjoy a healthier marine environment.

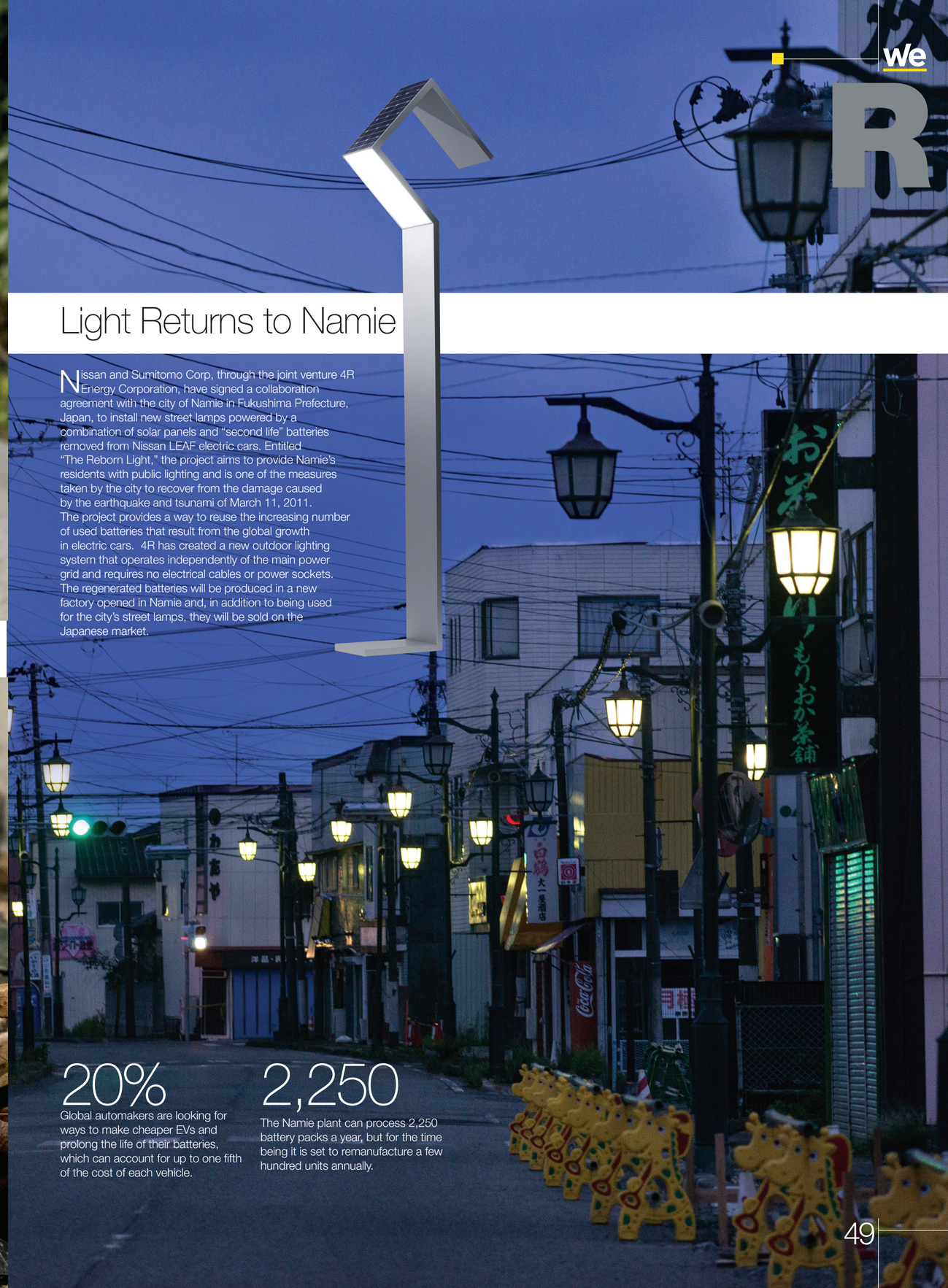
Networking

Thanks to the Net-Works project, fishing nets lost at sea are transformed into raw materials for textile flooring. This achieves a dual purpose: the toxic fibers of the old nets cease to pose a threat to marine fauna, and the local economy gets a boost, as less wealthy communities living along the coasts are paid a price per kilo for the nets recovered. The initiative was launched by Interface, a company that for twenty years has been manufacturing textile floor coverings from largely recycled materials, in collaboration with Aquafil, an Italian yarn manufacturer and the London Zoological Society, a British environmental organization. The Net-Works project was launched in 2012 on the Danajon Bank coral reef in the Philippines and in 2015 on Lake Ossa in Cameroon. Since 2013, local fishing communities have collected around 208 tons of nets.



Cycling on Bottles

Zwolle, in the Netherlands, recently inaugurated the first cycle track in the world made entirely from plastic bottles, caps and waste materials. The new PlasticRoad consists of modular panels made of recycled materials with an empty core to store rainwater, which flows directly into the sewer pipes. The material used for the track, designed by the Dutch engineering company Kws with Wavin and Total, also lends itself to the construction of sidewalks, parking lots and busy roads. PlasticRoads last three times as long as traditional roads and take 80 percent less time to build. The new “plastic” section is connected to an existing cycle track and is on Deventerstraatweg, between Lindestraat and Verenigingstraat. The plastic used to create Zwolle’s 30-meter PlasticRoad is the equivalent of 218,000 cups cups or 500,000 bottle tops.



Light Returns to Namie

Nissan and Sumitomo Corp, through the joint venture 4R Energy Corporation, have signed a collaboration agreement with the city of Namie in Fukushima Prefecture, Japan, to install new street lamps powered by a combination of solar panels and “second life” batteries removed from Nissan LEAF electric cars. Entitled “The Reborn Light,” the project aims to provide Namie’s residents with public lighting and is one of the measures taken by the city to recover from the damage caused by the earthquake and tsunami of March 11, 2011. The project provides a way to reuse the increasing number of used batteries that result from the global growth in electric cars. 4R has created a new outdoor lighting system that operates independently of the main power grid and requires no electrical cables or power sockets. The regenerated batteries will be produced in a new factory opened in Namie and, in addition to being used for the city’s street lamps, they will be sold on the Japanese market.

20%

Global automakers are looking for ways to make cheaper EVs and prolong the life of their batteries, which can account for up to one fifth of the cost of each vehicle.

2,250

The Namie plant can process 2,250 battery packs a year, but for the time being it is set to remanufacture a few hundred units annually.

NEW BUSINESS B MODELS

Ownership is increasingly losing its value. Changing users' attitudes to goods and services and the shift towards pay-per-use or hire solutions contribute to reducing waste and enhancing the efficiency of recovery and reuse processes.

From Ownership to Use



A symbol of low-cost design around the world, IKEA will soon offer customers the opportunity to rent its furniture. The announcement was made by CEO Jesper Brodin, who took over the reins of the Swedish multinational about a year ago. The initiative will revolutionize the company's whole business model, which is currently based on selling low-cost furniture. The offer would be aimed primarily at people who have to move periodically, like students and workers who live far from their families and would be limited at first to a few pieces of furniture. Ikea already has a return program allowing customers to bring back used furniture to the store where they bought it for a reward.

355 IKEA GROUP STORES IN 29 COUNTRIES
As of the end of the 2017 financial year, it also had 24 IKEA "order and collection" points in 12 countries, 43 shopping centers in 15 countries, 31 store distribution centers in 18 countries and 26 customer distribution centers in 13 countries.

149,000 EMPLOYEES
Retail: 134.400
Distribution: 9,100
Shopping centers: 2,100
Other: 3,400

85 MILLION LED LIGHT BULBS SOLD
If each LED bulb sold replaced an incandescent bulb, it would save enough energy to power 750,000 homes for a year. The calculation is based on the electricity consumption of an average European family.

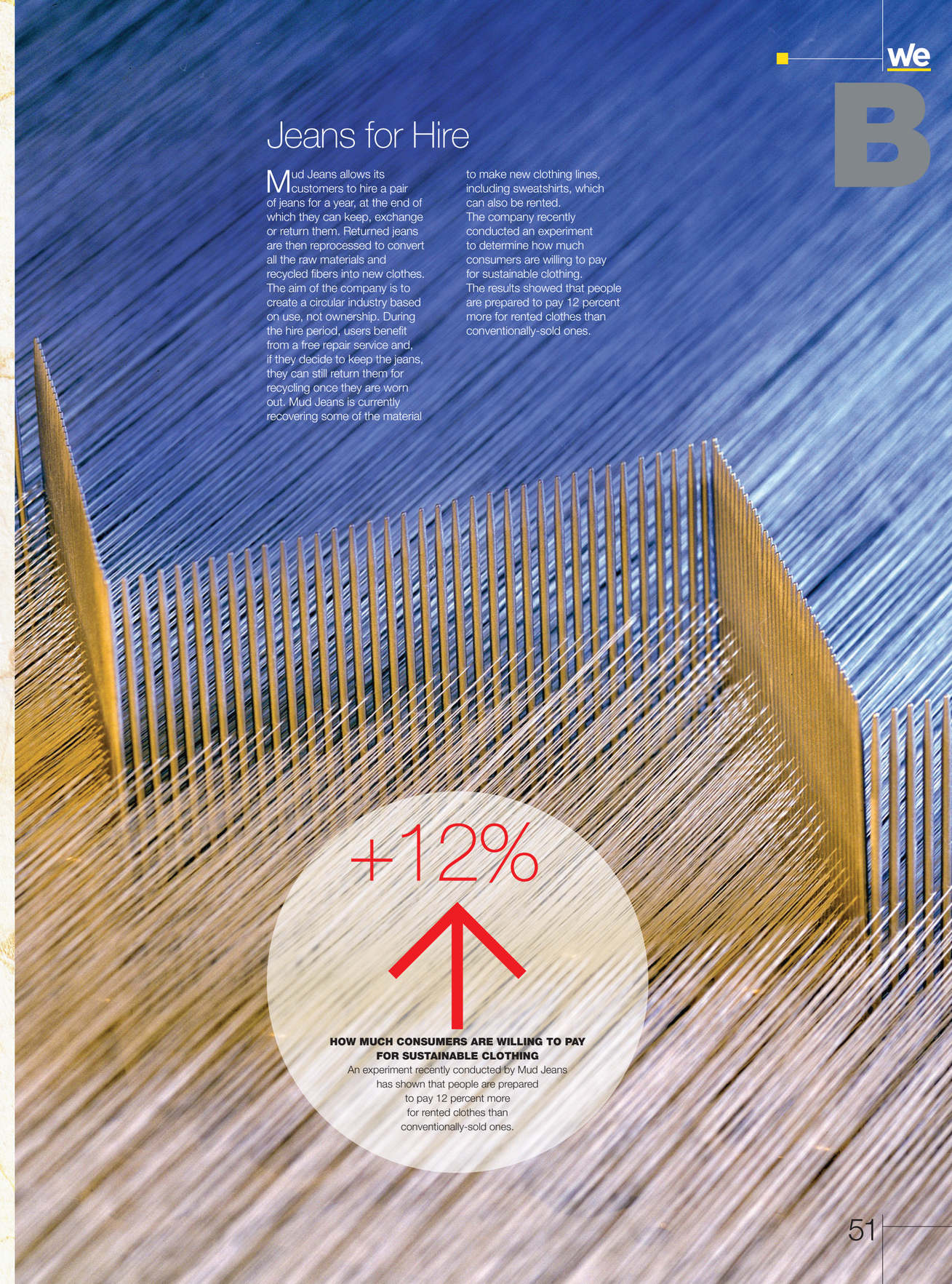
100%
of the cotton used to make IKEA products comes from sustainable sources.

€1.8 BILLION TURNOVER OF IKEA FOOD
Total turnover of restaurants, bistros, Swedish food markets and employee canteens.

49.2% OF WOMEN MANAGERS
Today more than half of employees, 49% of managers and 53% of the Management Group are women.

Jeans for Hire

Mud Jeans allows its customers to hire a pair of jeans for a year, at the end of which they can keep, exchange or return them. Returned jeans are then reprocessed to convert all the raw materials and recycled fibers into new clothes. The aim of the company is to create a circular industry based on use, not ownership. During the hire period, users benefit from a free repair service and, if they decide to keep the jeans, they can still return them for recycling once they are worn out. Mud Jeans is currently recovering some of the material to make new clothing lines, including sweatshirts, which can also be rented.
The company recently conducted an experiment to determine how much consumers are willing to pay for sustainable clothing.
The results showed that people are prepared to pay 12 percent more for rented clothes than conventionally-sold ones.



HOW MUCH CONSUMERS ARE WILLING TO PAY FOR SUSTAINABLE CLOTHING
An experiment recently conducted by Mud Jeans has shown that people are prepared to pay 12 percent more for rented clothes than conventionally-sold ones.

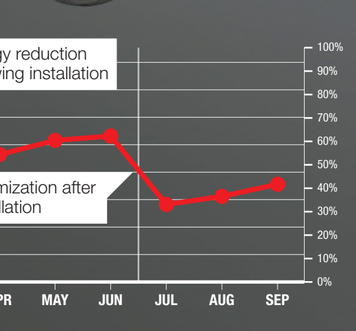
B

Pay per Lux

A collaboration between architect Thomas Rau and Philips has led to the creation of an affordably-priced, customized, “pay per lux” lighting system. Rau didn’t want to buy an expensive lighting infrastructure for his office in Amsterdam. Rather than a system he would eventually have to replace and dispose of, he wanted lighting as a service, and only in the amount needed for the building. This led to a collaboration with Philips to develop a system that would fulfill that requirement.
In order to avoid producing surplus energy, Philips created a minimalist lighting system that would make the most of sunlight. Introducing a lighting control system and a sensor that could decrease or increase artificial light based on the amount of daylight allowed energy consumption to be reduced to a minimum.
The result was a smart and customized “pay per lux” lighting system that satisfied the specific requirements of the site.
Furthermore, by moving from a one-off sale to a “pay per lux” system, in which Philips retains ownership of the equipment, Rau’s architecture firm benefits from a maintenance and support service and can adapt or upgrade the installation, while the producer can retrieve the equipment if necessary.



WHO IS THOMAS RAU?
The founder of Turntoo and Rau Architects, two of the first circular economy companies in the Netherlands, Thomas Rau, together with Sabine Oberhuber, with whom he has worked for over 25 years, has created some of the most original conceptual examples of circular economy and business models. The most visionary and innovative projects implemented by Rau and Oberhuber include “Pay per lux” in 2010, developed with Philips; a performance-based concession scheme for washing machines developed with Bosch in 2012; the first circular building as a deposit for raw materials for Brummen city council and the first net positive energy circular building for Liander in 2013.



Effective systems management resulted in a total energy reduction of 35%-55% as a result of the LED installation, and optimization by Phillips produced a further reduction of 20%.

NEW SOCIAL MODELS

The circular economy principle cannot be said to have been fulfilled if it fails to spread its beneficial effects throughout the community. This is where sustainability combines with social advantage in the form of improved well-being, new employment and professional requalification.

Venlo’s Town Hall

The new town hall of Venlo, in the Netherlands, is built entirely according to the cradle-to-cradle principle. This has a positive impact on employment, the environment and the economy. But how exactly? Having a healthy and safe working environment comes first and the abundance of green spaces promotes a good working climate. The green façade of the town hall, which is “watered” by the rainwater collected, helps purify the air and ensure natural ventilation. Thanks to large windows and solar panels, the structure is able to make the most of the sun, its main source of energy. Most of the elements that make up the building can be dismantled individually, allowing a constant cycle of raw materials. Finally, if the improved working environment reduced absenteeism among town hall employees by just 1 percent, the administration could save €480,000 a year.

Lille's Integrated Strategy

The mayor of Lille, France, has developed an integrated strategy to reduce carbon emissions. He started with the wastewater treatment plant, which uses the typical anaerobic biodigestion process to purify the water. Biodigestion produces biomethane and sludge which is full of nutrients and can be used as a fertilizer. Lille launched a pilot project to clean up the biomethane, removing some of the water and CO_2 and finally compressed and used it as gas for the city's buses. The initiative has been so successful that it has led the administration to seek another source of organic material. At the same time, however, problems occurred with the incinerator, forcing it to be closed. The administration therefore decided to build an organic waste recovery plant, with which every city should equip itself. This plant collects waste from restaurants and food processing and sorts organic and agricultural waste.
All this waste can then undergo biodigestion to produce methane or biogas from which to generate energy. In the case of Lille, the processed waste is used to power 150 public buses.

City numbers

Population: 1,091,438
Area: 611.45 km²
Density: 1.785 / km²
Total waste: 663,904 t
Household waste: 591,594 t
Commercial waste: 72,310 t
Recyclable: 109,935 t
Non-recyclable: 450,877 t
Organic waste: 30,782 t

The plant in numbers

Digesters: 3 x 1,900 m³
Capacity: 108,000 t/y
Treated: 64,702 t
Raw biogas: 7,400,000 m³/y
Biomethane: 4,111,000 m³/y
Digestate: 34,000 t/y
Employees: 39

Synergy Between Electricity and Telecommunications

India's rural areas have little access to energy, but an interesting innovation has allowed energy services to be supplied to the poorest inhabitants in these regions. The country has around 400,000 repeaters not connected to the electricity grid. As part of the energy transition process, the aim was to power them using renewable energy. Omnigrid Micropower has created an energy distribution model that could be defined as a solar micro-plant, the main clients of which are the transmission towers. Surplus energy is conveyed to a mini-network or micro-network to power LED lamps and small storage batteries sold to local communities. The service is therefore circular—and prepaid—with "lighting workers" distributing lanterns to customers which are collected every day to be recharged.
Over 50 percent of the proceeds from these power plants come from local residents, which dispels the belief that poor people cannot be a source of income in the energy sector. Furthermore, employment has been boosted with 10-15 jobs created for each power plant. The model has been widely replicated and the company has won several awards.
The process has been transformed into a small industry. People can hire these storage batteries to power equipment designed for the electricity mini-network, including fridges, irrigation pumps and fans. This allows all the necessary services to be supplied to local inhabitants without having to install a cable connection. It is a breakthrough innovation born by uniting the needs of two sectors: electricity and telecommunications.



10/15
jobs created for each power plant.

