White paper
Scientific Community

Circular economy, your digital path

How digital enables the transformation into the sustainable circular economy

Thought Leadership

Atos

Executive summary

This paper examines the principles of the circular economy and technological trends that could enable it. The study proposes a digital model for the circular economy and details some technology driven business opportunities. Moreover, it reviews the necessary conditions for the circular economy 's implementation, including challenges and potential preclusions, and reflects on its governance. Finally, as digitalization is considered a springboard for the circular economy [1], the paper describes the technological building blocks, which could make it a reality.

[1] https://www.linkedin.com/pulse/fighting-climate-change-digitalization-thierry-breton

Table of contents

Introduction

A planet under growing stress, the impact on humanity

The current levels of resource consumption and exploitation in addition to expected increases in population, will likely lead to an irreversible environmental stress for the planet. This will impact the availability of food, drinkable water, clean air, and many other resources, with dramatic consequences for citizens, businesses, and governments. Obtaining and paying for raw materials will become increasingly difficult (as they become progressively scarce), migrations and conflict will increase, and diseases will flourish. Our current mass production model, designed to meet a globalized economy is a factor of increasing pressure on resources, with adverse effects on health and biodiversity.

Different sources[2] estimate that the planet's current population of 7.3 billion could grow to between 9 and 12 billion within the century with about half located in Africa. If the current resource consumption model continues, the estimated stress on the planet's resources will become critical. Some studies indicate that by 2030, the population will require the resources of 2.1 planets and 2.9 by 2050[3].

Such consumption will put unprecedented pressure on natural resources, with an estimated increase of 55% in domestic water use, 400% in manufacturing, and more than 130% in electricity generation. Population growth will also increase energy use by 80%, with fossil fuels providing 85% of that energy, further exacerbating climate change as more greenhouse gases are released into the environment[4].

Considering all the factors and trends, the outlook is extremely challenging. Such linear growth models are likely to drive humanity beyond a point of sustainability within the lifetime of our children.

The circular economy opens up new prospects

The concept of a "Circular economy" has been around since the 1970s. Its conception was triggered initially by the high price of resources, and increasing dependency on countries that held them, which created a significant, global economic impact and thus caused alarm. Since then, the concept has gained momentum, paving the way for different movements pushing for real change in current economic models and industrial processes. One example is the circular economy package[5] adopted by the European Commission. However, our world economy is only 9.1% circular, leaving a massive "Circularity Gap"[6].

We have a perfect storm for change: technology is available, society is in a transition phase, and there are clear economic and business opportunities to seize. In addition, society's consumption pattern is already changing dramatically, from a consumption model to a sharing model, stimulated by the arrival of a digital age enabling the pooling of resources and the provision of services on demand.

Moving toward a circular model implies radical changes

Moving to a circular economy will only be possible with the continuation of the radical change in current economic and production models. A further transition from a linear consumption model (where resources are extracted, transformed, used and discarded) into a sustainable model (the circular economy which consists of a closed loop based on the 7Rs: Reduce, Reuse, Renew, Repair, Recycle, Recover and Redesign) is necessary. Businesses in general – and manufacturers in particular – will need to find ways to increase production while using significantly fewer non-renewable resources, noting that at the same time, natural resources will become scarcer and more expensive.

---

2 United Nations http://www.un.org/en/index.html ; World Bank http://www.worldbank.org/
3 WWF, 2012
4 OCDE 2012
5 European Commission https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/towards-circular-economy_en
6 The circularity Gap report, 2018 https://docs.wixstatic.com/ugd/ad6e59_c497492e589c4307987017f04d7af864.pdf