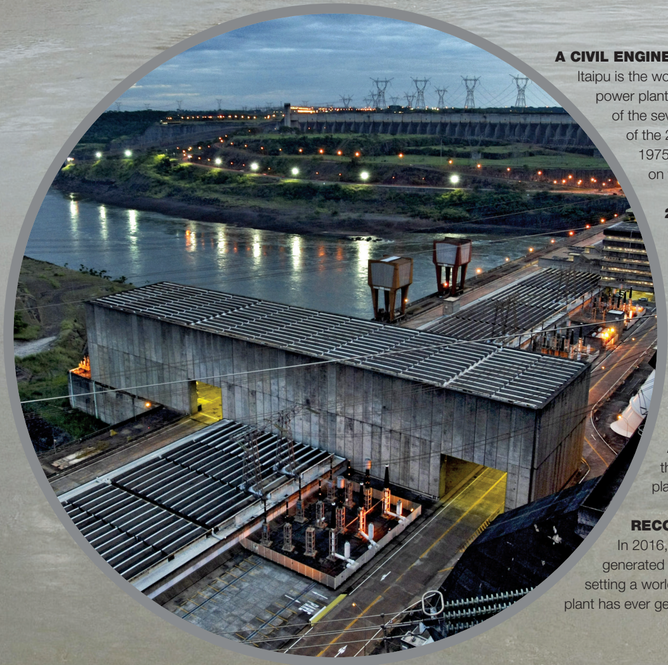
50%
of the proceeds from these power plants come from local residents.





All the Energy of the Dam

Making the most of the rivers that divide Paraguay and Brazil, the company ITaipu Binacional (IB) has become perhaps the biggest producer of hydroelectricity in the world.
IB built a huge dam but, as with many companies in the sector, the beginning was not easy. In fact, 59,000 people who lived along the Piranhas-Açu river were forced to leave their homes. Furthermore, the runoff from agriculture and livestock farming on this fertile land started to pollute the reservoir, resulting in the formation of algae, jeopardizing the generation of electricity.
IB therefore decided to work with the communities of local farmers and breeders to reduce pollution. This required most of the animal and agricultural waste to be cleaned up. As part of the Agro Energy Condominium for Family Agriculture project, 33 small farms were equipped with biodigesters. The biogas resulting from the organic waste is transported via pipeline to a small plant to produce electricity and heat.
The heat is then used by the farmers to dry their grain, thereby allowing huge savings. The surplus biogas is sold to the state energy company, which is another source of income for farmers.
This has allowed huge quantities of methane and carbon to be eliminated, electricity to be supplied to rural farmers who had none, while simultaneously restoring the quality of the water. One solution has therefore solved multiple problems.



A CIVIL ENGINEERING MARVEL
Itaipu is the world's biggest hydroelectric power plant and is considered one of the seven civil engineering wonders of the 20th century. It was built between 1975 and 1991 on the Paraná river, on the border between Brazil and Paraguay.

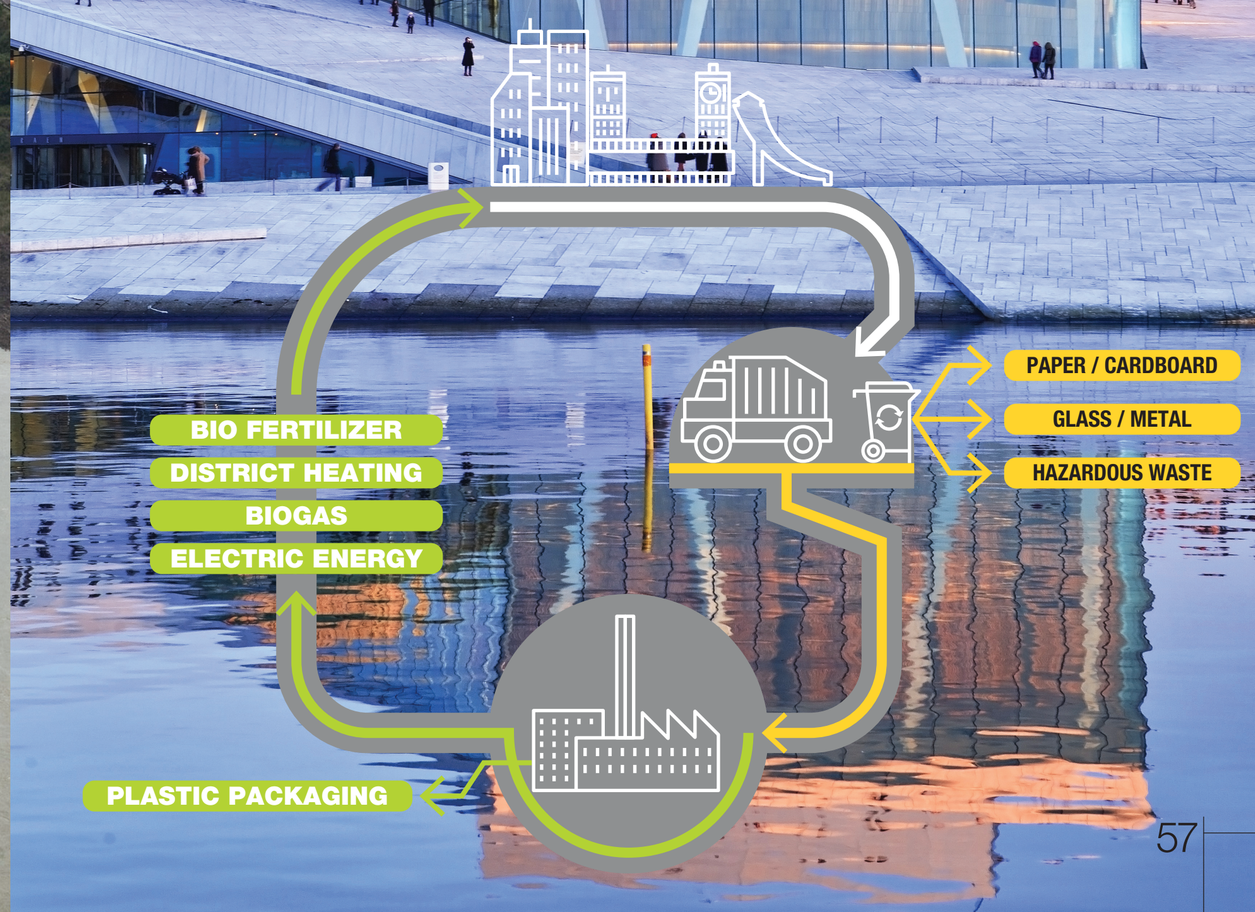
20 GENERATORS
The power plant, which cost 25 billion dollars, consists of 20 generators with a total output of 14 gigawatts, which alone covers 90% of Paraguay's electricity requirement and 25% of Brazil's.

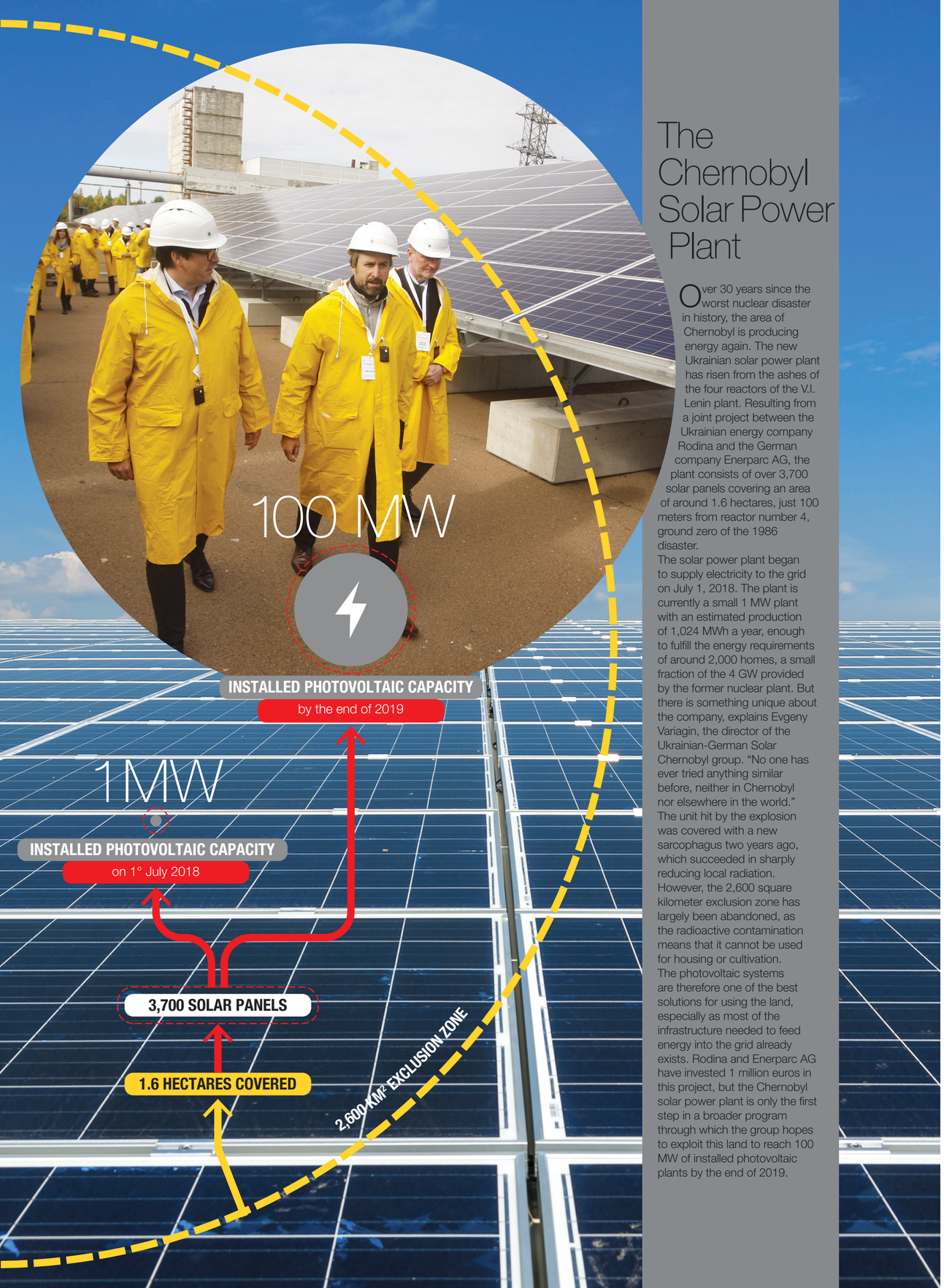
50 MILLION MEGAWATTS IN THE FIRST SIX MONTHS
50 million megawatt hours (MWh) were generated in the first six months of 2018. All this energy would be enough to satisfy the electricity demand of the whole planet for 19 hours; and Brazil's for 39 days.

RECORD PRODUCTION
In 2016, the Itaipu hydroelectricity plant generated more than 103.1 million MWh, setting a world record: no other hydroelectricity plant has ever generated so much in one year.

The Zero Waste Capital

In Oslo, the capital of Norway, the commitment of local inhabitants and the use of machinery based on the most advanced technologies guarantee very high recycling rates. All waste is transformed into raw materials used to manufacture new products—plastic objects, biomethane, biofertilizer—or for heating and electricity. Food waste, garden waste and waste water are transformed into biogas, products for the soil and biofertilizers.
In 2015, the city's two biogas production plants produced a total of 3 million cubic meters of biogas, which fuels all the garbage trucks and 150 of the 1204 buses in Oslo. These buses reduce CO_2 emissions as well as noise and air pollution.
After recycling, all the residual waste is used as a source of energy. Oslo's two waste-to-energy plants produce around 940 gigawatts of district heating and 160 gigawatts of electricity a year.
As for household waste, the incinerator's energy recovery rate is 99 percent. The district heating system supplies over 160,000 people, covering 20 percent of Oslo's demand.
At the city-owned Klemetsrud plant, the world's first pilot project for carbon capture and storage from non-recyclable waste is under way, which will help reduce CO_2 emissions by the Norwegian capital by 12 percent.





The Chernobyl Solar Power Plant

Over 30 years since the worst nuclear disaster in history, the area of Chernobyl is producing energy again. The new Ukrainian solar power plant has risen from the ashes of the four reactors of the V.I. Lenin plant. Resulting from a joint project between the Ukrainian energy company Rodina and the German company Enerparc AG, the plant consists of over 3,700 solar panels covering an area of around 1.6 hectares, just 100 meters from reactor number 4, ground zero of the 1986 disaster.

The solar power plant began to supply electricity to the grid on July 1, 2018. The plant is currently a small 1 MW plant with an estimated production of 1,024 MWh a year, enough to fulfill the energy requirements of around 2,000 homes, a small fraction of the 4 GW provided by the former nuclear plant. But there is something unique about the company, explains Evgeny Variagin, the director of the Ukrainian-German Solar Chernobyl group. "No one has ever tried anything similar before, neither in Chernobyl nor elsewhere in the world."

The unit hit by the explosion was covered with a new sarcophagus two years ago, which succeeded in sharply reducing local radiation. However, the 2,600 square kilometer exclusion zone has largely been abandoned, as the radioactive contamination means that it cannot be used for housing or cultivation.

The photovoltaic systems are therefore one of the best solutions for using the land, especially as most of the infrastructure needed to feed energy into the grid already exists. Rodina and Enerparc AG have invested 1 million euros in this project, but the Chernobyl solar power plant is only the first step in a broader program through which the group hopes to exploit this land to reach 100 MW of installed photovoltaic plants by the end of 2019.

Climate/Providing incentives to encourage radical choices

A Joint Change of Course

Cutting emissions by abandoning linear economy paradigms will require concerted action by markets and lawmakers, action that will provide increased benefits through a conversion to a circular economy



MARI PANTSAR

She is director of the Finnish innovation fund Sitra, leading the carbon-neutral circular economy theme. After working for forestry giant UPM, she moved to public and private positions in the cleantech sector. She led, among other things, the Finnish government's cleantech strategy programme. She holds the title of docent at the University of Helsinki and at Lappeenranta University of Technology.

The publication of the special report of the Intergovernmental Panel on Climate Change (IPCC), "Global Warming of 1.5°C," has stoked intense debate about how to close the gap between current climate policy and the goal of limiting global warming to 1.5 degrees Celsius. Much of the debate is focused on how to achieve another long-term goal of the Paris Agreement: an economy with net zero emissions. There is an air of urgency about the debate, as investment decisions made globally within the next one to four years will be decisive for the mitigation of climate change.

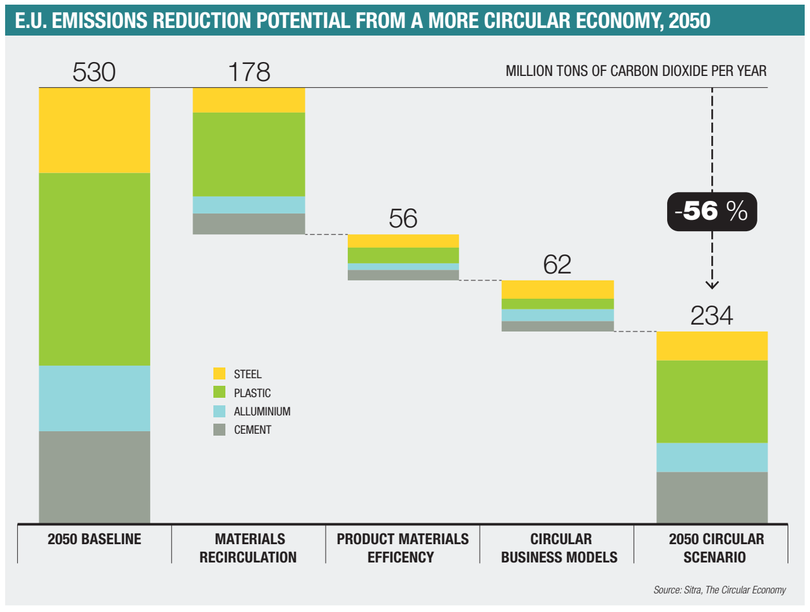
Thus far the policy discussions and the various proposed "road maps" have focused on increasing energy efficiency and deploying low-carbon energy sources. Both are crucial, but when it comes to industry, a major source of emissions, these measures offer only a partial solution. Additional strategies are needed to address the substantial amount of emissions from the production of materials such as steel, cement, plastics and aluminium.

The transition from a linear to a circular model

Our current economic model is linear in that natural materials are ex-



A concerted strategy of materials recirculation, circular production models and production efficiency would allow the E.U. to reduce carbon dioxide emissions by 56% by 2050.





tracted to produce more and more products which are disposed of after short lifespans. On a planet with 7.7 billion people, soon to be 10 billion, with ever-growing levels of mass consumption, the transition towards a circular economy is inevitable. In the circular economy, waste is eliminated as far as possible, and where waste can't be avoided, it is converted into a valuable resource and raw material. The life cycles of products are extended and their usage rates are maximized with business models that focus on sharing and leasing with the help of digital platforms. Recycling and reuse of products will become mainstream. In fact, the circular economy is much more than recycling. It is a new, sustainable and vital economic model in which consumption is based on using more services—sharing, renting and recycling—instead of owning things. According to a study conducted by Sitra, Material Economics and the European Climate Foundation (2018), increased global circulation of just four main material streams—steel, plastics, aluminium and cement—would go a long way to meet the targets of the Paris climate agreement. Circular economy measures could reduce European Union (E.U.) industrial emissions by 56 percent (300 Mt) annually by 2050. That is more than half of what is necessary to achieve net zero emissions. Globally, the reductions could be as much as 3.6 billion tons annually over the same period. Industry accounts for 24 percent of global CO_2 emissions, a total of 37 billion tons in 2017 (see infographic). If we want to meet the Paris Agreement commitments, the future economy must include circular business models—increased recycling and recirculation of materials and far more material-efficient products. Globally, governments and businesses need to put the circularity, fuelled by advancements in digitized technology, at the heart of their industrial innovation strategies. And that with a clear goal of achieving net zero emissions by 2050.

How it can be achieved

To exploit the circular economy to its maximum potential, a smart regulatory framework is needed. This includes at least the four following steps.

1 | Plot a defined course of action and recognize the potential of the circular economy as a major contributor to climate targets.
The potential of circular economy measures to contribute to climate targets is far from recognized in current climate or industrial policy, and climate action plans at international, national or local levels currently make little reference to the overall agenda. Therefore, as a first step, focus needs to be on policymakers, civil society, researchers and business leaders. Those responsible for shaping policy at all governance levels can help make clear that it is necessary to incorporate circularity in all aspects of E.U. climate and industrial policy.