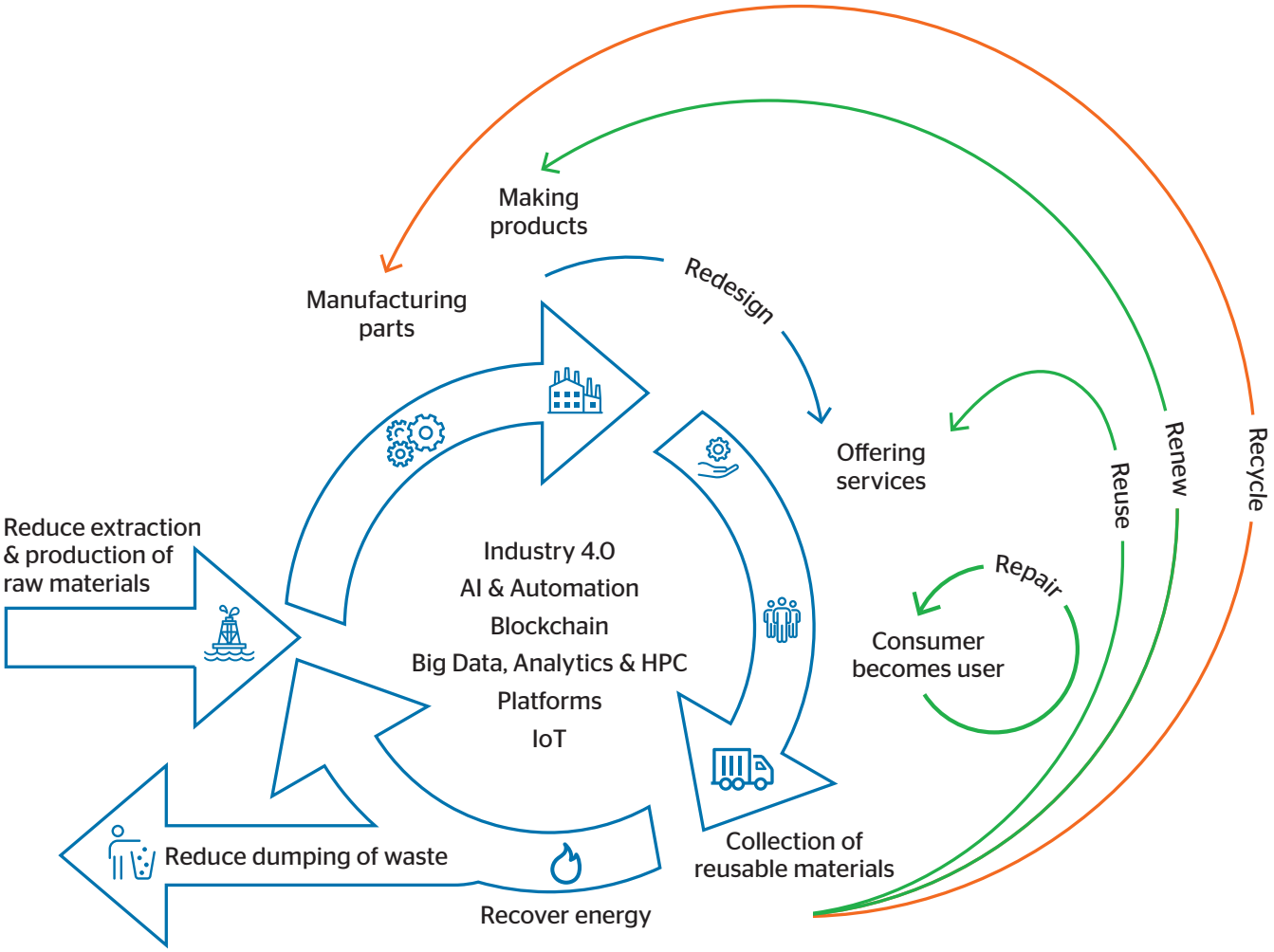

Figure 1 - Cycles within the circular economy

In the circular economy, products are designed to minimize reliance on non-renewable resources taking a holistic view of both the supply and value chain, to maximize the lifespan of a product, its components, reusability, and lifetime efficiency. Circular economy concerns the design, manufacturing, delivery, and reuse of products in ways that are efficient, cost effective and sustainable both economically and environmentally. There are many implications from the circular economy, such as the question of tooling to be used to achieve this, the change management to modify cultural habits of consumption, the required governance to implement a new global model, and the adoption of new common metrics to be deployed.

Of course, moving to a circular economy means current companies could close, some existing jobs could disappear and mass industrial reinvention will be required in many areas. However, there are also positive implications for growth, the emergence of different industries and innovative business opportunities, and the creation of new jobs.

The circular economy: overview

The circular economy encompasses several business models all based on a common theme: minimize consumption and waste whilst maximizing utilization and value.

The three main principles of the circular economy are[7]:

- Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.
- Optimize resource yields by circulating products, components, and materials.
- Foster system effectiveness by revealing and designing out negative externalities[8].

These principles can be simplified and translated into:

- High efficiency of resource management (extraction, storage, distribution and consumption).
- Energy must come from sustainable sources (solar, wind, hydro and biomass to a certain extent) – specifically waste is used to generate energy or as raw material for other processes.
- Prices or other feedback mechanisms must reflect real costs (including negative externalities).
- Sustainability challenges are at the core of the circular economy's principles; they include climate change, environmental pollution and resource depletion, human health and geopolitical security, but are also closely connected to economic and social development.

Resilience is at the core of circular business models

The circular economy is an alternative to the standard concept of "selling more = more income"; it is a new economic model providing benefit for society as a whole[9], with better:

- Economic development: acceleration of growth, including job creation, from new products and services.
- Performance reinforced: cost reduction in production, mitigation of price volatility (market stability) and minimization of resource dependency and risk of supply:
  - Risk mitigation: control of negative externalities (carbon-dioxide emission and environmental pollution) preserving earth, biodiversity and humanity from high risks.
  - Environment preservation: conservation of resources (energy, raw materials) allowing us to project ourselves into a more stable and sustainable future .
  - Social wellbeing: improved access to resources/products at affordable prices (from ownership to a sharing economy model) in a more respectful environment.

> The Blue Economy principles "*Invest less, innovate more, generate multiple cash flow, create jobs, build up social capital, stimulate entrepreneurship*".
>
> Dr. Gunter Pauli

Value creation in the circular economy

Following the World Economic Forum's work[10], there are several methods for generating value from this new model regarding the use and consumption of materials, as presented in the diagrams below.