2 | Create an enabling framework that includes publicly funded research and infrastructure and regulatory guidelines.
It is largely the private sector that will construct the circular economy. The companies producing mass-use materials, the manufacturers, construction firms and the consumer goods retailers, and, at the end of the line, the waste management and recycling firms. Nonetheless, the public sector has a crucial role to play by shaping the business environment, infrastructure, policy frameworks and incentives that help, encourage and facilitate private action. One essential thing is to stimulate innovation. Technological development is making circularity measures more viable and cost-efficient. Opportunities to increase revenue and add value abound. There are countless opportunities: platforms for car-sharing; autonomous vehicle schemes; sensor-based sorting of scrap metals; automated tracking of material flows in buildings; chemical marking of different types of plastics to allow for easier sorting and recycling; automation of construction processes; automated disassembly of complex products; chemical recycling technologies; methods for removing copper from steel—the list is long. Those companies that are smart and quick enough to seize these opportunities will position themselves as future global leaders. While many companies may not be ready to make major investments in these innovations, the public sector can accelerate the process by funding research and development and encouraging through example early take-up. Legislation and regulations need to be adapted or introduced to enable circular economy opportunities. As always, all regulatory approaches must be analyzed carefully to ensure fair balance between the different objectives of interested parties.
As an example, in waste management, there are many regulations to consider: the management of current and future incentives for the incineration of waste; the impact of additives and toxicity in plastics recycling; "end-of-waste" policies that can often prevent or hinder trade in secondary materials; and ensuring clarity about the ownership of and access to end-of-life materials. Efforts to create internationally recognzized standards for the ownership and use of secondary materials should also be encouraged.

3 | Level the playing field to remove incentives for creating waste and to improve the profitability of investments in circular economy measures.
Market conditions today favor waste against material efficiency and reuse. To improve the profitability of circular business models, financial incentives need to change. The fact that so many negative-cost opportunities that make clear economic sense remain undone suggests that existing policy measures such as carbon pricing in the E.U. are not enough. Materials are internationally traded commodities making it difficult for the E.U. alone to unilaterally introduce carbon prices at levels required to ensure significant cuts in emissions—both on the supply or the demand side. But even setting high carbon prices may not be enough, because many of the barriers that prevent reducing emissions are non-financial. Regulations steer key sectors such as the construction industry and waste management in ways that might encourage but in reality often discourage circularity. Thus, while setting carbon prices can help, policymakers need to do more to unleash the full potential of their actions. A major issue is how best to provide incentives to manufacturers to account for the impact of materials and design choices on the value of components and materials once products have reached the end of their lives. To date, the main approach has been to encourage "extended producer responsibility," but in practice its implementation provides very little incentive for manufacturers to modify their product designs. As a result, numerous unhelpful externalities remain in place, and priority needs to be given on a global scale to how to implement creative approaches for addressing this anomaly.

4 | Take government action across a range of areas, especially where governments have the greatest role in shaping outcomes.
Governments can also be the principal influencers in enabling the transition to more circular mechanisms. For example, the public sector is a major provider and user of mobility services, it owns and manages much of the built environment, and it is a large consumer of a wide range of material-intensive products. This means governments, at all levels of administration, are well positioned to push the market towards a more circular economy through their own investments and purchases. Governments also decide how transport infrastructures and the built environment are designed, developed and managed. This is true particularly if one considers decisions taken at the level of individual towns and cities around the world. One priority is to ensure that public transport systems are integrated with car and bike sharing schemes. City planning also influences buildings—how they are constructed, what materials are used and how they are heated and cooled. Considering the vast potential for the reduced use of materials, it is vital that material efficiency and flexible use of the building stock of a town, city, county or nation are considered as an equal measure alongside more traditional concerns such as occupation density and social, employment or transport issues. Public procurement is another area open for consideration. Concerted efforts to incorporate recycled and recyclable materials and wider material-efficient strategies into purchasing decisions could help boost nascent markets. As with all other suggestions touched upon, further work and evaluation is required, but all are economically feasible and technologically easily within reach.

AN EXAMPLE TO FOLLOW
The modern waste collection system in Ljubljana, one of the greenest cities in Europe. Of the 170,000 tonnes of waste produced annually in the Slovenian capital, 98% are recycled (Source: European Commission).

The circular economy needs a systemic change

It is often said that the transition to a circular economy requires "systemic" change, which seems difficult if not unfeasible. It is true that a recent IPCC report calls for fundamental change. But what is comforting and exciting is that there are smaller, manageable policy packages, which, when combined with a clear, ambitious vision for the future and strong political will, could unleash a wave of innovation and new investments that would pay off for generations to come. All this progress requires is a profound and yet very slight change of mindset, one that realises that the circular economy is not just an environmental issue or a means of reducing greenhouse gas emissions. It offers tremendous opportunity for business, government and the whole of society, providing companies with a significant competitive edge through more efficient use of materials by minimizing dependency on virgin raw materials, something which benefits us all. It is a winning strategy.



Examples/Circular London and the fight against food waste

The Role of Politics in Creating a More Sustainable Society

The circular economy must become central to the way we think —locally and at the national and international level. Policymakers, businesses and individuals will all need to do their part



LIZ GOODWIN

A chemist by background, she was CEO of WRAP in the U.K. for 9 years until 2016, when she joined the World Resource Institute (WRI) as Senior Fellow and Director of Food Loss and Waste. Goodwin is also Chair of the London Waste and Recycling Board (LWARB), to which she was appointed in 2017 by the Mayor of London Sadiq Khan.

have long been an advocate for the circular economy. The term, often used but not always understood, refers to our effort to find an alternative to the traditional "linear" economy in which we use resources to make things and then throw away the waste. Proponents of a circular economy argue that we must engage people to find ways to use resources wisely—to select carefully, use only what we need, keep materials in use for as long as possible and recycle or recover what we can. Everything should be treated as a precious resource, whether that's paper, plastic, glass, metals or rarer materials. This more circular approach has been shown to have wide benefits, creating jobs, making better use of resources and contributing to the economy.

The circular economy can operate at many different levels—internationally (for example where international supply chains are involved), nationally, at city level and even more locally. And it's important to recognize the different roles played by policy makers, businesses, entrepreneurs, individuals and communities.

Policymakers have an important role to play in providing the framework within which businesses can operate. This provides the context for decisionmaking, planning and business operations. Businesses then need to operate within the policy framework, using circular principles and reaping the benefits which result.

Let's look at a couple of examples to illustrate this. Firstly, at the city level by looking at the policy developments and work to develop a more circular economy in London and secondly, looking at developments across the food sector and supply chains to make the food systems more efficient and reduce food loss and waste.

London Route Map in numbers

11 million

By 2050, 11 million people will be living in London. To keep up with its growing population, the city will require a more flexible and sustainable approach in terms of products, housing, office spaces and essential infrastructure.

£7 billion

is the value of the benefits that a circular economy could bring to the city in sectors such as constructions, food, textiles, electrical goods and plastic by 2036.

12,000

new jobs will be created thanks to material reuse, regeneration and innovation.

£2.8 billion

is the total contribution that the Route Map initiatives can provide the overall growth potential of £7 billion.

The London Route Map is worth £2.8 billion

In June 2017, LWARB (the London Waste and Recycling Board), of which I am Chair, launched its Circular Economy Route Map to accelerate London's efforts to become a circular city.

London is growing fast. With the capital's population predicted to reach over 11 million by 2050, a more flexible and sustainable approach to products, housing, office space and critical infrastructure is crucial to London's ability to adapt and grow.

By 2036, the circular economy could provide London with net benefits of at least £7 billion every year in the sectors of built environment, food, textiles, electricals and plastics, as well as 12,000 net new jobs in the areas of reuse, remanufacturing and materials innovation.

The Route Map recommends actions for a wide range of stakeholders, including London's higher education, digital and community sectors as well as London's businesses, social enterprises and its thriving finance sector. Some stakeholders are already signed up to deliver actions, but LWARB is looking for others to get involved and help make London a city where circular economy businesses can flourish.

The route map is an action-oriented document, developed in partnership with London stakeholders. An economic analysis of the route map estimated that the actions within it could contribute £2.8 billion towards the £7 billion opportunity identified.

In parallel with the route map, in June 2017, the Greater London Authority (GLA) published an updated Responsible Procurement Policy. The document is a high level strategic policy setting out the GLA's plans, ambitions and commitments for ensuring continuous improvement in London, delivered through its procurement activities, which supports the delivery of the mayor's commitments and related strategies. For the first time, the policy includes reference to the circular economy. Also in 2017, the GLA published its London Environment Strategy, which covers air quality, green infrastructure, climate change mitigation and energy, waste, climate change adaptation, ambient noise, and transition to a low carbon circular economy. Both of these policy documents are important in demonstrating the mayor's commitment to the circular economy and the benefits it can bring.

The policy environment created by the GLA gives the context in which businesses and others make decisions about investments, strategies and plans. There will always be some forward-thinking businesses who take a long-term perspective, but many businesses need the policy environment to encourage them in the right direction.

The circular economy needs to become central to our thinking not just at a city level, but nationally and internationally. There is a role for policymakers and businesses alike at all levels. Many businesses operate internationally and have global supply chains, so national borders should not be a barrier to their thinking.

In Europe, it's encouraging to see the progress of the E.U. Circular Economy Package and the commitments and direction of travel that will come through as a result.

It's also important that governments don't just think about impacts within their own borders—what about the impacts associated with goods and services which are imported (and exported)? One of the weaknesses of current climate change legislation and actions is the focus on impacts within country borders, so there is no real driver to consider climate change implications of overseas manufacturing, which ends up as products that are imported and consumed within the country.

As a result, the U.K. has emission targets to reach to fulfill its obligations under Climate Change Agreements but it is only focusing and monitoring emissions within the U.K. border. The fact that a lot of manufacturing has moved overseas means that we don't have a real picture for the emissions the U.K. is responsible for (or ought to be responsible for) i.e., the emissions associated with the consumption of goods and services by the population living in the U.K.

Food waste

Food waste is another area where policy has an important role to play, but it's only part of the picture. We all, as householders, communities and businesses, have a role to play in tackling this issue. Food loss and waste occurs all the way along the supply chain until it reaches the wholesaler or shop, and then again in our homes, restaurants, hotels, schools, hospitals and other community areas. This all costs money, causes greenhouse gas emissions, wastes water and land resources, and leads to harmful social consequences.

Policymakers have been begun to do their part. At the international levels, the UN has recognized the importance of this issue by setting Sustainable Development Goal 12.3, which aims to halve household food waste by 50 percent and reduce food loss in the supply chain by 2030.

At the regional level, a great example of policy development is the work in the E.U., where there is now an objective to reduce food waste and commitment by member states to monitor and report on food waste starting in 2022. This measurement will provide valuable information to allow targeting of food waste hot spots. As well as measurement, the E.U. has sought to make it easier and clearer for member states to encourage food donation and redistribution.

An example of national level policy development is the National Food Waste Strategy published by the government of Australia in November 2017, which provides a framework to support action towards halving Australia's food waste by 2030, a target that was set in 2016. And finally, city level examples include Dubai, which launched a zero-tolerance approach to food waste; London, which committed to reducing food waste by 50 percent by 2030; and, Buenos Aires, where a program was launched to reduce waste across the city.

This hierarchy of policy is important and provides a helpful framework for action. However, we need more countries to translate the international goals into country specific targets and action programs. In parallel, we need all businesses to work up and down the supply chains, in collaboration, to maximize the effectiveness of supply chains and reduce waste overall.

Let's unpack the issue of food loss and waste a bit. We know that the average U.K. household with children wastes around £700 every year by purchasing food that's never consumed. Figures are likely to be similar in the majority of developed countries in the world—and levels of household food waste are growing in developing countries as people become more affluent and food becomes cheaper.

This issue needs more attention. It's natural that people strive to become more affluent, but how can we grow the middle class without losing our connection to food and its value?

Food loss in the supply chain is a cost to businesses and to farmers—and while a growing number of businesses are recognizing this and starting to do something about it, we need to be smarter about how to measure the impact of waste and take targeted action. That's why the World Resources Institute- (WRI) and WRAP-authored report, The Business Case for Reducing Food Loss and Waste, is important. It seeks to demonstrate that case using good practice from a range of businesses and companies. The headline conclusion from this report was that the median organization had a 14:1 return on its investment to reduce food waste.

All of this is vital if we are to tackle climate change. Wasted food produces huge amounts of greenhouse gas emissions—food waste sits third in the list of emitters behind China and the U.S., and just ahead of India and Russia.

Wasted land and water

Water is also at risk as a result of food systems and waste: when we waste food, we waste the water used in its production. This might not seem important in countries where there is plenty of water, but it does matter when many of the foods we buy are grown in countries with water scarcity issues. Wasting food is also a waste of the land used for the crop or grazing—and as a population grows, pressures on land use will only grow.

And there are social impacts from food loss and waste, ranging from subsistence farmers who are struggling to produce enough to sustain themselves, through to householders in developed countries who don't know how to cook and have a less healthy diet of processed food and ready meals.

There are real opportunities and reasons for all of us then to reduce food loss and waste and make our food production and usage as efficient as possible. This will improve our finances, our environment and our health.

But reducing food waste is not always easy. Once we're motivated to change, the steps to improve things are simple—but we need that motivation first. For businesses, it can be as straightforward as understanding the financial case. For householders, finding the incentive to act can be trickier: financial drivers are not always enough on their own. No matter what the motivation, it needs to be easy for people to change.

Work to tackle the U.K.'s food waste made great strides in the early days, but it has slowed down more recently.

If we want to halve food waste by 2030, we need to focus on the root causes of food waste:

- We have lost the value placed on food by previous generations—why is that, and how do we address it?
- We are busy and our household structures mean that we don't always get to sit down to eat together or even eat the same thing.
- Recent generations have lost basic food understanding and cooking skills. It's too easy to rely on a date label to tell us when something's gone off, rather than using old-fashioned sight and smell, for example.
- We are more affluent so we can afford to waste more food.

Of course, there will always be some waste, such as peelings, bones and other inedible things; so we need effective ways of handling food waste to recover what we can from it. This is where separate food waste collections from households and treatment by anaerobic digestion (AD) and composting come in.

The benefit of composting is that it produces a product (digestate or compost), which can then be used to return nutrients to the soil, helping close the loop and improve soil quality. As the experts will tell you, the benefits of doing this should not be underestimated. In many places, such as East Anglia, there are real concerns about the condition of the soil and farmers need to find ways of restoring balance to the earth in which our food is grown.

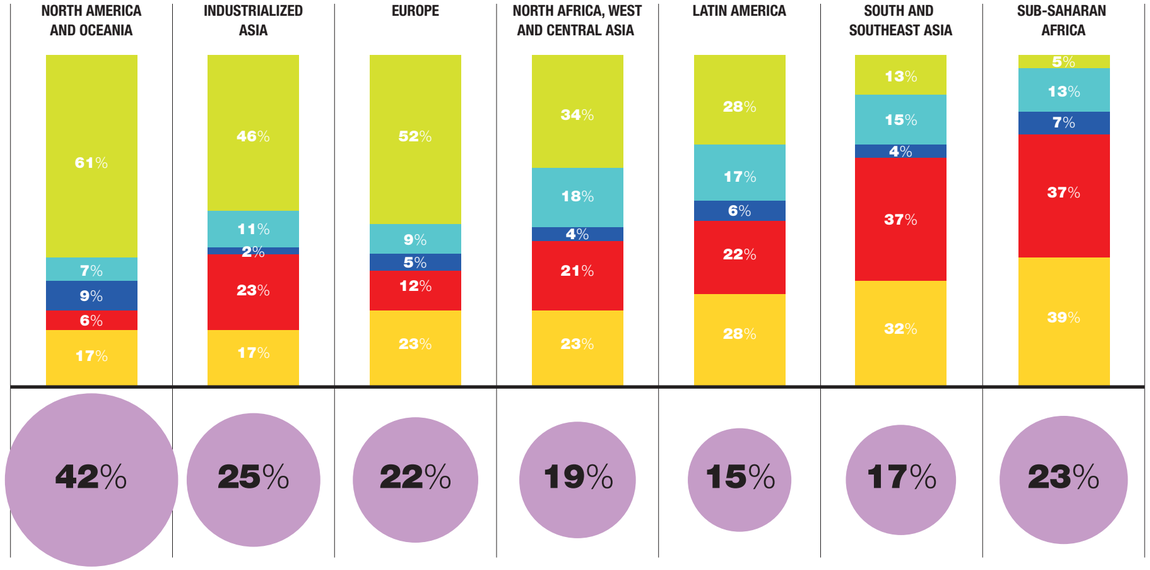
And in the case of AD, energy that can be used locally or fed into the grid is also produced. These processes then play a role in helping drive a more circular economy.

Conclusions

This article has sought to look at the circular economy from two different angles, a city perspective and a food sector perspective. There are real challenges, which need to be overcome—policy has an important role to play, as do businesses and all of us as individuals and members of communities. Overall, I am positive about the future and believe that we are developing our understanding of the issues, complexities and linkages all the time. We are increasingly well-placed to do something about it, and this is one of the reasons why I work in this area. It is hugely important to both individuals and planet, but an issue where, with a collective will, we can make genuine progress.

Food waste

This diagram shows the percentage of food lost or wasted between the time it is produced and the time it is eaten by geographical area. Food losses during production are more frequent in developing regions, while food waste by end consumers occurs most often in developed countries.