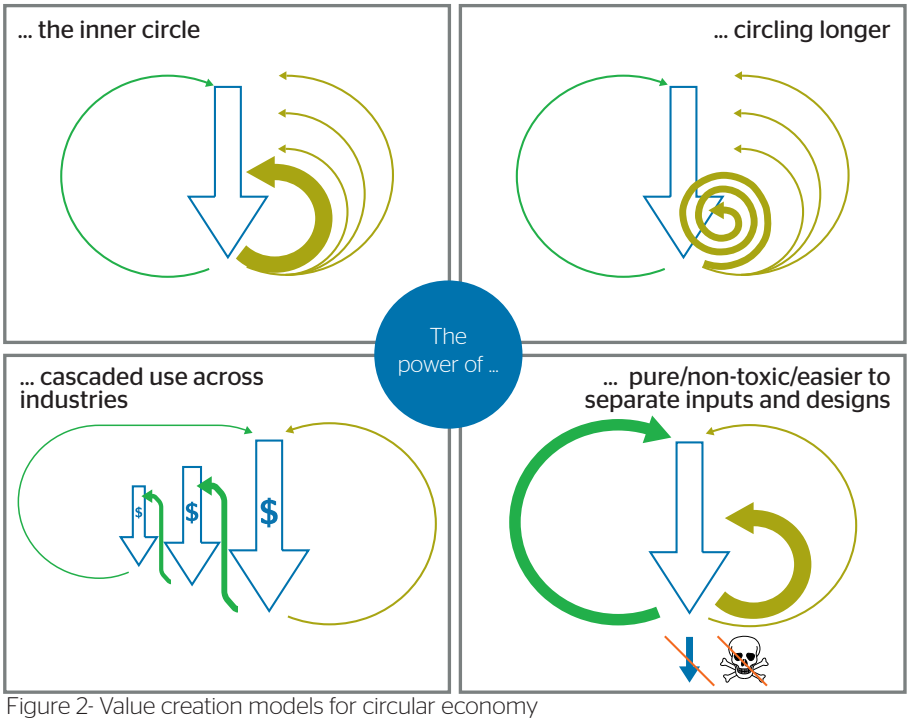

Figure 2- Value creation models for circular economy
Source: Ellen MacArthur Foundation circular economy team[11]

7 Intelligent assets: Unlocking the circular economy Potential. Ellen McArthur Foundation
8 Ellen Macarthur Foundation, circular economy principles
9 Gunter Pauli, The Blue Economy: http://www.worldacademy.org/files/Blue%20Economy%202009.pdf
10 http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply chains/from-linear-to-circular-accelerating-a-proven-concept/
11 https://www.ellenmacarthurfoundation.org

In a circular economy, the **inner circle** aims to minimize the use of materials in the linear production system, pushing for product and materials reuse. Smaller and incremental changes are required for greater savings. **Circling longer** refers to the maximum number of reuse cycles that a product can reach. The **cascade use across industries** illustrates the reuse of a product in different sectors. This also gives new value in other industries and reduces the generated waste.

Last, but not least, the power of pure inputs refers to the use of uncontaminated material streams to extend longevity and productivity. The combination of these four practices opens a new set of revenue models and business opportunities devoted to address the enhancement of economic models and driving the reinvention of current business models.

New business models can be seen within the circular economy paradigm, the most relevant of which are described below:

Circular supplies (or sustainable supply chain): this model is based on the use and reuse of resources to feed the next level of the chain, allowing businesses to integrate fully renewable, recyclable, or biodegradable materials in their commercial processes. The careful and sustainable consumption of finite resources is critical, and therefore this model is necessary to minimize and ration resources and energy consumption.	BMW claims that it can recover 95% of the material that goes into the i3 model. Apple created Liam, a line of robots that can disassemble the iPhone 6, sorting its high-value components and reducing the need to mine further natural resources. With two Liam lines, up and running, Apple can take apart up to 2.4 million phones a year.
Eco-design: this model is focused on designing products with a special focus on environmental impact during a product's lifecycle. This model aims to reinforce the circular model from the beginning.	GREENSPECTOR is a solution to eco-design software. It is designed to support developers in improving performance and reducing battery consumption of applications.
Product life-extension: instead of current planned obsolescence models, future models should push toward product life-extension and designed reuse addressing how businesses can profitably manufacture or use longer-lasting products.	The Fairphone is a modular mobile phone. It is designed to last longer by focusing on modularity and spare parts (making it easy to repair). Additionally, it uses open-source software that helps ensure the phone can be maintained in the long-term.
Resource recovery and recycling: one of the key principles of the circular economy is the use of waste as energy or raw materials, affording new market niches and opportunities.	Suez uses the energy in wastewater treatment networks to produce ecological heat. By producing green energy, the solution cuts greenhouse gas emissions by 50% to 70% compared with traditional thermal solutions. It also helps to conserve natural resources by reducing the consumption of non-renewable energy by 30% to 60%.
Product as a service: rather than purchasing and at some point, disposing of a product, consumers will purchase the outcome. This allows for building strategies to reuse, repair and replace a used product, increasing the reuse and recycling of components and materials.	Autolib' is an electric car sharing service available in Paris. The scheme maintains a fleet of all-electric vehicles for public use on a subscription basis, employing a citywide network of parking and charging stations.
Industrial and territorial ecology: Also, known as industrial symbiosis, this model describes a mode of inter-company organization based on exchanges of flows or a mutualization of needs.	Timberland and Omni United have teamed up to produce a line of tires designed to be recycled into footwear once they reach end-of-life on the road.

Digital as an enabler of the circular economy

Moving to the circular economy requires a redesign of the current value chains, focusing not just on adding value for the next step in the chain, but rather the whole from resource extraction and manufacturing to end of life. This requires well defined feedback loops across the entire value chain to offer the information required by each participant at each stage. Established attitudes and business models must change at all stages of the product value chain.

From a governance point of view, we must take a global perspective of the economic cycle. Digital technology becomes essential: both to map, organize, control and ensure consistency throughout the chain. Operationally, this is expected to have a profound impact on all levels of the chain, through new deep interactions and new interdependencies between the manufacturing, distribution and consumer ecosystems.

To better understand the nature of the changes and the role of technology as an enabler, a closer look at a potential digital model for the circular economy is necessary.