EMISSIONS

Percent of kcal lost and wasted in 2009*

- PRODUCTION
- HANDLING AND STORAGE
- PROCESSING
- DISTRIBUTION AND MARKET
- CONSUMPTION
- SHARE OF TOTAL FOOD AVAILABLE THAT IS LOST OR WASTED

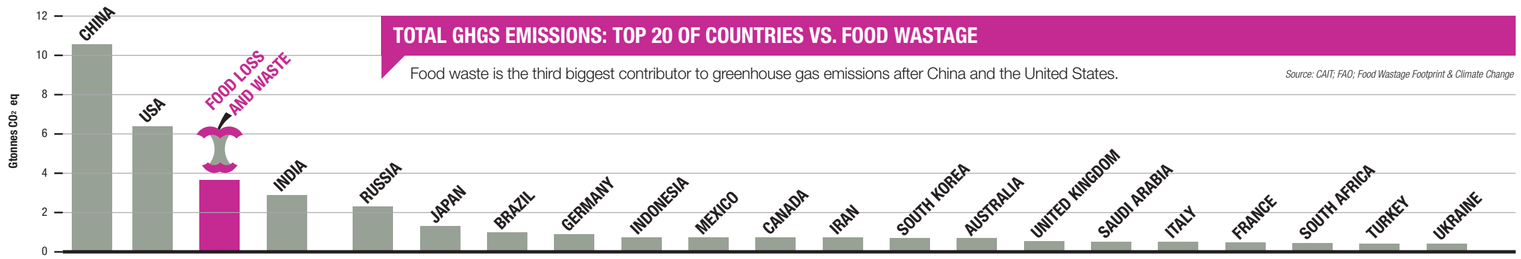
** Numbers may not sum to 100 due to rounding*

Source: World Resources Institute

TOTAL GHGS EMISSIONS: TOP 20 OF COUNTRIES VS. FOOD WASTAGE

Food waste is the third biggest contributor to greenhouse gas emissions after China and the United States.

Source: CAIT; FAO; Food Wastage Footprint & Climate Change





Mobility/The world faces the test of sustainability

Brave Decisions

Rethinking the transport sector, especially urban transport, means abandoning the paradigm of privately owned vehicles in favor of more sustainable solutions. There is a still a great deal to do, but many cities around the world are shifting their focus to the use of renewable energy sources



NANCY VANDYCKE

She is Economic Advisor of the Transport Global Practice in the World Bank. She led the creation of and currently heads "Sustainable Mobility for All"—a global platform that unites 50 international organizations worldwide to change the future of mobility.

TRANSPORT NEEDS RETHINKING
An image of Tokyo. There are approximately 80 million cars in Japan. Transport around the world is responsible for 23% of global greenhouse gas emissions from energy consumption and for 18% of all anthropogenic emissions.

he world of transport is changing rapidly, and its future path is uncertain. By 2030, annual passenger traffic will exceed 80 trillion passenger-kilometers—a fifty percent increase. Aviation alone will provide about 100 million jobs and generate USD 5.9 trillion in GDP—a third of the US GDP. Similarly, global freight volumes will grow by 70 percent in the next fifteen years. The numbers of cars is expected to double by 2040—with an additional 1.2 billion cars on the road—the result of a growing middle class aspiring for more mobility.

Meeting the growing aspirations for mobility sustainably has the potential to improve the lives and livelihoods of billions of people—their health, their environment, their quality of life—and to help minimize the effects of climate change. Transportation is also a lifeline for communities hit by natural disasters, famine and war.

But the costs of today's mobility systems to society are simply too high. Overall, mobility is associated with gross inequalities in access to opportunities; transport-related fatalities; intensive fossil fuel use with large emissions of greenhouse gases, degradation of the environment and increases in air and noise pollution. In 2012, transport was the largest energy consuming sector in 40 percent of countries worldwide and the second in the remaining others, and energy-related CO_2 emissions are expected to grow by 40 percent between 2013 and 2040. The sector contributes to 23 percent of global energy-related greenhouse gas emissions and 18 percent of all man-made emissions in the global economy. This has serious implications, with air pollution both indoor and outdoor being recognized as the biggest environmental risk to human health. Outdoor air pollution alone kills around 3 million people each year. It is time to reverse this trend. Meeting today's mobility needs is coming at the cost of future generations, and this path is unsustainable.

For the international community to reverse this trend will require the pursuit of four policy goals: equity in access, efficiency, safety, and green mobility. Achieving sustainable mobility is the new Global Public Good.

Transport's role recognized

Several governments have pushed for specific solutions. Mexico pledged to decarbonize the transport sector to cut its green house gas (GHG) emissions by 40 percent by 2030. India set a target of 30 percent electric vehicles by 2030, with at least 15 percent of them on its roads in five years. A few front-running cities around the world have taken proactive steps to ensure healthier lifestyles and decrease GHG →

emissions. For example, more than a dozen cities in China have promoted dock-less bike-share systems. Some companies, such as Boeing and Virgin, are also striving to develop alternatives to existing mobility solutions.

These actions have taken place in the context of increased awareness of the role of transport to address global challenges such as climate change and social instability. The United Nations has embraced this agenda, and it has promoted multiple international agreements and conventions that set long-term directions for transport. Among others, the Sustainable Development Goals, the UN Decade of Action on Road Safety, the New Urban Agenda, the Vienna Landlocked National Program of Action, the Paris Climate Agreement, and the United Nations Global Sustainable Transport Conference have all established new benchmarks against which progress toward sustainable mobility will be measured in the future.

The last five years have seen a significant paradigm shift. Transport is no longer seen as just as aiding improvements in other sectors, such as better educational outcomes, health benefits, or lower agricultural waste. Rather it is seen as a sector in its own right, one crucial to delivering a better and more sustainable future. Political stability and social inclusion cannot be achieved unless everyone's individual travel needs are met—including older persons, children, people with disabilities, women, and those in vulnerable groups. The changing climate cannot be reversed unless transport cuts its dependency on the fossil fuels associated with road transportation. In a world increasingly rich and aspiring for more mobility, getting the mobility system "right" has become a defining factor of society's future.

Tentative steps towards the future

But results have trailed behind the vision. Aspirations have more often taken precedence over bold actions; innovative solutions have been implemented on an ad hoc basis; and short-term tactics from policy-makers have superseded the pursuit of an international vision for the common good. Effort by the private sector, countries and cities have at best had impact on one or two of the policy goals. In many countries, policy makers have promoted the construction of more roads to increase people's accessibility to opportunities; often, though, this has translated into an increased number of vehicles on the roads, with associated fatalities and pollution. In other countries, policy makers have promoted a particular technology—for example, electric vehicles—to cut down on GHG emissions and thereby continued to support a car-centric view of mobility.

In 2017, in an effort to bring the international transport community together around a common vision, the Sustainable Mobility for All initiative—a global platform hosted by the World Bank, with 53 international organizations and agencies committed to act with one voice and influence the direction of transport—completed an 18-month-long consultation effort with transport stakeholders to agree on what is "sustainable mobility" and how to measure country performances on it. Sustainable mobility requires changes in the fundamentals that have structured our post-World War II quest for a mobile and prosperous society. Lack of progress in the past two decades has unsurprisingly led the world to an unsustainable path. Whether one is looking at driverless cars, electric vehicles, or car sharing, all these technological breakthroughs tend to reinforce a car-centric ecosystem that arose from the Industrial Revolution more than a hundred years ago. Although we know that motorization comes with a number of adverse consequences, new technologies risk making car use even more dominant. Preliminary research has shown that technology-enabled mobility services like car sharing are already taking riders away from buses, trains, taxis, and bicycles. More alarmingly, women who formerly used more public transport than men have recently changed their mode of choice to individual car use.

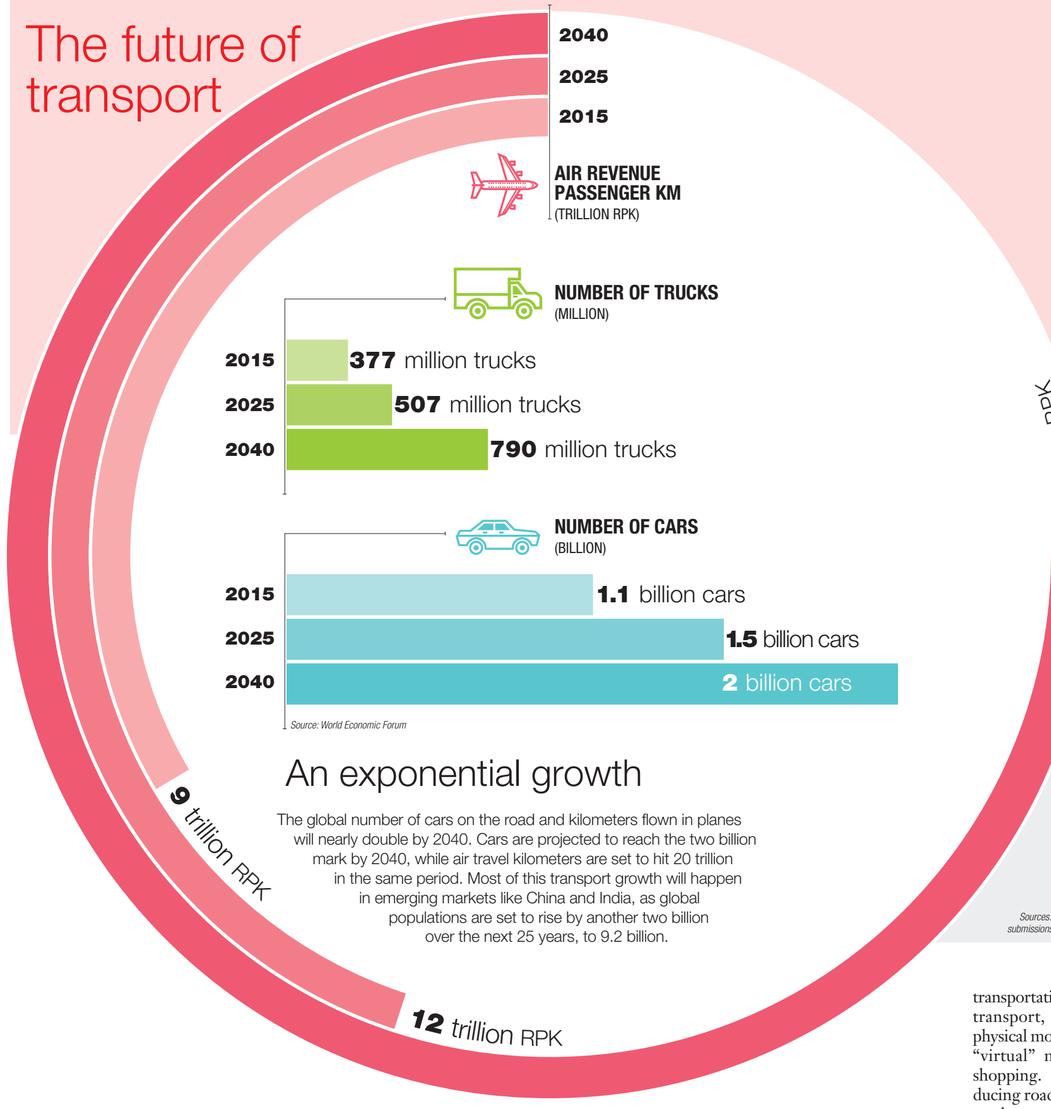
There is no path toward sustainable mobility without a system change. With rapid urbanization, booming world trade, and yet unchanged basic technologies, the current mobility system is stressed. Its survival necessitates a deep structural transformation involving behavioral changes, technology, and interaction with other sectors:

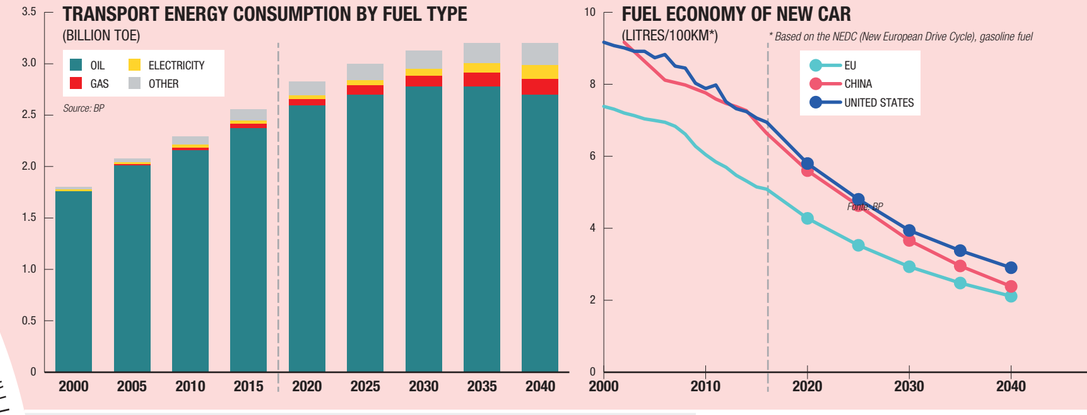
- The prevailing system largely promotes improvement in dominant modes of transportation, principally individual car use on roads and a shift to public transportation. All in all, it promotes road use over any other modes of transportation, such as rail and air transport, and encourages the physical movement of people over "virtual" mobility, e.g., online shopping. The future lies in reducing road use, expanding other modes, creating new ones and avoiding trips.
- Technology is redefining what is possible for transport. The ongoing wave of innovation opens up a range of exciting new possibilities—for example, fully automated cars. But there is still uncertainty on alternative solutions envisioned for the future, solutions such as e-mobility associated with batteries and hydrogen, green methane, sharing, and the seamless integration of transport modes. Can it be developed at the required scale in an economically sound way?
- Real transformation of mobility will only come with bold progress throughout all sectors, and energy in particular. For example, 96 percent of transport currently depends on fossil fuel energy. Many fossil fuel suppliers consider that, by 2050, oil will still be the dominant fuel source for mobility, with natural gas and electricity taking on a growing role. Research from the IPCC, IEA, and others shows that such a scenario is not compatible with the ambitions set in many international and regional agreements and conventions. There is a disconnect between the long-term aspirations of stakeholders and their current actions.

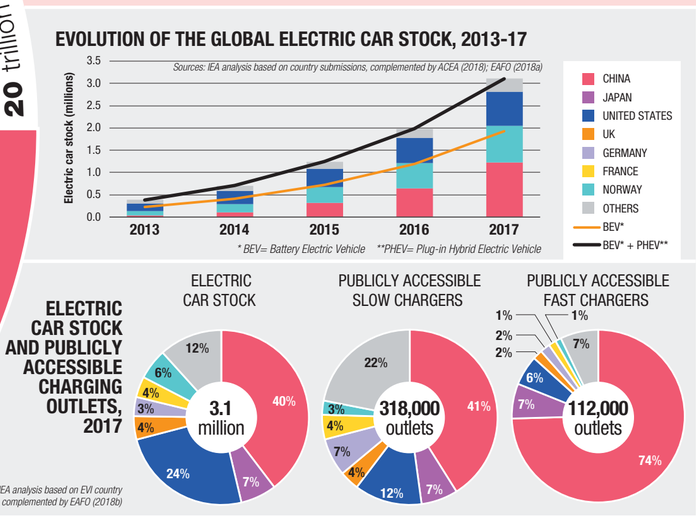
Best practices all around to achieve change

To ensure sustainable mobility, the circular economy model of economic development, with its objective of making the most effective use of local resources and protecting the environment offers a promising pathway, especially one to reduce transport's dependency on fossil fuels. Traditional renewable energy solutions such as solar, wind and bioenergy are being explored around the world as alternatives to fuel the transports sector. For example, the Santiago metro in Chile has signed agreements with both solar plants and wind farms with the objective of powering the underground rail network. Wind and solar energy will take center stage in the Bay Area Rapid Transit's long-term electricity supply, with at least 50 percent of its electricity provided from renewable sources by 2025. Bioenergy, one of the key technologies to reduce CO_2 emissions and dependency on liquid transport fuels, accounts for roughly 9 percent of world total primary energy supply today, with less than 6 percent used for transport, while 90 percent is still dependent on oil. The International Energy Agency projects that biofuels would grow to 27 percent of the world transportation fuel by 2050. Waste-to-energy technologies offer a promising alternative to more traditional renewable energy. Organic materials, such as food scraps and green waste are broken down via anaerobic digestion and turned into gas, fertilizer and fuel. For example, the city of Sacramento uses it to power school and commuter buses. Its application to power plants is also under development. These alternative technologies open up a range of new possibilities to reduce fossil fuel consumption and production, cut large costs associated with its long-distance transportation from one side of the world to the other, and make the most of resources locally available. There are, however, important technological obstacles to overcome, and scalability remains a question mark.

In the meantime, national and subnational policy makers, together with businesses and civil society, must craft and implement a shared and tailored roadmap of action to achieve the access, efficiency, safety, and green policy goals. Today, public decision-makers have at best policy measures at hand to achieve one policy goal, like cutting on GHG emissions. Most often, though, these recommendations follow a one-size-fits-all approach and are disconnected from where a country stands relative to achieving that particular goal. Also, the public often assumes that the responsibility for the pursuit of the common good primarily rests upon national and subnational governments, while the private sector should be free to follow its own interests. The Sustainable Mobility for All (Sum4All) initiative embarked into a major effort to draft a Global Roadmap of Action toward Sustainable Mobility—a prerequisite to change the direction of transport. We invite you to engage to shape this key policy tool for ensuring that the world moves toward a future of sustainable transportation.









Cities/Flexible local governments adopt innovative policies

The Linchpin of the Circular Revolution

Urban systems are becoming increasingly accessible and regenerative with their capacity to minimize waste and inefficiencies. They are laboratories in which to create prosperity through a virtuous process that breaks the traditional link between the concept of economic growth and the increasing use of resources to fuel it



NICOLÒ SARTORI

He 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.

Cities are dynamic organisms with the potential to play an increasingly vital role in the global arena and can become key actors in the implementation of sustainable development and energy transition policies. The socio-economic significance of urban centers, cities and mega-cities is rapidly expanding, with some four billion people currently living in urban areas, accounting for 54 percent of the global population and for 85 percent of global GDP generation. Additionally, cities account for 75 percent of global resource consumption, 50 percent of global waste production and 80 percent of global greenhouse gas emissions.

According to United Nations projections, at current urbanization rates almost 70 percent of the global population is expected to live in urban areas by 2050. Therefore a wider reflection on the evolution and implementation of policies to promote a circular economy and the sustainable use of resources must include the active participation and innovative potential of cities. This is equally relevant for formulating those active mitigation policies and adaptation measures that are crucial for contemporary urban communities.

In view of the growing complexity of the organization of present-day urban areas and their consumption patterns, it is essential to rethink the role of cities, taking into account the dramatic effects of the climate-related and environmental changes taking place worldwide. 90 percent of urban centers are located near coastal areas, which are increasingly at risk from the devastating effects of climate change, including rising sea levels and a rapid succession of extreme events.