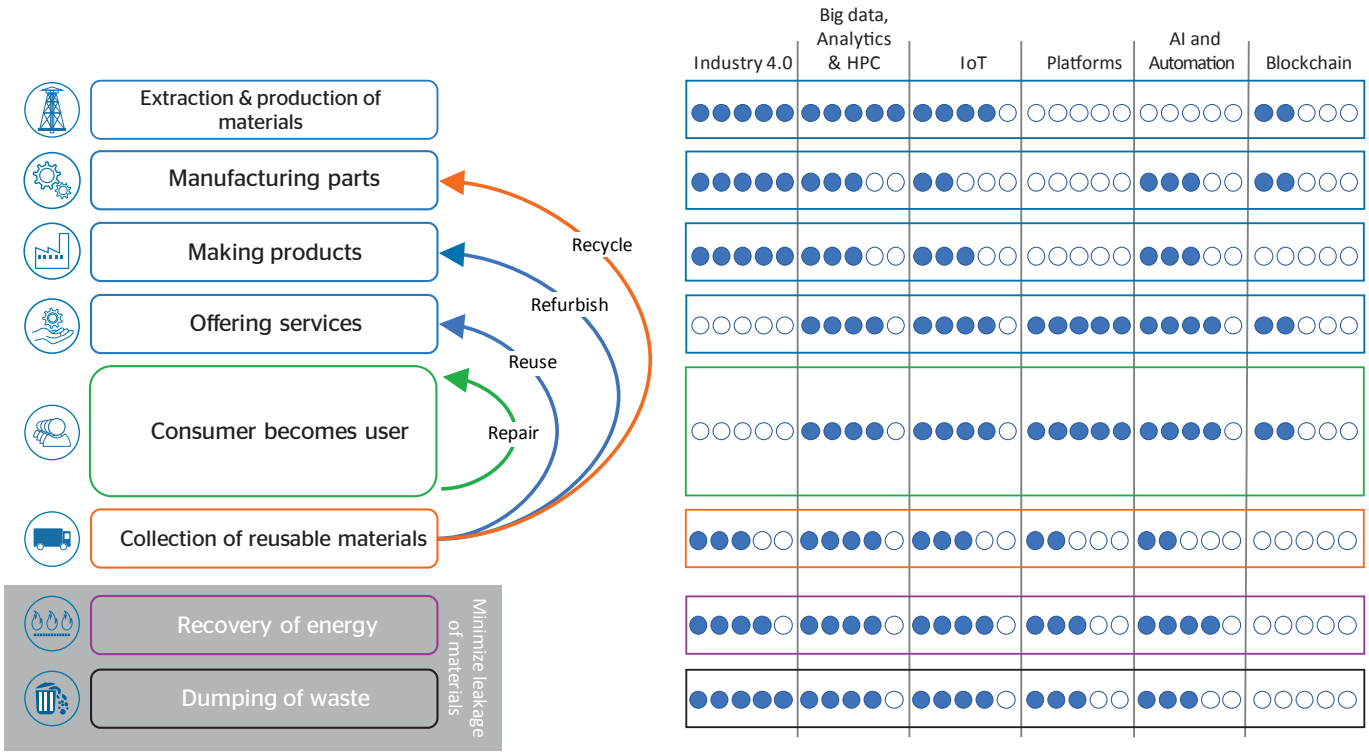

Figure 3 - Circular economy digital model (Industry example)

Figure 3 above maps the product lifecycle in the circular economy to the relevant digital enablers. Technological pillars on the right are explained in more detail in the upcoming section. The circles represent how the technology supports or enables the concrete step: from five blue circles which indicates this is a key pillar to zero blue circles meaning that, in principle there is no major value. The left side shows the main steps of a product lifecycle.

Now let's explore this in more detail:

- Consumption of raw materials must be minimized and be substituted by materials with low environmental impact known as "green materials" (natural capital preservation). Industry 4.0 with 3D printing as the flagship allows for not only reducing the volume of raw materials used (on demand personalized production) and waste, but also it allows reusing the materials in new components.
- Product design has to support extended product life and product-as-a-service models. In addition to integrating eco-design upstream processes, this requires designs for remanufacturing and support of predictive maintenance models to eliminate malfunction and waste during operation. Big Data, analytics and High Performance Computing (HPC) are technologies which can make scaled predictive maintenance a reality.
- Products should be designed to enable a sharing business model (product-as-a-service) which is also potentially more cost effective. Data platforms and blockchain can connect all parties to a common model in this case.
- To further support the product-as-a-service model, design should allow easy personalization (mass customization versus mass standardization).

> Digital technology is critical to the circular economy concept both to map, organize, control and ensure consistency all along the chain.

Furthermore, it should be designed for continuous improvement and zero fail service (zero default standard). This can be done through a connected flow, allowing for feedback data to be used to improve the design and efficiency of a product and provide predictive analytics.

- Products should enable the easy and efficient recycling of all parts without environmental contamination (cradle to cradle concept). The use of Industry 4.0 technologies together with the predictive maintenance tools provided by big data and also the use of AI and automation are extremely relevant to improve this critical section of the production chain.
- The product and manufacturing must be efficient and sustainable by eliminating waste and the cost of non quality (negative externalities), while allowing for a collaborative, flexible, and responsive manufacturing process (industrial data platform model).

The traceability of products, spare and waste is crucial to monitor the cycle (type of usage, product status, CO2 footprint and geolocation) and control the end-to-end chain (materials flows, compliance of components and ownership). This will rely on IoT and big data analytics.