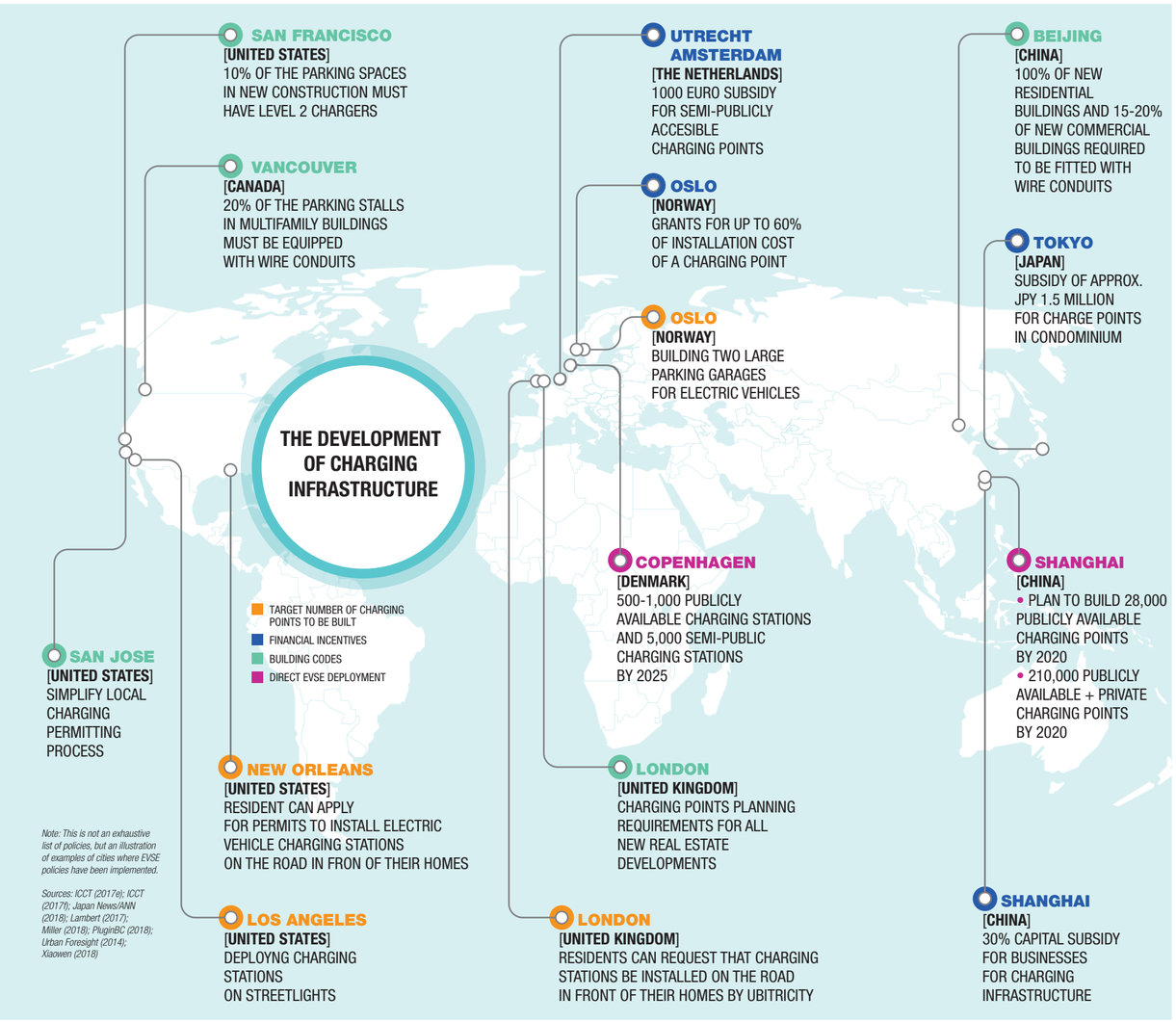
A key role for cities

Cities account for most of the consumption—as well as disuse and disposal—of globally produced material goods. They have by far the heaviest vehicle traffic for goods and passenger transport and the highest concentration of energy demand, particularly in relation to electricity consumption, and they are home to the largest infrastructure developments. At the same time, urban centers enjoy a growth and concentration of human, financial and creative capital inconceivable in rural areas. This combination of need and opportunity is what drives the search for alternative solutions geared towards a more attentive and efficient use of available and often scarce resources. Within this model, civil society and private actors, whether large, medium sized or micro enterprises, play a key role in supporting institutional actors. Initiatives ranging from the promotion of sustainable business models to attempts at social experimentation have been possible thanks to the capability and flexibility of local governments, qualities that allow them to introduce innovative policies and governance practices. In this respect, they are able to do more than national governments even though national governments have access to greater resources.

Urban systems, or at least some of them, are thus becoming increasingly accessible and regenerative, with the capacity to minimize—or, rather, eliminate—the waste and inefficiencies generated by the various sectors of urban life. They are laboratories in which to create prosperity, enhance livability and increase resilience through a virtuous process that breaks the traditional link between the concept of economic growth and the increasing use of resources in order to fuel it.

Recycling, reuse and valorization

The recycling and reuse of the resources produced, processed, consumed and disposed in the urban environment are at the heart of the efforts by cities and municipalities to shift towards a circular and sustainable economic system. Waste management is one of the biggest challenges for local authorities, especially in large cities and megacities. The →



Note: This is not an exhaustive list of policies, but an illustration of examples of cities where EVSE policies have been implemented.

Sources: ICCT (2017e); ICCT (2017f); Japan News/ANN (2018); Lambert (2017); Miller (2018); PluginBC (2018); Urban Foresight (2014); Xiaowen (2018)



LAUDABLE LJUBLJANA
Ljubljana was the first European capital to set itself a "ZeroWaste" objective. Today it separates and recycles 67% of materials and has reduced non-recyclable waste by 59%. The image shows electric buses and taxis in Presernov Square.

world's cities produce over two billion tons of solid waste per annum, amounting to more or less 500 kilograms per person, with huge costs that average between 20 and 50 percent of municipal budgets, services that have dramatic implications for citizens and their health. The situation is becoming unsustainable and could lead to a 70 percent increase in the next few decades compared to current levels, rising to the 3.4 billion ton mark.

In addition to encouraging responsible consumption and the fight against waste, cities must develop strategies and processes to reduce waste levels in absolute terms and minimize waste treatment costs, exploiting their intrinsic residual value through recycling and reuse procedures. And while waste collection, separation and storage models are evolving rapidly and in innovative ways, how these accumulated materials can be used to avoid incineration and landfill disposal remains an open question.

One approach is the utilization of urban waste for energy generation. By harnessing methane emissions through anaerobic digestion, it is possible to generate biogas with a 55-70 percent methane content, and its utilization for household use, heating and electricity generation is considerably less harmful and less polluting when compared to traditional waste disposal practices that involve the burning of waste in people's homes or by incineration plants.

Regardless of the various uses being made of urban waste, its reduction in absolute terms remains a priority, as shown by the "Zero Waste" campaigns embraced by many municipalities in Europe and around the world. In light of the data and projections published by the United Nations, the goal of totally eliminating the production of urban waste seems highly ambitious and hard to achieve, yet urgently necessary at the same time. In Europe, Ljubljana, Slovenia was the first capital city to set itself the goal of "Zero Waste," and to date some 67 percent of its waste is separated and recycled, while its production of non-recyclable materials has been reduced by 59 percent. In Italy, a notable example is set by the Province of Treviso, which has earned the title of Europe's best performing organization in the management and treatment of waste thanks to the innovations introduced by the company Contarina. In just fifteen years, the company's integrated management model has enabled the urban community of over 500,000 residents to increase its recycled materials from 27 to 85 percent and to reduce locally generated non-recyclable waste from 217 to 55 kilos per person.

Energy and sustainability

When we consider circular economy and sustainability in the urban context, the energy sector plays a vital role. Although in absolute terms cities are huge energy consumers—urban areas account for roughly two thirds of global primary energy demand—studies on energy intensity and per capita consumption levels show that cities make more efficient use of energy inputs. And while topographic and behavioral factors contribute significantly to this, practices related to the circular economy—such as public measures aimed at reusing waste materials, for example—represent serious attempts to reduce the energy footprint on the life of cities. They include the use of wastewater, as shown by virtuous cities such as Aqaba, Bangkok, Chennai and Beijing, where the treatment of organic waste contributes to savings from 45 to 100 percent on the final energy consumption for the purification process, with implications also for the CO_2 emission levels registered in these areas.

Added to this is the growing and increasingly sophisticated use of self-generation/self-consumption of power models, combined with the introduction of smart technologies and processes during the management, dispatching and distribution phase. New smart grids enable electricity flows to be managed through optimal integration and valorization of the new energy generation and consumption patterns created by the penetration of renewables, resulting in the efficient use of installed capacity, the minimization of resource waste and the reduction of greenhouse gas emission levels. Singapore, London and Barcelona are among the most virtuous large cities when it comes to smart systems, while among small-to-medium sized cities the Italian city of Savona stands out for its pilot project combining different power generation technologies that include photovoltaic, thermodynamic solar, geothermal power, gas micro turbines and a smart grid to provide energy autonomy to the entire university campus.

Sustainable mobility for a circular economy

The mobility and transport sector is also a major factor affecting the development of the circular economy in urban areas. Urban road congestion gives rise to a series of negative externalities, including noise pollution and higher emission levels. Globally, 80 percent of urban areas have air pollution levels higher than the limits set by the World Health Organization. This is compounded by further critical issues, including the time wasted in traffic congestion, with an average of over 100 hours per annum wasted in Los Angeles, closely followed by New York and Moscow, and more road accidents due to frequently inadequate and unsustainable urban transport systems. According to some estimates, traffic congestion in the United States costs the American economy roughly USD 300 billion per year. In this sector, the introduction of models based on the circular economy can improve citizens' quality of life at three different levels. The first is at the systemic-infrastructural level, with a multimodal system of accessible and efficient urban mobility integrating public transport services with the new solutions introduced by the sharing economy, including the use of bicycles and multi-passenger vehicle rentals. The second level concerns the energy sources used to power the urban mobility system. In this case, innovations such as the generation and self-consumption from renewables for electric vehicles and the use of locally produced biogas for combustion engines are necessary options for reducing pollution levels and achieving sustainability in urban areas. Finally, the third level concerns the industrial sector and the manufacture of vehicles specifically designed for urban transport. The adoption of highly effective and innovative production processes would not only contribute to dealing with the issue of waste but also have a significant impact on the costs and competitive advantage of the automotive industry.

A tripartite alliance

Given the magnitude of the challenges of sustainable development, especially in urban areas, there is virtually no choice but to go down the path of the circular economy. But in such a complex and dynamic context, local government action—however farsighted—must be matched by the impetus provided by innovations delivered by private stakeholders, as well as by the active cooperation of civil society and the population.

A new economic model for urban areas that is both circular and successful can only get off the ground if there is a joint and tripartite effort. The regulatory, technological-industrial and social-behavioral dimensions must necessarily go hand-in-hand and mutually stimulate one another to ensure that the benefits of the circular economy can permeate the dynamics of the urban fabric and have a global impact.

Cities in numbers

4billion
Today, 4 billion people, amounting to **54% of the global population**, live in urban areas

In 2050
In 2050, almost **70% of the word's population** will live in urban areas

75%
Cities account for **75% of global resource** consumption, **50% of global waste** production and **80% of global** greenhouse gas emissions

2billion
The world's cities produce over **two billion tons of solid waste** per annum, amounting to more or less 500 kg per person, with huge costs for public finances that average between 20 and 50% of municipal budgets

80%
80% of **urban areas** have air pollution levels higher than the limits set by the World Health Organization



Alberto Burri, "Grande bianco plastica" (Big white plastic), 1964, Palazzo Albizzini Foundation, Città di Castello (Italy).

Chemistry/The innovation built upon consolidated expertise

On the Front Lines of Change

Plastic, so ubiquitous, is undergoing a process of far-reaching transformation, thanks to the development of cutting-edge technologies that are increasingly improving both the efficiency of products over their life cycle and the effectiveness of recycling of their materials



DANIELE FERRARI

He is Chief Executive Officer of Versalis (Eni) and Chairman of Matrica, a joint venture in chemicals from renewable sources. Vice-Chairman of Federchimica since 2011 and outgoing Chairman of PlasticsEurope, the European Association of Plastics Manufacturers, he has recently been appointed Chairman of CEFIC, the European Chemical Industry Council.

The need to honor the commitments to global environmental protection undertaken at the international level, expressly set out within the framework of the agreements signed in Paris in 2015 during COP21, has provided an impetus for the international community to adopt models of sustainable development. Progress towards this goal can no longer be delayed and is taking concrete shape through the choices being made by numerous countries, with Europe in the lead, to adhere to the principles of the Circular Economy. The theory underpinning this model is solid, well-known and widely accepted, and the time is ripe to put it into practice.

The Old Continent is playing a leading role in implementing the model, spearheading efforts to enable European citizens and businesses to reap its benefits in terms of new jobs, social policies, more sustainable consumer patterns and a healthier environment as soon as possible. Such ambitious goals, however, can only be achieved if there is a level playing field at the international level. Today's consumers are overwhelmed with statistics, particularly on the issue of plastic waste in our oceans. Magazines, documentaries, social media, TV and radio programs are constantly raising an alarm about the challenge that the world is facing. And yet the world's beaches are polluted by all kinds of waste, including drinks bottles, cans, and cigarette butts. That trash should end up in the sea because of a lack of public awareness or inadequate waste treatment is no longer acceptable. However, while the goals necessary to meet this challenge couldn't be clearer, the process to achieve them is slow and complex and, above all, requires commitment. It also involves adopting new mindsets, both within the industry and in social and individual consumer choices. With initiatives ranging from Earth Overshoot Day—the day of the year when humanity's ecological footprint exceeds the Earth's ability to regenerate its ecosystems—to climate change, and from marine pollution to waste management, the transition is inevitable, and what is required is a strategy that will completely rewrite the rules of the game.

Chemistry as a springboard for change

The chemical industry has all the means necessary to drive this transformation and play a leading role in providing innovative sustainable solutions, thus paving the way for the creation of a more circular economy on a global scale. The entire sector is a key player for a successful transition from the current linear model to an alternative economic and manufacturing system. In addition to being at the heart of almost every industrial supply chain and a driver of innovation, the chemical industry also plays a significant role in developing sustainable solutions that take into account environmental, economic and social aspects. In other words, it is a technology provider with the ability to develop new processes and products that will improve efficiency and circularity–elements which are crucial for competitiveness. The plastics industry in particular is already engaged in this new chal-→

> The chemical industry, at the basis of most industrial supply chains, is an essential player in the successful transition to a circular economy. The development of new recycling technologies, increasingly efficient products and the research for alternative feedstocks requires a continuous innovation process that draws on the experience acquired by the chemical sector over the years. At Versalis, we have embraced this challenge and started a deep transformation of our business model wherein we plan each product and process with its entire life cycle in mind in order to generate new and more sustainable solutions.

The company considers circularity as a strategic driver applied to processes and products at all stages of their life cycle. The three pillars of Versalis' strategy for circular economy are the diversification of feedstock, eco-design and the development of polymer recycling technologies.

The circular universe of Versalis

1

PRODUCT ECO-DESIGN

Development of integrated solutions aimed at improving the efficiency of resources throughout the life cycle and the recyclability of manufactured goods.

RECYCLABLE ARTIFICIAL TURF PROJECT

When it reaches its "end of life," artificial turf is thrown into landfills or incinerated. To increase its circularity, Versalis is sponsoring a project to develop fully-recyclable artificial turf, with the entire chain made up of Italian companies: Versalis, as the supplier of the raw material (polyethylene), Radici Group, as the fabric manufacturer, and Safitex as the mat manufacturer (Eco Next).

This artificial turf mat can be recycled or reused as a secondary raw material in industries requiring high standards of quality. All companies involved have obtained the Product Environmental Footprint (PEF) certification and are currently being assessed for the "Made Green in Italy" scheme.

2

DIVERSIFICATION OF FEEDSTOCK

Feedstock diversification projects for products and packaging made from renewable sources and/or secondary raw materials.

MANUFACTURE OF THERMAL INSULATION SLABS FROM RECYCLED PLASTICS

Versalis has successfully simulated the use of 20 percent of the product derived from post-consumer polystyrene packaging in its Mantua pilot plants and has tested its use for the manufacture of expanded polystyrene slabs for thermal coating insulation. Therefore, it is now possible for single-use products essential to our basic daily lives to be converted after use into durable goods for energy efficiency.

BAG-TO-BAG, A PROJECT TO RECYCLE BAGS USED FOR PACKAGING OF VERSALIS PRODUCTS

In collaboration with others in the industry, Versalis is conducting tests aimed at recovering and recycling industrial bags used as packaging for Versalis products packaged on pallets, according to the circular "bag-to-bag" scheme. The new "green" bag will be produced using 50 percent of selected and verified renewed material, inserted in the central layer.

PLATFORMS FOR CHEMICALS FROM RENEWABLES

Versalis is currently involved in the development of platforms for chemicals from renewable sources.
In Porto Torres (Sardinia) with the Joint Venture Matrica, Versalis has created an innovative platform for chemicals from renewable sources to produce bio-intermediates for high-added value applications and in line with the circular economic model (e.g., paints and inks, bioplastics, bio-lubricants and bio-herbicides). Another chain is the production of natural rubber and resins from guayule, a plant indigenous to the Central American desert, as a sustainable alternative to Hevea Brasiliensis production. Versalis has recently signed an agreement with Bridgestone to create synergies and accelerate the development of the Guayule technology platform, using their pilot plant and farms in Arizona. Versalis is also working on the integration of the "bio" platform of the Mossi&Ghisolfi Group. The platform is based on Proesa® technology used to convert biomass into second-generation sugars and subsequently produce biofuels or, potentially, other biochemical intermediates. The industrial plant in Crescentino (Vicenza province) produces bio-ethanol and green electrical energy through the use of lignin, a by-product.

3

POLYMER RECYCLING

The company is involved in the development of technologies for physical and chemical recycling, focusing on synthetic polymers used, for example, for packaging and thermal insulation and on plasmix, plastic residues from post-consumer packaging generated during plastic recycling, residues which currently cannot be recycled using mechanical recycling systems. These technologies are developed by Versalis's R&D, in partnership and collaboration with associations and consortiums.