Industry 4.0 as an enabler of the circular economy

Industry 4.0 is the term given to the connecting of data, machines, people, and processes to deliver the next generation of manufacturing. By exploiting such mechanisms, manufacturing is moving toward a "servicized" business model, tending to replace a product by a service with "intelligence" embedded. This equipment will have to be designed taking into consideration the repair path and upgrade process to meet the users' expectations to get latest generation models (outstanding design and technology). As a result, the demand for spares and customized upgrades is expected to increase dramatically. This will probably drive a part of the need for "print on demand" parts and flexible manufacturing systems provided by industry 4.0.

The use of new materials with optimized obsolescence and smart materials (connected devices) able to communicate their identity, position, status and role (their role in the full product or indeed the supply chain) is part of the revolution brought by Industry 4.0 to support the switch to the circular economy . In this context, materials can be booked, stored and sent to the appropriate place for manufacture. Materials become an asset that can be tracked, managed, improved and reused. Ultimately, the material could become autonomous monitoring its own condition and call for maintenance (repair or replacement) before it fails and finally providing the information to be recycled. Indeed, when the IoT reaches maturity, interconnected devices on the global plant floor will be able to react autonomously to a broad range of events.

Factors such as direct fabrication close to the end customer and to the local ecosystem, new sustainable materials and products, as well as a move away from planned obsolescence toward designed reuse, repair, and recycling, all contribute to a more sustainable and effective manufacturing business. On the technical side, the world is seeing sweeping revolutions in robotics, 3D printing, nanotechnology, and artificial intelligence, which will likely continue to transform the factory ecosystem and the effects of consumption on our way of life.

In production, using fixed and programmable automation for batch control and robots and flexible automation will leverage quick changeovers. Automated assemblies and robots are now being used for material handling, assembly, and inspection.
As the world moves toward intelligent manufacturing – real-time based optimization throughout the entire value chain – with supply chains performing just-in-time deliveries, ever changing production lines need to be fully up-to-date. Moreover, power, cooling, heating, and other infrastructure should be automated to reconfigure themselves to the needs of production. Because Industry 4.0 is more flexible, easily reconfigurable and self-configurable, it should not only meet the demand in less time, but also optimize the manufacturing process in line with the requirements of the circular economy.

Big data, analytics and High Performance Computing

Predictive maintenance is a pillar of the circular economy. The lifecycles of products and assets must be extended to take advantage of reuse, reconfiguration, and repair with lower costs in terms of energy and materials. Most methods focus on the early detection of faults and preventing defects or failures.

In the future, production environments will be transformed into data-driven decision environments, where data from operations within (and outside of) an organization – such as product design and production, process, information, real-time data mining, and event and equipment monitoring – can be collected and used to aid and make quality decisions.

Internet of Things and connected objects

By 2022, the number of connected objects will reach an estimated 45 billion[12]. All those objects connected to the internet will generate €11 trillion[13] of new value and generating 44 zettabytes[14] of data.

IoT will enable and accelerate the circular economy in three principal ways. First, connected objects could make available the data to support market regulation by reporting on areas where participants are corrupt, such as illegal tree logging or diversion of waste. Secondly, connected objects can ensure that they perform optimally and minimize their power consumption or maintenance needs. Finally, they can be designed to minimize or at least record and optimize their environmental footprint.

12 Statista research, 2018
13 McKinsey, taken from Herman Gouverneur presentation to Atos Digital Experts group
14 IDC, Ibid

IoT is one of the key digital enablers of the circular economy. IoT allows the implementation of traceability and analytics systems[15] (using synthetic information from a large scale data analysis) but also automation of control systems which adjust their behavior autonomously based on information collected by a battery of sensors.

To be a power for good, supporting the circular economy rather than reinforcing the status quo, systems should:

- Use connected objects to report on the status of raw materials through the supply chain to reduce waste at the source and thus minimize primary production while ensuring that communities whose livelihood depends on their production are not disadvantaged.
- Report on the readiness of intermediate components increasing the accuracy of just in time or other lean manufacturing techniques and hence reduce waste.
- Help to drive moves from reactive to lower effort and cost preventative maintenance. For example, in smart cities, a cracked pipe can be detected and fixed with a weld rather than by digging up the road.
- Match supply to demand more precisely, for example, by facilitating secondary markets for waste products, such as unsold food in supermarkets, or chemical waste products, such as carbon dioxide for industrial baking soda[16].
- Generate data consistently so that downstream analytics can gain novel insights into ways to make the economy more efficient.
- Support location based waste tracking or reclaiming objects.

Of course, this will not be easy and will require time, political commitment and a clear business driver. Digital too will make possible the shift toward a circular economy model and could allow a large scale transformation. Greater innovation, better design, robust infrastructure, and alternative rewards are necessary for those who may be impacted, whether they are subsistence miners in the Democratic Republic of Congo or executives in the boardrooms of major mining companies.

Digital platforms

Organizations – mostly private but also some public – have begun to transition to a platform economy. In a traditional economy, value is created within a closed pipeline from commodities to end users (customers or citizens) via an enterprise and its subcontractors. In contrast, in a platform economy, value is created in an ecosystem of partners that share business and operational data in a controlled manner within a digital platform that connects demand and supply, enabling value to emerge from multiple points, more frequently, and closer to the needs of the customer. Industrial data platforms[17] are an example of such digital platforms.