Versalis also forms part of "OPERATION CLEAN SWEEP," a voluntary international program designed to prevent and limit the loss of plastic granules in the environment along the entire value chain of manufacturers, processors, compounders, freighters and recyclers, a problem identified as one of the sources of marine plastic pollution.

lenge. Several existing "circular projects" are gathering momentum, while many further initiatives are currently under development in response to Europe's appeals. Transforming plastic waste into a precious resource is breathing new life into the industry and, what's more, new and increasingly sustainable products could be developed to cater to new market trends. In many cases, plastic materials are the best option in terms of overall environmental impact, but there is still considerable room for improvement through ecodesign for our products and innovative recycling technologies. If we are to achieve these goals and promote the transformation process instead of hindering it, lawmakers will have to do their share.

Circularity as a strategic factor for Versalis

The effort to achieve full circularity requires, first and foremost, a commitment to research and development across the chemical industry and along the entire supply chain in order to develop solutions with a lower environmental impact over the product's complete life cycle, as well as to design and employ new recycling technologies. With regards to recycling technologies, mechanical processes alone are not always sufficient to obtain materials with the same properties as virgin polymers. Hence, as an industry, we are developing new chemical de-polymerization processes for reclaiming monomers and thereby obtaining a secondary raw material with the same characteristics as the virgin material. Another important issue is raw material diversification, which enables us to exploit the full potential of renewable and secondary materials. As part of the circular economy approach, alternative raw materials now include post-consumer plastic in a growing trend. Versalis (Eni) can be seen as a good example of this approach. The company is developing a new business model in line with circular economy principles, and to this end, is also working in partnership with trade associations and the various players involved in waste collection and recycling activities, as well as technology and supply chain partners. Versalis views circularity as a strategic factor in its integrated approach and makes it a key part of its operations and medium- and long-term development plans. The relaunch plan we embarked on a few years ago has concentrated our attention on consolidation and growth, with a particular focus on research and development, technological innovation and international development. Today, that process has made the company more solid and more resilient to changing scenarios. It is now time to take up the circular economy challenge and make every effort to create new market opportunities. Our strategy for accomplishing this transition is built on three pillars:

1. development of solutions designed to improve resource efficiency over the full life cycle of the product and/or to facilitate the recycling of the product;
2. diversification of raw materials, exploring all the opportunities offered by renewable sources and secondary raw materials to employ in both our production processes and our product packaging and logistics, for example;
3. development of different polymer recycling technologies, including chemical, physical and mechanical recycling processes.

Concrete examples of how these strategies have translated into practice include a completely recyclable artificial turf, recycling of the industrial bags we use to package our products and the development of recycling technologies for post-consumer polystyrene products.

The value of partnership for successful projects

In addition to our research and development efforts, many projects involve partnerships and collaborations with a variety of stakeholders. This year, for example, alongside the other members of PlasticsEurope, the leading trade association of European plastics manufacturers, we have adopted "Plastics 2030," a commitment by the plastics industry to increasing circularity and resource efficiency. This is an ambitious initiative that aims to achieve high rates of reuse and recycling, set at 60 percent for plastics packaging by 2030, with the goal of reusing, recycling and/or recovering 100 percent of plastic packaging materials in the 28 European Union member states, Norway and Switzerland by 2040. To achieve these targets, PlasticsEurope has coordinated the establishment of the World Plastics Council, the global forum of plastics manufacturers. The forum's main mission is a commitment to finding solutions to the problem of waste loss into the world's oceans and improving the management of plastic products' end-of-life stage. Versalis and many other players in the plastics industry have also signed up to Operation Clean Sweep®, a voluntary international program that provides a set of guidelines and initiatives to limit the discharge of plastic pellets into the environment at every stage of the value chain.

Biofuels/A pillar of the energy transition

Closing the Loop

Ideal support to the move to a circular economy, biofuels make the most of existing feedstocks and technologies and link the traditional energy sector with bio-based industries such as food and organic waste processing. However, innovation has a price and policy support is indispensable



HUGHES BELIN

A journalist on energy and climate issues for twenty years, he has been Brussels correspondent for various energy media such as Platts, Enerpresse, Energy Post and energy reporter at EU policy broadcaster ViEUws.eu. He was awarded the 2007 Louise Weiss Prize for European Journalism.

All energy transition scenarios agree that one of the biggest challenges is the transport sector, as it accounts for a quarter of global greenhouse gas emissions and they are growing. Worse, the number of cars on the roads is rising exponentially. According to Morgan Stanley Research, economic growth in developing countries could double the number of passenger cars from one to two billion in just a few decades. In spite of India's Paris climate pledge to reduce its carbon intensity by 33 to 35 percent by 2030 compared to 2005 levels, its CO_2 emissions grew by 4.6 percent last year. In 2017, vehicle sales hit a record four million units in India, the largest car market in Asia Pacific. It's a trend confirmed by the International Energy Agency (IEA), which foresees a doubling of the number of cars globally by 2030.

Can electrification solve the problem? The number of electric vehicles and hybrids sold sees double-digit growth every year. According to the latest edition of the IEA's Global Electric Vehicles Outlook, the number of electric and plug-in hybrids on the world's roads exceeded three million in 2017, a 54 percent increase compared with 2016. Based on current and planned policies, the IEA scenarios foresee 125 million units on the road by 2030, up to 220 million if policy ambitions rise. But it's not enough—or fast enough—to meet the goals of the Paris Climate Agreement. The European electricity association Eurelectric recently presented a new study that suggests virtually all cars would need to be electric in 2050 for a 95 percent E.U.-wide emissions reduction target. This would not only require big changes in driving habits, such as the widespread adoption of shared mobility and the development of autonomous driving, but also a drastic halving of the size of today's total vehicle fleet.

"You have to decarbonize the existing fleet," says Nour Amrani, Public Affairs Senior Manager at Novozymes. So electrification is necessary but not sufficient or fast enough to decarbonize the transport sector. "It's the most difficult of all sectors because you have to decarbonize vehicles, fuels and infrastructure at the same time," sums up Valérie Corre, Director for E.U. Public Affairs ethanol/alcohol at Tereos, a French sugar producer. Liquid fuels will have a big role to play.

Help wanted

"For this to happen you need policy support," says Amrani. Corre concurs saying "Everywhere in the world where you have a market for biofuels, there are regulations backing it." She recalls that In the 1970s, Brazil supported sugar cane-based bioethanol production to fight starvation in the countryside by creating jobs. And the U.S. bioeconomy has been thriving for more than 15 years, thanks to the support of the U.S. Department of Agriculture's BioPreferred® program, which replaces more than one billion liters of petroleum annually, contributing USD 370 billion to the U.S. economy and reducing emissions the equivalent of 200,000 cars.

The E.U., which has been at the forefront of global energy transition, has recently reviewed its legal framework to support renewable energy sources including biofuels over the next decade. For the first time it has introduced a mandate for advanced biofuels to become 3.5 percent of the market while capping first generation biofuels at 7 percent. These developments are within the context of an overall goal of 14 percent renewables in transport by 2030, up from half that which exists in the E.U. today. At the national level governments can promote blends such as E10, 10 percent of biofuel incorporated into conven-



CREATING CONNECTIONS
In addition to fully exploiting existing raw materials and technologies, biofuels create a connection between the traditional energy sector and bioindustries such as the food, agriculture and organic waste processing industry. The image shows a biogas production plant.



Advanced biofuels

The following describes in general terms some of the main types of advanced biofuels being developed globally.

- Typically they are biofuels produced by **advanced processes** from **non-food feedstocks** such as wastes, agriculture and forestry residues, energy crops and algae. **The end-product** may be equivalent to fuels produced by first generation technology (e.g., ethanol or FAME), or it may be a different type of advanced biofuel (e.g., BioDME or bio-kerosene). Generally, these "next generation" biofuels are considered **more sustainable** as the feedstock and processes used offer greater levels of greenhouse gas emission reductions and do not compete with food crops for land use.
- The term "advanced biofuels" is also applied to biofuels with **advanced properties**, such as hydrotreated vegetable oils (HVO), biopetroleum, biojet fuel and biobutanol. These **end-products** may be **more compatible** with existing fuel infrastructures or offer other technical benefits. However, biofuels with improved properties may be made from a range of feedstocks, including oil crops. Ultimately, the aim is to produce biofuels with advanced properties from sustainable feedstocks that do not compete with food production, or lead to loss of stored carbon through deforestation.

Source: ETIP Bioenergy

E.U. by 2030 to meet market demand in the energy sector.
Earlier E.U. initiatives started in 2012 with the first bioeconomy strategy, followed by a €3.7 billion public-private partnership called Bio-based-Industries Initiative in 2014, and a European Technology and Innovation Platform on bioenergy in 2016 to promote knowledge-transfer between all players at the European level.
The new E.U. rationale is holistic and acknowledges the link between biofuels and other sectors. It's about time. "The circular economy has become a vital model for us because of the end of sugar quotas in the E.U. in late 2017, thereby ending a price control system," Corre explains. "And the pressure on our business is exacerbated by international competition." The price of sugar has fallen, so more than ever companies need to maintain traditional and develop additional outlets to stay competitive. They need to extract more value from by-products and thus diversify. Oil refiners know the importance of extracting as much value as possible from the distillation of an oil barrel, until the last drop, as long as science and technology allows it. Welcome to the bioeconomy, where biofuels are not an isolated sector but an integral part of a resource-efficient economy.
European support for a bioeconomy—which will support agriculture at the same time—is vital. "Innovation is generated by demand. You need demand. You need a potential, because you have to invest in R&D first and it's expensive," Corre explains. Flexibility is at the core of a biorefinery business model. The output of biorefineries has to adapt to local feedstocks today and changing demand in the future. Amrani explains: "Biorefineries produce ethanol today—conventional or cellulosic—as well as co-products like animal feed and lignin which can be used for power generation. But over time, these processes can evolve to include other downstream processes that yield a variety of hydrocarbon fuels as well as feedstocks for chemicals and materials. This versatility gives the biorefinery its unique adaptability to future changes in demand." The Beta Renewables biorefinery project at Crescentino in Northern Italy was the first of its kind worldwide. Inaugurated in 2014, the USD 350-million investment aimed at producing bio-based products including biofuels from straw. It implemented the principle of the circular economy, where residues from one sector become raw material for another. This pioneer project was a test case for real-world biorefining. It acknowledged the need for an expensive pre-treatment of biomass and various challenges with supply flows. For example, biorefineries are typically located in the countryside and, unlike liquid fuels, biomass is light and of high volume, so the emissions from its transport need to be taken into account.

tional fuel, to boost the share of biofuels. Belgium, Finland, France, Germany and Sweden have typically done that. But for industry to accept the multi-hundred-million-Euro risk of building new biorefineries, you need much more than a biofuel mandate.

The "bottom of the barrel" principle

Bioenergy is Europe's largest renewable energy source and is expected to remain a vital component of the energy mix in 2030. Hence Europe has just refocused support for its bioeconomy in line with a renewed industrial policy, a circular economy action plan, and a clean energy strategy. It has launched a €100-million Circular Bioeconomy Investment Platform to support, amongst other things, the development of new biorefineries. According to E.U.-funded research 185 second generation ethanol and 50 jet fuel biorefineries need to be deployed in the

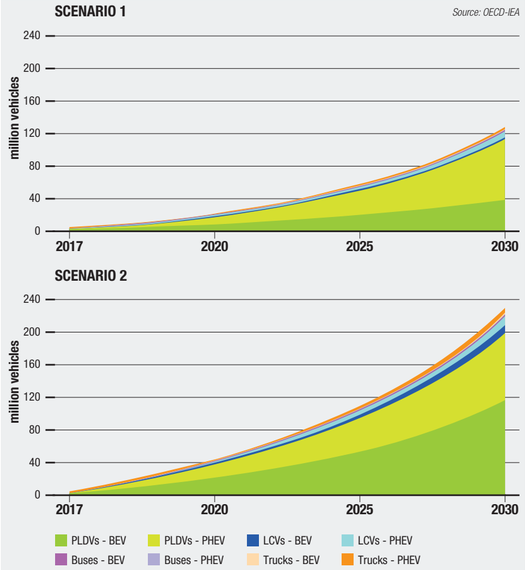
New projects

Today, the advanced biofuel sector is in a learning phase and some deployment is starting. A couple of advanced biofuels projects are underway in the world. A wood-based cellulosic ethanol plant should be completed this year in southern Finland by St1 Biofuels. The Finnish company also has projects to produce advanced ethanol from tall oil from pine trees in Sweden and from cassava waste in Thailand.
Several plants have been announced in southern and eastern Europe: Enviral/Clariant and Energochemica in Slovakia, Clariant in Romania and Ethanol Europe in Macedonia. These are likely to be operational in the early 2020s. In Brazil, Raízen, a Shell joint venture, has started to produce ethanol from bagasse in the São Paulo region. Meanwhile, ArcelorMittal steel mills in Ghent, Belgium will house an interesting new project, Steelanol, which will convert carbon-containing gas from its blast furnaces into bioethanol, through a partnership with Chicago-based LanzaTech. Commissioning and first production is expected by mid-2020. "This facility in Europe embodies the key principles of the circular economy and drives to a zero-waste steel production world," commented Jennifer Holmgren, CEO of LanzaTech. The project has received €10.2 million in funding from the E.U.'s Horizon 2020 research and innovation program towards an expected project cost of €14 million. It may not be a biorefinery exactly, but it is the circular economy in action.

A revolution for the oil sector

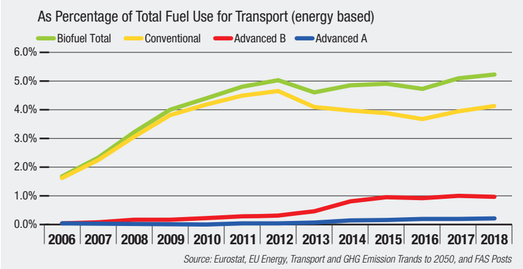
As we have seen above, the oil sector is part of some of the biorefinery investments. As Europe has embraced an economy-wide energy transition, its oil industry has responded with a strong commitment to embrace non-petroleum feedstocks, a revolution! In a "Vision 2050" roadmap, the European refining association Fuels Europe says it is wants to decarbonize through low-carbon liquid fuels. "The evolution of the E.U. refining system has already started," it claims. But to unlock investments in low-carbon technologies, "the policy framework should enable investors to be remunerated for their risk capital" with support similar to that received by renewable energy producers during the last almost 20 years. The industry also asks for a single carbon price across the whole economy and measures to safeguard its international competitiveness.
The oil industry has several examples of R&D projects that showcase different pathways to develop the next generation of advanced biofuels, for example, biofuel made from lignocellulosic biomass such as straw and forest residues through thermochemical conversion or third generation biofuels made from algae.
Another interesting development is taking place among European refiners, who have suffered 20 closures over the last ten years. Several refineries have been reconfigured into biorefineries and they produce a range of biofuels and other products from feedstocks such as vegetable oils, tallow, used cooking oil and oil from algae waste. Using existing techniques and infrastructure, this shift of production can avoid refinery closures, which would lead to heavy job losses. The biofuels produced in this way have a hydrocarbon structure similar to conventional fuels. In some cases, such as hydro-treated vegetable oils (HVO), they are of such high quality that they can be fully blended with conventional fuels like liquid petroleum gas (LPG), diesel, kerosene or gasoline.
One example is Eni's Venice Refinery. Here, Eni invested in an innovative Green Refinery project, which led to its transformation into a biorefinery able to produce a new generation of biofuels. The required investment was estimated at one-fifth of that needed for a completely new biorefining unit of the same capacity. Some of the equipment in the former plant could be reconfigured for the new process and the operational set-up was changed to create a new production route dedicated to biofuels. Since 2014, the biorefinery in Venice has processed around 360,000 tons of vegetable oil per year. This production level is scheduled to increase this year with a similar shift in operations at the Gela biorefinery. It will have the capacity to process about 720,000 tons of vegetable oil and produce 530,000 tons of green diesel a year.
In many ways, biofuels fit perfectly with the move to a circular economy. They make the most of existing feedstocks and technology and link the traditional energy sector with bio-based industries such as food, agriculture and organic waste processing. The result is a much needed reduction of emissions in the transport sector, and the creation of a core pillar of the circular economy. However, innovation has a price and policy support is indispensable. The scientific community has just told the world that there is no time to waste. Biofuels can help, as consumers have been using convenient liquid fuels for a century and expect them to be available, no matter what the fuel is made from.

GLOBAL EV DEPLOYMENT TO 2030 BY SCENARIO



Based on current and planned policies, the IEA scenarios foresee 125 million electric vehicles on the road by 2030 (scenario 1), up to 220 million if policy ambitions rise (scenario 2).

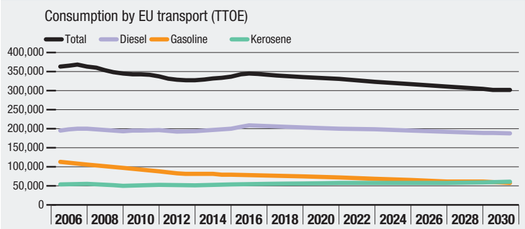
CONVENTIONAL AND ADVANCED BIOFUELS



Source: Eurostat, EU Energy, Transport and GHG Emission Trends to 2050, and FAS Posts

Blending of advanced (non-food based) biofuels is estimated at 1.2%: 0.1% of these is produced from waste fats and oils (B), and 0.2% is produced from agricultural and forestry by-products (A).

FOSSIL FUELS



Source: Eurostat, EU Energy, Transport and GHG Emission Trends to 2050, and FAS Posts

Both increased efficiency and electrification will reduce the use of gasoline significantly by 2030.



Carlo Ratti

Architect and engineer, he teaches at the Massachusetts Institute of Technology, in Boston where he leads the MIT SENSEable City Lab, a research group on the future design of urban centers. He is also the founding member of the international design and innovation firm Carlo Ratti Associati, based in Turin and with a second office in New York.



THE TROPICAL ECO-SKYSCRAPER
In Singapore the 280m tall high-rise on 88 Market Street, jointly designed by CRA-Carlo Ratti Associati and BIG-Bjarke Ingels Group, is an oasis in the bustling Central Business District (CBD) of the city. The new 93,000 SQM green skyscraper shows an interplay of orthogonal lines interweaved with tropical vegetation. It is also tech-integrated and includes the "office of the future."