These data sharing platforms enable informed and orchestrated supply chains, as well as the delivery of smart services and highly market reactive products. They can also provide abundant and timely streams of data along and across the supply and value chains, around the complete economy of data lifecycle[18], which could provide valuable insights when subject to real-time predictive or prescriptive analytics. Such analytics would further streamline processes, decrease materials use and waste, and identify where generated waste can be reused, diminish energy use, etc.

Data sharing platforms have already been included in businesses' digital transformations. If implemented and managed wisely, they could enable and accelerate the circular economy.

AI and automation

The circular economy requires the ability to create intelligent and connected end-to-end supply chains, from resource extraction to consumers, on platform ecosystems. Being able to make autonomous, intelligent and collaborative decisions considering the entire supplychain or cycle will support improved circular and sustainable behavior.

Cognitive capabilities and machine intelligence will allow comprehensive and dynamic automation and process optimization, complex decision making (including swarm behavior), prescriptive analytics and natural user interfaces for seamless engagement. These capabilities will become pervasive and ubiquitous as they are key drivers for IoT, Industry 4.0 and industrial data platforms. We might even see a circular cognitive architecture, with cognitive technologies, such as deep learning, at the core. As well as automated decision making AI and automation will improve communication and interaction among the autonomous devices, machines and various actors in the circular chain.

As stated in the Atos Journey 2022 description of 'Human centric AI' decision making will be highly distributed and pushed to the edge of the network. Whenever possible, intelligence will take place at object or machine level, to decrease latency and enable real-time responses. Intelligence and decision making will be escalated to higher levels only when they cannot possibly take place on site.

This type of intelligence represents the next step in automation, asset productivity, real-time decision making and, consequently, in the creation of new business models and business value. It will also establish a world whereby orchestration of ecosystems currently too complex to comprehend becomes normal and therefore drives positive externalities, and the interconnected nature of elements can therefore position themselves for reuse in an optimized fashion previously unimaginable.

Blockchain

Blockchain is a public ledger of verifiable and auditable transaction blocks. It is a promising technology because it enables the establishment of trust between essentially trustless transacting parties. It can play a fundamental role in a business ecosystem which shares sensitive data, removing boundaries of existing trust relations and potentially perform at much faster rates than the current norm. Such transactions will reach finer degrees of granularity and take place between connected objects and sensors.

---

15 http://www.mckinsey.com/industries/high-tech/our-insights/the-internet-of-things
16 http://www.bbc.co.uk/news/business-38391034
17 https://atos.net/content/dam/global/flipbooks/journey-2020/mobile/index.html#p=4
18 https://atos.net/content/dam/global/flipbooks/journey-2020/mobile/index.html#p=14

One key application of blockchain could be establishing smart contracts. Blockchain combined with microgrids provides an excellent example as to how digital technologies support the creation of a peer-to-peer marketplace for distribution networks and regulated markets. It allows the emergence of new individual players in the renewable energy market thus helping to meet local demand and simultaneously reducing over production of these resources. Blockchain technology could provide an opportunity to promote the circular economy and capitalize on the multitude of electricity micro-generators such as homes with solar panels.

Blockchain can also combat counterfeiting. This will make it possible to identify products that are "non-circular" or that do not meet the set standards. In an environment with massive exchanges of data and real-time processing, transactions and agreed upon actions will need to be validated and triggered (or rejected) in an automated fashion, e.g. products could be automatically withdrawn if given quality standards are not met. A provider could automatically lose environmental reputation or certifications for consuming too much energy or producing too much waste, thus negatively contributing to its ecosystem's compliance. Blockchain has limitations which must be addressed if it is to be fully used for data sharing platforms. In its current dominant incarnation, the energy consumption of such distributed processing networks is far too great to justify its inclusion in any sustainable economy model. However, innovative consensus protocols that do not rely on sheer computational power are already being used on a smaller scale, showing great promise for wider implementation.

From green IT to lean ICT

About 10% of the world's electricity is used to power the internet infrastructure and equipment manufacturing. This amount is expected to dramatically increase in the coming years. Digital energy consumption increases by 8.5% per annum[19].

Its share in the global electricity consumption (growth of 2% per year) could reach from 20% to 50% by 2030. Digital technologies are one of the enablers implementation of the circular economy, but they must bring a net positive effect[20].

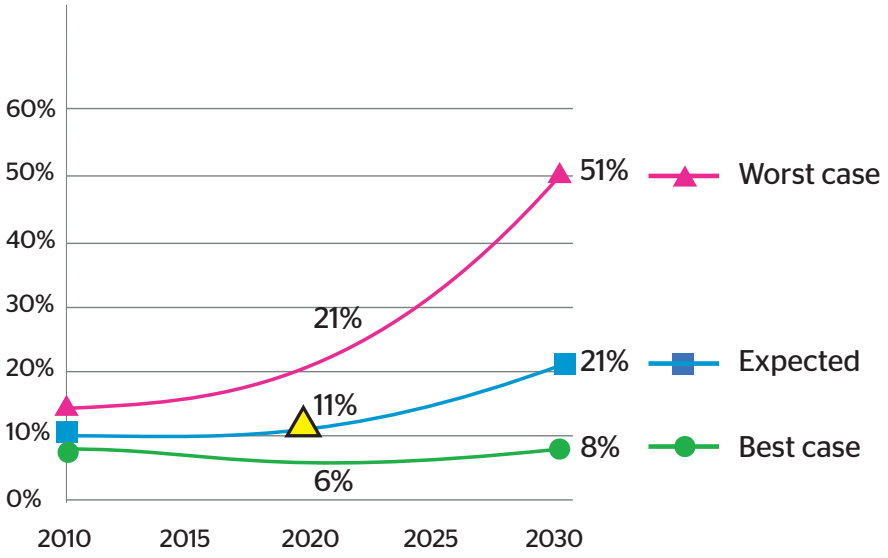

Figure 4: Share of Communication Technology of global electricity usage

[19] http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy
[20] The Sift project http://www.theshiftproject.org/

Circular business opportunities

If businesses were continually consuming 1.5 times their available financial resources each year it is likely that investors would expect this to be addressed. Surely the same is true for other finite resources - whether they are raw materials, energy or even water - of which an estimated additional $650bn[21] savings per annum could be realized in net materials across the EU alone. In this section, we explore the potential business value and opportunities of embracing the circular economy but they must bring a net positive effect.