Future/The circular urban planning of Carlo Ratti, the guru of sustainable architecture

Between the Physical and the Digital

To be "circular" big cities around the world need to prepare themselves to tackle a revolution driven by software and the rapid transfer of information. Less concrete, more data. Among other things, this transformation involves projects to improve energy efficiency through the tracking and recycling of waste



GIANCARLO STROCCHIA

Editor at World Energy (Eni), he has collaborated with newspapers like *La Voce* di Montanelli, Euronews, Rai Format. Has worked at the Department of Public Information of the United Nations in New York, where he dealt with corporate communication and CSR projects.

n the trade they are known as visionaries. They are all those—including scholars, scientists and urban planners–with the ability to anticipate global development paradigms, through which they are able to grasp the intrinsic spirit and reveal outcomes. These abilities, which we might call foresight, spring from factors such as passion, expertise, the capacity to interpret the future from the perspective of sustainability and a keen awareness of the ongoing transformation of society. Carlo Ratti, born in 1971, is one of these people. Trained as an architect and an engineer, but first and foremost a true citizen of the world, he studied in Milan, Paris and the United States, and now teaches at the Massachusetts Institute of Technology in Boston, where he directs MIT's SENSEable City Lab. This research group explores how technological advances can change the world, analyzing how the less tangible characteristics of the contemporary urban environment can radically transform the way in which cities are conceived and designed. Perhaps that is why he has embraced an expression voiced by the great American urban planner Lewis Mumford that goes something like this: "Forget about motor cars and build cities for lovers and friends."

Professor Ratti, are you among those who believe that the future of the world is circular and that we must inevitably abandon linear manufacturing systems?

The concept is not new; it appeared in the report "Our Common Future" published by the United Nations in 1987. But today it is increasingly relevant and key, and it has been interpreted in many different ways over the years, including by William McDonough's book *Cradle to Cradle*. As far as linear manufacturing systems are concerned, we don't have un- →

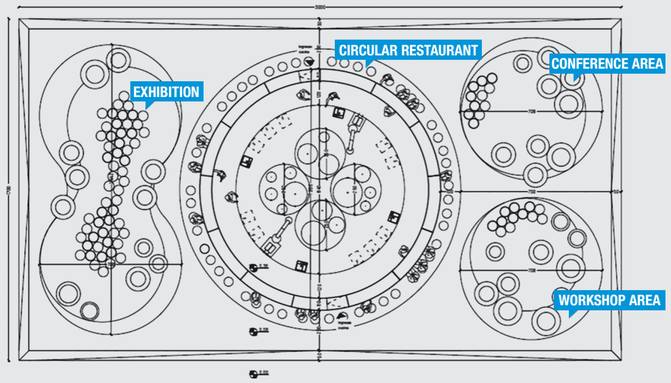


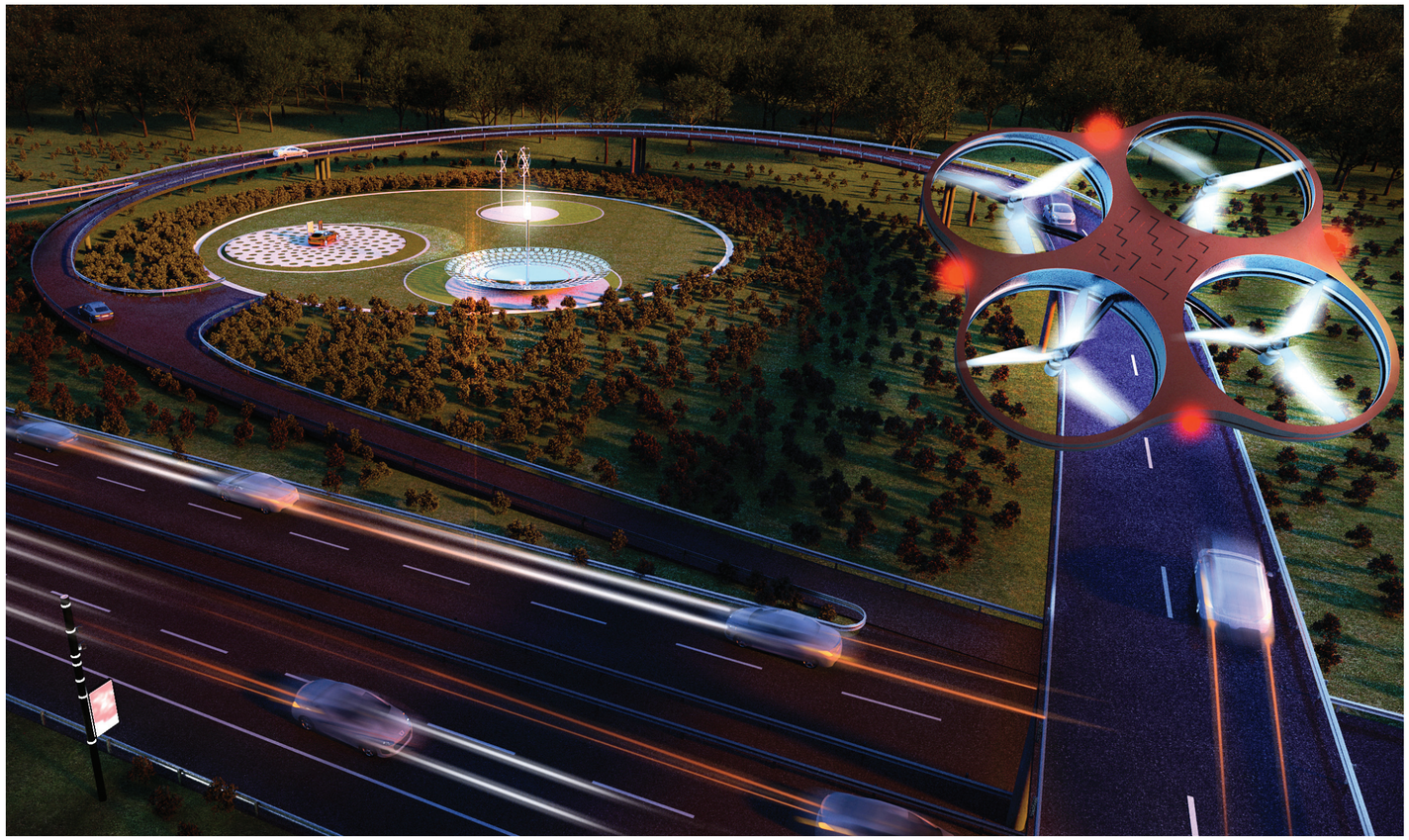




Feeding on Innovation with CircularEni

During the 2018 edition of Maker Faire, the event showcasing creative technology held in Rome on October 12-14, 2018, Eni illustrated its commitment to the circular economy by creating, with the contributions of the design firm Carlo Ratti Associati and others, the first circular restaurant, one that showed how an everyday gesture—correctly disposing of food waste—can become a concrete tool to reduce waste and generate new resources. Other features in Eni's 612 square meter stand included an installation with a visual representation of the company's approach to the circular economy, an area for talks and round-table discussions and laboratories for kids.





THE FUTURE HIGHWAYS
International design office CRA-Carlo Ratti Associati has been working with Italy's leading road agency ANAS to design a Smart Highway program that will be implemented on more than 2,500 kilometers of roads and highways. The project involves a pioneering infrastructure system featuring drones that are able to deliver first-aid support, as well as sensing poles that can send useful information to both today's drivers and tomorrow's self-driving vehicles.

limited resources available, and these sorts of systems are clearly unsustainable in the long run.

The global energy sector is reviewing its business models based on greater environmental sustainability. Do you believe we are on the right track to achieve a transition?

Yes, absolutely. Circularity in the energy sector must be at the heart of circularity as a whole.

What, in your view, are the guidelines that will be applied to future design and building criteria for urban infrastructure especially in terms of improving energy efficiency?

In the 19th century, urban infrastructure was made up of concrete and asphalt, whereas in the 21st century it will include silicon applied to data and information. It will be increasingly important to work on the boundary between the physical and digital world.

You are the Director of the MIT SENSEable City Lab in Boston. What technological and digital solutions are you working on, and which of these may have practical applications in the near future?

We are working with many technologies, some of which already have practical applications. More specifically, we are working in partnership with CRA (Carlo Ratti Associati) on studies and projects related to the Internet of Things (IoT), looking at the ways in which digital technologies are impacting space and deeply changing today's approaches to design. As an example, last year we remodeled the old headquarters of Fondazione Agnelli in Turin. We installed IoT sensors in the building, which can detect the location of occupants and monitor variables such as CO_2 levels. By interacting with a series of fans that can switch on and off as occupants move past or remain stationary in a given space, the system of sensors enables considerable energy savings.

What are the most rapidly expanding areas associated with sustainability and circular economy principles in your view? Self-driving vehicle systems? Waste recycling and reuse?

I can't make a ranking list, but waste recycling and reuse is crucial. At MIT in Boston, we have been working hard in recent years to "track" waste and get a better understanding of the waste disposal chains rather than the manufacturing supply chains. Recycling was also at the heart of the project we designed for the Eni stand at Maker Faire in Rome—a "Circular Restaurant" to experience the circular economy hands-on. In the restaurant, after eating fried foods or drinking smoothies, visitors become "virtuous actors" in the transformation cycle, participating in the industrial processes routinely adopted by Eni, recovering food waste, plastic tableware and even the waste oil used for frying, in order to give waste products a second life. The waste frying oil, for instance, is transformed into biodiesel. It's one way to sensitize everyone to good practices in the recycling of materials. Because the key to everything is "behavioral change" across society.

THE INTERNET OF THINGS
The image shows the historic headquarters of Fondazione Agnelli in Turin, renovated in 2017. The building was fitted with IoT sensors able to recognize users' geolocation and monitor variables such as temperature and CO_2 levels. With its system of fans that can be switched on and off based on the number of people walking through or stopping in a given area, the sensor system allows for significant energy savings.

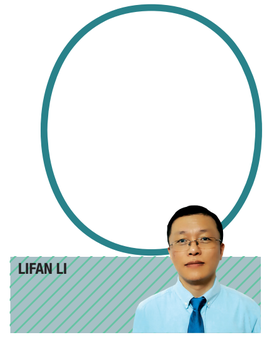




China/The energy sector's low-carbon transition

An Inevitable Choice

As early as 2005, Xi Jinping emphasized the strategic importance of developing a circular economy in order to meet the challenges of globalization. But the nation's path towards a sustainable system is strewn with challenges



LIFAN LI

He is Associate Researcher at the Shanghai Academy of Social Sciences and Secretary General of the Shanghai Center for Organization and Cooperation. Lifan Li was recently appointed as a member of the team of energy experts of the China Task Force of the Italian Ministry of Economic Development.

ECONOMIC GROWTH AND ENVIRONMENT

If China wants to maintain an average annual economic growth of 4-5% over the next 30 years, it will require reliable, cheap and clean energy resources. The economic benefits of energy transition are as important as its environmental benefits. The image shows Jing'an Park in Shanghai.

n June 22, 2005, Xi Jinping, then a leader of the Zhejiang Provincial Party Committee, stated that it is necessary to understand the strategic significance of developing a circular economy. He pointed out that the development of a circular economy is an inevitable choice for transforming the growth model, achieving sustainable development and is a key tool to meet the challenges of economic globalization and enhance international competitiveness. He proposed that China should develop renewable resource industries, strengthen resource recycling, adhere to scientific, technological and institutional innovation, improve the development level of a circular economy and promote the construction of a resource-saving and environment-friendly society.

Circular economy is the fundamental goal of a country's sustainable development. The green cycle and low-carbon transformation of the energy industry is the key to the sustainable development of China's economy and society. The rapid growth of the economy requires the support of cheap energy as well as the reduction of social burdens. Therefore, the transformation of energy structure must not only emphasize green but also economic benefits.

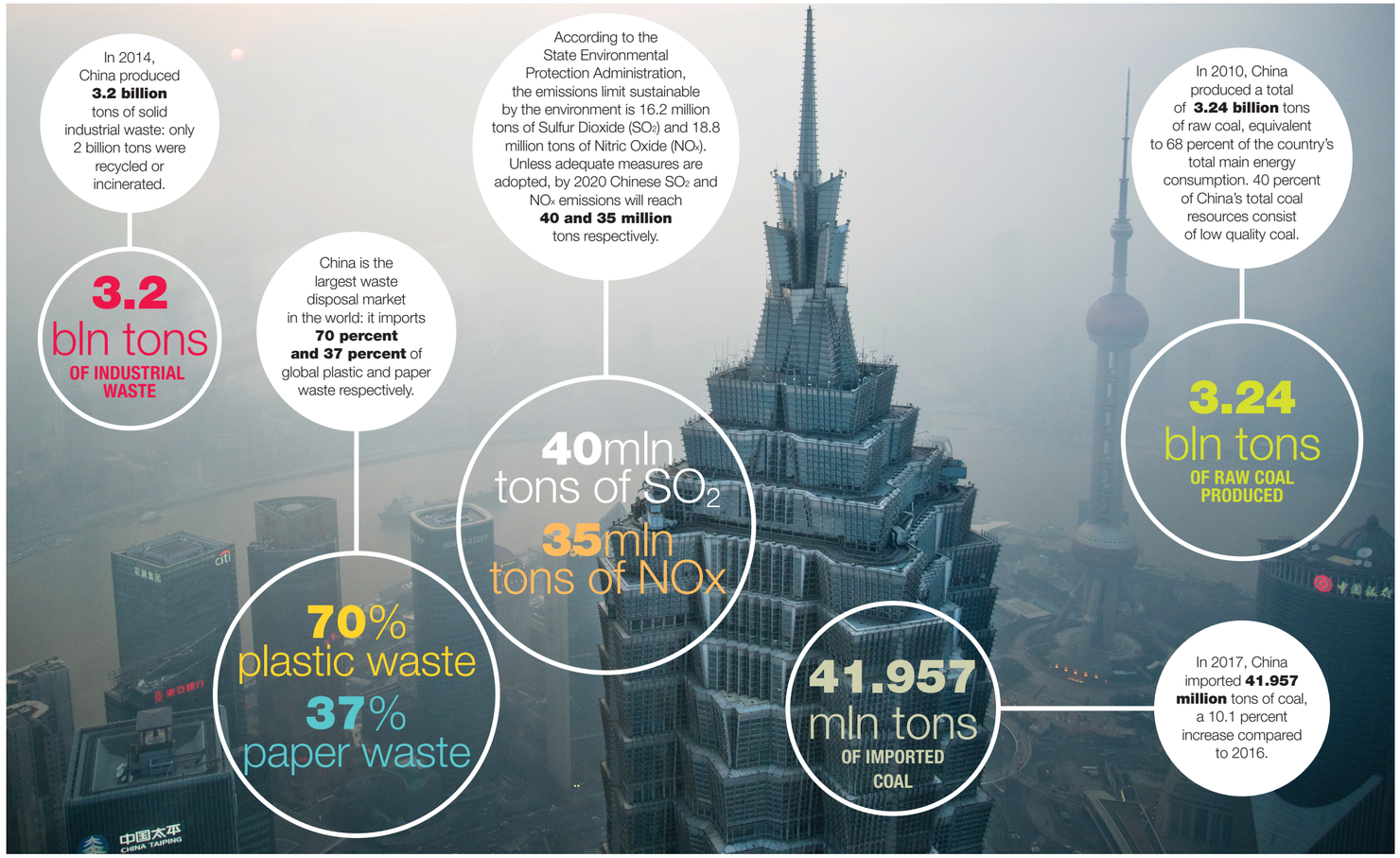
If China still needs to maintain an average annual economic growth rate of four to five percent over the next 30 years, the energy industry must be sufficient, safe, low-cost, and clean.

The impact of circular economy on China's development

As a major country in the production and processing of natural resources, China understands the serious consequences of disorderly resource extraction and excessive waste. In 2014, China produced 3.2 billion tons of industrial solid waste, of which only 2 billion tons were recycled or incinerated.

Meanwhile, China became the world's largest waste disposal market: its imports of waste plastics and waste paper account for 70 percent and 37 percent of the global total respectively. However, the Chinese government began to abandon imports in early 2018. The Chinese government promotes the development of circular economy by setting goals, introducing fiscal measures and enacting laws. China is one of the few countries that have formulated circular economy strategies and laws, and the "Twelfth Five-Year Plan" and "Thirteenth Five-Year Plan" have placed the concept of circular economy in a prominent position.

In addition, China is vigorously promoting the construction of the "Belt and Road." How circular economy →



fits with China's current international priority development strategy that includes the"Belt and Road Initiative" is an important issue. The long-term success of the "Belt and Road" initiative depends on whether China can share its vision and financing projects with its partners. One way to promote such cooperation may be to focus more on the development of a circular economy, a focus that will attract cooperative attitudes from economies like the E.U., ones that view the circular economy as a major priority.

Obstacles to the Dragon's energy transition

1 | Energy shortage and unreasonable structure. In 2009, China's total primary energy consumption exceeded three billion tons of standard coal, breaking the illusion of "doubling the energy by doubling the GDP in 2020 compared with 2000" at the beginning of this century; China's 2017 annual import volume of coal was 41.957 million tons, an increase of 10.1 percent compared with 2016. In 2010, China's primary energy consumption reached 3.25 billion tons of standard coal, as it surpassed the U.S. to become the world's leading consumer. Despite this, China's per capita energy consumption is still lower than the world average.

China is in the acceleration period of industrialization, and the contradiction between energy supply and demand is increasingly sharp. According to the current coal-led energy structure, China will face an energy gap of at least one billion tons of standard coal in 2020.

2 | China's energy market reform has not yet been completed, and the market mechanism has not yet been established. Taking the electricity market as an example, China has not yet established an independent dispatching mechanism; the market concentration in the provinces is high, and the barriers between provinces are strict and serious. In the oil sector, the upstream crude oil import channels have not been fully liberalized, the government's price control has long been ineffective, the retail market is highly oligopolistic, and State-Owned Enterprises (SOE) have sufficient space to exercise market power. In the field of natural gas, the competitive system is not in place, the problems caused by the dual price system are prominent, and the double-headed monopoly of urban gas is a serious problem.