The opportunity to innovate, the opportunity to survive

Earlier on in this paper we discussed the main principles of the circular economy and new business models which will be formed as a result. The table below is a guide to help businesses consider how they might innovate. It sets out the:

- 12 dimensions described in the MIT innovation radar[22];
- Opportunities relating to the business models;
- Main principles of the circular economy which they support.

For each, benefits are highlighted and categorized as:

: Improved consumer experience.

€ : New or increased revenues, from new markets or products or simply improved pricing.

: Reduced waste, of any form, including materials, time or money etc.

Using this table, businesses can develop and assess their plans in addressing the circular economy challenge and understand the optimum approach and areas of potential benefit.

Model	Preserve and enhance natural capital	Optimize resource yields	Foster system effectiveness
Customers (Who)	General benefit to society.	General benefit to society.	Introduce new products addressing the under-served demand for sustainable products and services, e.g. by addressing customers in new ways with product as a service. €
Customer Experience	Enhanced brand image (being part of a circular & sustainable endeavor).	Enhanced brand image (being part of a circular & sustainable endeavor). In some cases it may lead to lower prices (less material waste).	Satisfaction of demand for sustainable products, and consequently higher brand engagement. Possible savings may arise from the shift from product to service.
Value Capture	In some cases value could be captured in a community setting or public-private partnership, as businesses reduce negative externalities that must currently be proactively or reactively covered by the public sector.	Monetize the aspects of product design to create circular supplies and generate new revenue streams. €	Introduce premium pricing linked to perceived value in eco-design and leverage longer relationships with customers to sell added-value services associated with product life-extension. €

[21] Toward the circular economy, report vol. 1, Ellen MacArthur Foundation (2012)
[22] MIT Management Review - 12 Different Ways for Companies to Innovate

Processes (How)	Establish programs to reduce waste in the production cycle through designing in circular supplies.	Reconsider the positioning of products and services relative to the ecosystem of the customer base, how can the ecosystem be better leveraged to deliver products and services in new ways making Industrial and territorial levers available.	Multitude of opportunities arise in an IoT environment: with sensors, various types of analytics and actuators / decision making, new processes can be created (or old ones enhanced) with the objective of making the overall system more efficient.
Organization	Retrain existing resource and/ or introduce new roles or functions to focus on circular suppliers with the responsibility of minimizing the consumption of finite resources.	Retrain existing resource and/or introduce new roles or functions to focus on the complete platform or value chain with the responsibility of minimizing the consumption of finite resources.	Retrain existing resource and/or introduce new roles or functions to focus on the complete platform or value chain with the responsibility of minimizing the consumption of finite resources.
Supply chain	Review current supply chain to evaluate how it could be optimized to support the circular economy, identifying not only sourcing strategies supporting circular supplies, resource recovery and recycling but also those to avoid future costs either from price increases due to resource scarcity or legislative increased taxation – especially with primary resources.	Change product design methods and product road-maps to build in eco-design and improve the way resources are consumed throughout the supply chain.	Consider how alternative sourcing methods might help change the longevity (life-extension) of the product, reducing life-time costs, and open alternative product as a service revenue streams.
Presence (Where)	Localize manufacturing to reduce the impact of transformation and logistics as well as the associated costs – considering Industrial and territorial ecology.	Create distributed support capabilities, including leverage of the repair economy to encourage resource recovery and recycling as well as circular suppliers and potentially increase customer loyalty or at least elongate the length of the customer relationship.	Create virtual circles throughout the platform, by means of feedback loops, to enable multiscale circularity in the platform.
Networking	Creation of communities or public-private partnerships around the preservation of natural capital and the reduction of negative externalities.	Capture and analyze data on product manufacturing and usage to ensure the effectiveness of eco-design and optimize, resource recovery, allowing the improvement of the customer experience and potentially reduce cost of delivery and operation.	Develop ways to share, and potentially monetize data about products or their performance relative to the ecosystem. Allowing suppliers, consumers and partners to better contribute to the performance and longevity of the offering.
Brand	Enhanced brand image, regulatory compliance and CSR.	Enhanced brand image, regulatory compliance and CSR.	Build the values of the circular economy into organizations values and brand. Acceptance and power of brand improves the consumer experience and evangelizing eco-design and product life extension leading to a differentiated market position therefore new revenues.