3 | Environmental pollution has been caused by energy problems. China's coal-based energy production and consumption structure has seriously damaged the ecological environment. According to relevant research reports, China's air pollution is a soot-type pollution, 85 percent of SO_2, NO_x, and CO_2 emissions, and 70 percent of soot are derived from coal. China's 63.5 percent air environment is moderately or seriously polluted. The proportion of acid rain in southern cities accounts for 61.8 percent, and the national acid rain area accounts for a third of the country's land area. According to the calculation of the State Environmental Protection Administration, the upper limit of China's environmental capacity is as follows: SO_2 is 16.2 million tons, and nitrogen oxides are 18.8 million tons. If no effective measures are taken, by 2020, China's SO_2 and nitrogen oxide emissions will reach 40 million tons and 35 million tons respectively, greatly exceeding China's environmental capacity.

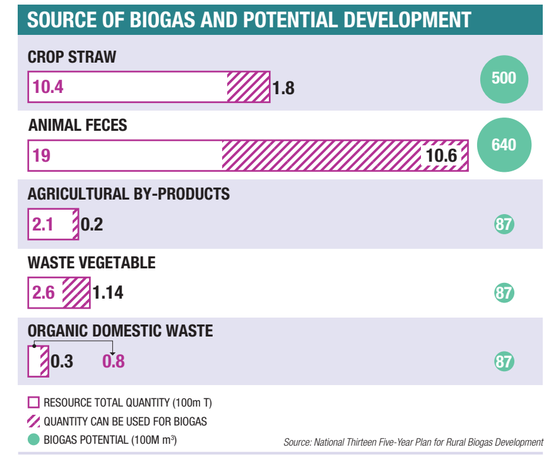
4 | China's energy policy system is not coordinated, and there is a lack of consistency in environmental protection policies. The anti-monopoly mechanism is still weak, the regulatory methods such as incentive supervision, share supervision, and supervision has not yet been established and the government departments have little ability to monitor and identify market forces.

At the level of natural monopoly regulation, power grid supervision has made progress, but the supervision tools are single, investment supervision is absent and the monopoly supervision of urban gas companies' pipe network is seriously underdeveloped. In terms of industrial policies, the government is still using compulsory means to distort the market, affecting the role of market pricing mechanisms and reducing the scale of market transactions. In terms of social policy, the issue of universal service financing will gradually emerge after the grid reform. The benefits of cross-subsidization are regressive, the efficiency loss is serious, and energy subsidies are obtained by high-income groups.

In the field of environmental and climate policy, China has adopted a market-distorting approach: the setting of environmental tax deviates from the principle of optimal taxation. The carbon market mechanism has not been fully established, and the price of pilot carbon trading is too low. More seriously, various energy policies are separated from each other, lacking synergies and there are situations in which policy effects offset each other.

5 | Energy technology innovation investment is not high and the ability in this area is not strong. It is generally believed that technological innovation depends primarily on the input of R&D.

In terms of indicators related to scientific and technological activities, the energy industry lags behind the national average. Energy company R&D funds accounted for only 0.25 percent of the main business income. Almost the lowest of all industries, it is far below the national average (0.71 percent). This shows that China's energy industry's technological innovation capability is not strong, and innovation investment is not high.



How does the energy industry transformation serve the green cycle and low carbon development?

1 | First, improve the efficiency of primary energy, and control pollution at the source. According to the forecast of energy demand and energy supply, coal will continue to be the main force in China's energy structure now and in the future (until 2050 or even later), and the absolute annual consumption of coal will continue to increase in the next two or three decades. The proportion in total energy should be gradually reduced. In 2010, China produced a total of 3.24 billion tons of raw coal, accounting for 68 percent of China's total primary energy consumption. Low-quality coal with high ash content, high sulfur content and high water content accounts for 40 percent of China's total coal resources, resulting in low overall coal use efficiency. The raw coal washing and selection process can control coal pollution at the source and reduce the desulfurization of power generation enterprises. And with the burden of dust removal, it is also possible to separate a large amount of coal gangue, which greatly reduces transportation costs.

2 | Second, improve the recycling and utilization of energy waste. According to statistical calculations, if the recovery rate and utilization efficiency of coal mines are increased by 10 percent, the amount of power generated by the extra coal resources will be able to exceed the power of dozens of Three Gorges and hundreds of times more than the currently operating nuclear power plants.

Permitting the use of "green" coal is one of the important strategies for China's energy structure green cycle and low carbon transformation.

3 | Third, improve the processing and conversion of biomass energy, for example, coal gangue power generation and urban waste power generation.

From the perspective of engineering planning, China is committed to the development of advanced biomass thermal power, which is called alcohol and electricity co-production, or alcohol electrification.

Biogas enters the circular economy system. Biogas is green and renewable gas that has been purified. According to the National Thirteen Five-Year Plan for Rural Biogas Development, China's national biogas production potential reached 122.7 billion cubic meters (bcm), while the production capacity in 2015 was 15.8 bcm, with a utilization rate of only 12.9 percent. In the future, the new investment in bio-natural gas will reach 120 billion RMB by 2020.

Conclusion

Circular economy is the only way to break through the bottleneck of the development of our country's energy industry. It should be said that the ability of a country to control and use energy and resources in today's society also represents, to a certain extent, the space in which the country develops in the economy and society.

You may have noticed when the "Kyoto Protocol" "Bali Agreement" and "Paris COP21" came out that the world's largest energy consumer is actually the largest carbon emitter, and the U.S. has no intention to implement these agreements. After Donald Trump took office, the U.S. abandoned its attitude toward climate change. In contrast, the E.U. and China have taken over the banner of energy and climate and explicitly proposed energy and climate policies. China's energy resource endowment is similar to that of the E.U., and its energy policy experience is worth learning. As a result, the energy market price will be raised, and the market space will be created for the development of renewable energy. Then, the market will choose the renewable energy varieties that meet the needs of China's energy market. The competitive renewable energy industry relies on solid market development.

Therefore, under the strategy of circular economy, China will accelerate the transformation of economic development mode, promote energy system mechanism innovation and energy technology innovation, accelerate the transformation of energy production and utilization methods, improve energy conversion and utilization efficiency, control energy consumption and build modern energy. The industrial system guarantees the sustainable development of the economy and society.

MARKET PERFORMANCE

Prepared by Anna Capalbo, Simona Serafini, and Francesca Vendrame - Eni

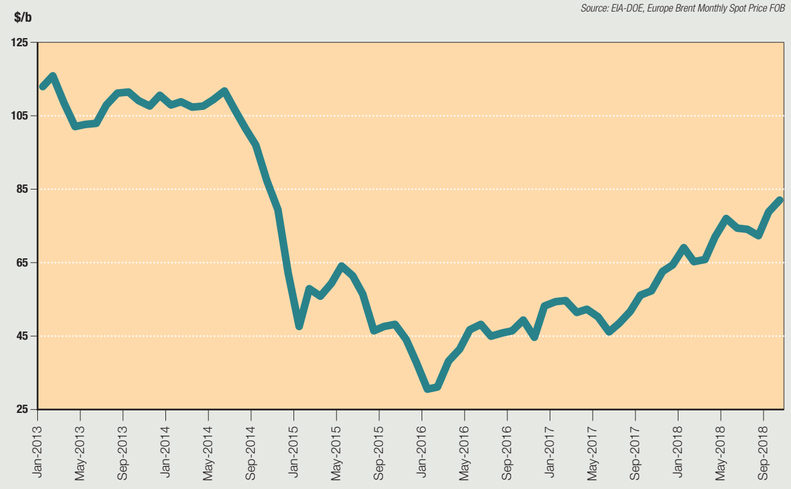
Economy and Iran: diverging risks

THE PRICE OF OIL

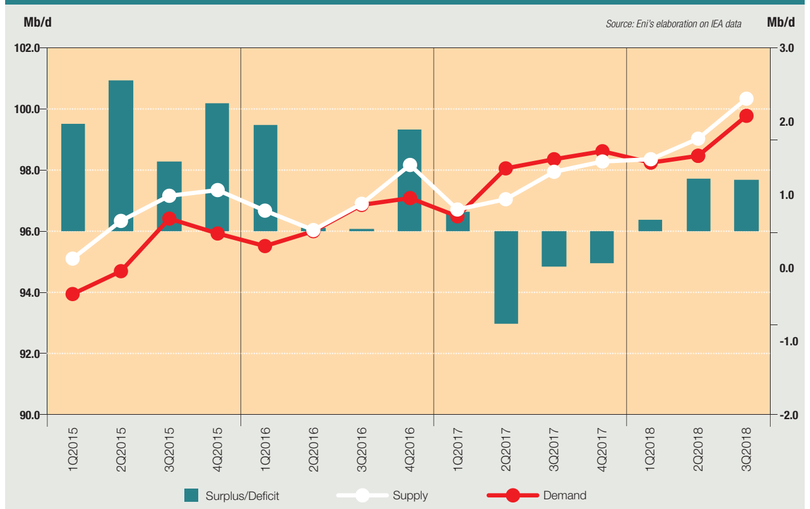
OPEC continues to guard against shortage and oversupply

At their June meeting, OPEC and non-OPEC producers agreed to return to 100 percent compliance, with an increase in production of between 0.8-1.0 Mb/d. The worsening crisis in Venezuela and the U.S. sanctions imposed on Iran gave rise to concerns of insufficient supply, against the backdrop of robust demand growth and the absorption of all surplus inventory. The price stabilized at over 70 $/b during the summer and then neared 80 $/b in September, when the risk of a shortage became more acute as Iranian crude oil purchases began to be cut back earlier and more deeply than expected. Iranian exports started to fall as early as September, declining by approximately 1 Mb/d from their April peak, and this decline also extended to unexpected countries such as China and India. Compared to one year earlier, Iran and Venezuela together withdrew more than 1 Mb/d of crude from the market, driving the other Gulf producers to compensate by stepping up production. However, outside the U.S. growth potential appears limited. Spare capacity has fallen from approximately 3 percent of global demand at the beginning of the year to just 2 percent at present. Saudi Arabia alone – which accounts for 60 percent of the world's spare capacity – saw its spare capacity drop to just 1.3 Mb/d in October. In October the risk of a shortage drove the price above even 85 $/b, and there were those who predicted levels in excess of 100 $/b due to the scarcity of new supply as a result of limited investments in recent years. The renewed risk of an economic slowdown reduced upwards pressure: concerns of the effects of the tariff war between the U.S. and China intensified, resulting in a downwards revision of global growth forecasts by the IMF and OECD. More moderately growing demand, constantly rising U.S. production and the recent increase in inventory put markets on alert due to fears of renewed oversupply. According to the IEA, the balance between supply and demand has remained in surplus territory in recent quarters, albeit to a modest degree. In any event, OPEC has promised careful monitoring to keep the market in balance: the Saudi minister stated that he was ready to cover geopolitical shortages, without losing sight of the inventory target.

BRENT PRICE



SUPPLY/DEMAND BALANCE

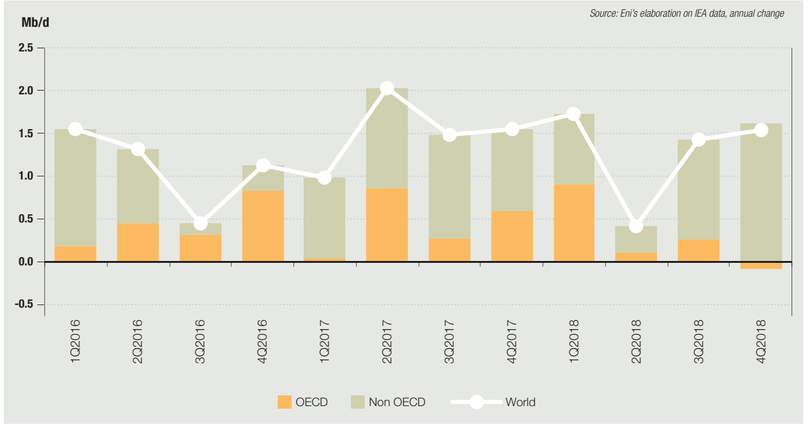


OIL DEMAND

Concerns surrounding emerging markets and the risks of a potential global recession are on the rise. In recent history, recessions have been the only factor capable of triggering a sharp drop in demand. Global growth is expected to come to +1.3 Mb/d in 2018, marking a slowdown compared with 2017 (+1.5 Mb/d) due to the higher price of oil and the weaker global economic scenario. The increase will be driven by the non-OECD area (+1 Mb/d). OECD countries will also contribute positively (+0.3 Mb/d), driven by North America only.

- **China and India** account for 60 percent of global growth. In China (+0.8 Mb/d), economic growth remains solid, despite the trade conflict with the U.S. and slowing credit policies. In India (+0.2 Mb/d), demand is being driven by the civilian sector and booming aviation industry. However, gasoline and diesel consumption is weaker, held back by the sharp increases in end prices, due to both the depreciation of the local currency and higher international prices. In October, the government decided to cut end prices to compensate for recent increases.
- In **North America**, demand is rising due to the start-up of new petrochemical capacity and a robust industrial production performance, driving commercial road haulage. Gasoline demand remains near 2017 levels due to the higher prices at the pump.
- In **Europe**, demand is falling after three years of increases. Diesel consumption was particularly weak as a result of the decline in diesel auto sales. The phenomenon of disaffection with diesel cars is most pronounced in England and Germany, due to rising concerns of air pollution and the declining value of diesel vehicles on the used car market.

OIL DEMAND (YEAR-ON-YEAR CHANGE)

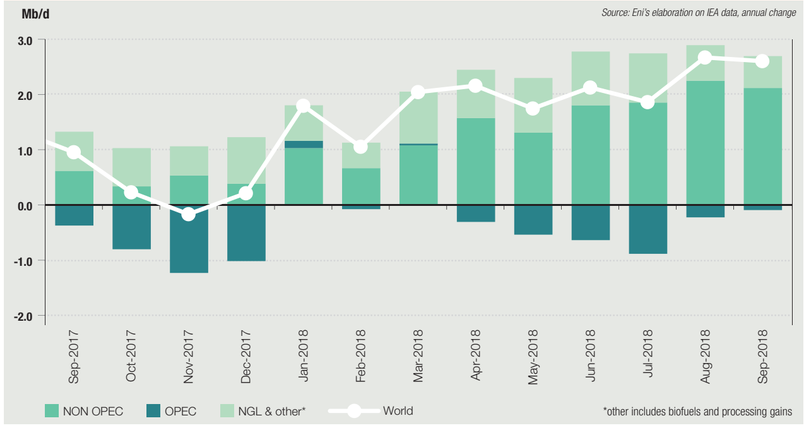


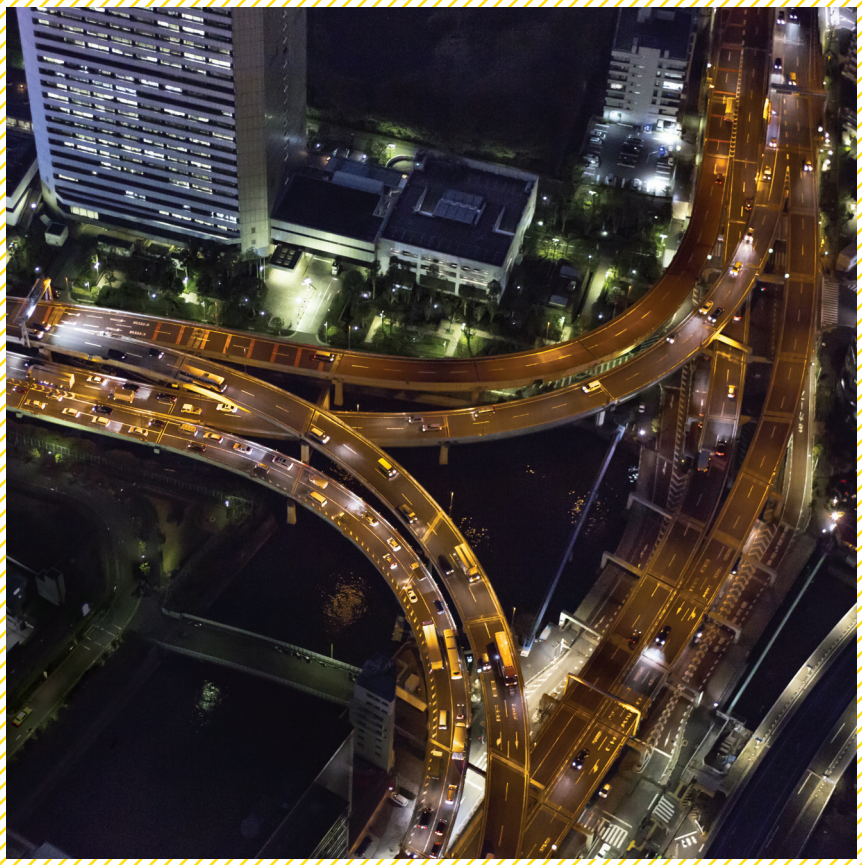
OIL SUPPLY

All eyes are turned to OPEC's reactions to possible shortages, on the one side, and the risk of a return to oversupply. A lack of investments is impeding growth, with the exception of the U.S. with tight oil, while at the same time Russia and Saudi Arabia are seeking to maintain control of the market.

- **OPEC.** Production continued to fall, penalized by the crisis in Venezuela, which has halved production since the beginning of 2016, and the cut-backs by Iran, which came before the official entry into force of the sanctions. The other Persian Gulf countries grew, reaching their highest levels since the end of 2016. Saudi Arabia reached 10.5 Mb/d in September, guaranteeing production at the limits of its capacity (12 Mb/d). In Iraq, increases in Kurdistan pushed production to 4.6 Mb/d. The UAE and Kuwait also posted increases. Libya and Nigeria remained essentially stable.
- **Non-OPEC.** The pace of growth picked up, led by the U.S. production reached nearly 11 Mb/d, with robust rates, particularly in the Permian. After setting aside its policy of cutting production, Russia climbed back above 11 Mb/d, and the Russian minister has promised an increase of 0.2-0.3 Mb/d in 2019. Canada remained at high levels (4.2 Mb/d), setting a record in August, while Mexico and China continued to decline.
- **Inventory.** Levels rose slightly, while remaining above the average for the past five years. At the end of August, OECD commercial inventories reached their highest levels since February, with an increase in refined products in particular, in keeping with the seasonal effect and the high refinery processing level, whereas crude stocks fell. The mid-October U.S. data point to an increase in crude levels as well.
- **Financial markets.** Following the exceptional long exposure to oil at the beginning of the year, financial operators have pared back their positions, in keeping with weaker global markets tied to heightened concerns of slowing economic growth. However, the volumes held by money-managers on the London and New York exchanges remained high.

OIL SUPPLY (YEAR-ON-YEAR CHANGE)





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