Offerings (What)	Consider the use of alternative materials, specifically circular supplies which over time as commodity prices increase could generate direct economic savings. Also changing offerings to less consuming resources could open-up more immediate cost savings, although to be considered against any revenue impact. 	Engage with public sector in the reduction of negative externalities, sharing the gains. 	Transform current product as a service offerings leveraging assets over an elongated lifespan thus reducing the total cost of ownership relative to revenue (over time) – i.e. designed reuse rather than planned obsolescence – could bring significant cost savings. Joint recycling efforts with platform members, including end customers (with 2nd hand markets being an option). 
Platform	Creation of communities or public-private partnerships around the preservation of natural capital and the reduction of negative externalities. 	Use common components and design patterns which can give economies of scale to new ways of working – thus reducing the cost to market of engaging the circular economy. 	Engage end customers in the ideation, design and production cycles, with optimization and waste reduction as primary aim. 
Solutions	Community efforts for the preservation of natural capital.	A multitude of IoT based solutions can be created to optimize resource yields across the platform and value chains. 	Consider the "Total Product Experience". Build case specific solutions based on the sense-analyze-decide-act processes (see "Processes How" above). 

[15] circularity indicators, An Approach to Measuring circularity, Ellen MacArthur foundation and Granta, 2015

[16] http://ec.europa.eu/eurostat/web/circular-economy/indicators

In summary

The circular economy is as much an opportunity to business as it is a necessity. Early engagement could mean improved customer experience, reduced costs or new revenues. Whether this is achieved through direct cost savings, improved brand position or simply taking the opportunity to rethink your business. It is important to act now to ensure your business can take advantage of these benefits before any change is simply the norm.

Investments must be reallocated in compliance with the circular economy's guidelines. Many industries will need to reinvent their business models, which may be at risk.

The circular economy will greatly impact the business models of industries which will then be forced to reengineer processes, retool plants, build new logistical arrangements, and upskill staff.

Another aspect to consider is that the circular economy will modify and extend the responsibilities of producers (in the way they design, produce, collect and treat goods) and consumers (in the way they buy, use, and sort goods). The responsibilities are now interconnected, and behaviors of some, influence the practices of others. Similarly, roles are changing.

The circular economy could also encourage new players with the development of a second-hand market. With online platforms designed for negotiation and trade at a large scale, digital technologies should accelerate the "go to market" of these new products and allow the development of this new economy. This should support multisided markets which could allow manufacturers and resellers to interact with reusers and recyclers, driving up profits if there is demand for waste products for instance.

Circular economy driven by data

The primary role of data in the circular economy is to enable the traceability and measurement of the various activities linked to the flow of materials. But the role of data goes well beyond this imperative. Data is at the heart of the redesigned business models and resources flows that will enable the circular economy .

Data is indeed present at every stage:

- Sustainable Sourcing; improving resource extraction modes and limiting their negative impact on nature.
- Eco-designing to take into account the entire lifecycle of a product from the design stage.
- Ensuring compliance with standards, norms and regulations.
- Reaching industrial symbiosis by organizing intercompany flows and "mutualization" of resources.
- Enabling the "Servicization" of the economy to give priority to usage over possession.
- Allowing the consumer to be accountable on their choices by providing adequate data on the overall environmental impact of the product.
- Expanding the life of a product through repair, loan, sales.
- Increasing product recycling capabilities.
- And finally providing insights about anthropic footprint, through pressure exerted by production and consumption, to secure the momentum toward a circular model.

The tools and enablers required to successfully achieve these objectives all have data at their core: data models to optimize product design, data flows to organize the various economic players, marketplace to provide the service provider and users with real-time information on available equipment, status and location, monitoring dashboards, etc.

Let us take a few examples: the capacity to manage the circular economy requires knowing the characteristics of a product, but also following its movements, understanding its use, quantifying it, anticipating maintenance issues, etc. Beyond the individual product, data is also critical to align the overall production, distribution and consumption cycles & processes, to optimize production requirements, minimize waste, and maximize recycling capabilities.

At the product level, the first step is to create and collect the data related to the product. For example, tags in stores could adjust in real-time the carbon footprint of a product, depending on the product's life cycle (production, transportation ...), vary the price or inform the consumer to influence her/his choice. This may create a widespread use of non-recyclable components like RFID tags, or embedded circuits, the intrinsic non-recyclability of which will have to be offset by the positive impact on the shelf-life and recyclability of the products that will embed them. Alternative data collection methods, based on image recognition, environment sensors, etc. will help capture the required data.

We can see that the use of data in the circular economy processes and in the products also raises several issues linked to data property, the privacy and the use of data, including information ownership, possible users of the data, the right to share or access and intellectual property.

Built upon digital foundations, the circular economy will reshape the frontier of data protection. The availability of data whether public or private, and the ability to exploit it commercially or otherwise, will become a pillar of the circular economy. It is therefore important to provide a framework that protects data when necessary and allows unrestricted use when appropriate. The General Data Protection Regulation has introduced new framework that will structure the approach but also will limit the use of data to what is strictly relevant for the service to be delivered. In this respect, continuous monitoring based on real-time traceability could put at risk personal data and as such, privacy. It potentially jeopardizes the anonymity of practices and so, the intimacy of usages. Therefore, data protection, ethics and compliance need to be natively embedded into the design of a circular model.

Circular economy governance

The circular economy requires transforming a generalized resource intensive model, to a nearly closed loop, where production and consumption will integrate natively the constraints of sustainability (society needs versus negative externalities). This will only be possible if a sufficient portion of influential nations and economic actors, commit switching toward such model while demonstrating the performance gains it produces. This is unlikely to happen naturally. This is likely the most important challenge to resolve. That is why a new governance model will have to emerge combining market power, a regulatory framework and digital technologies as enablers and accelerators of the transformation.

The adoption of a universal development model at the global level will certainly be hampered by economic stakes, but also by development gaps between countries, particularly those where demographic curves call for a massive consumption model. A new governance mode will have to overcome these differences nurtured by historic inheritance, economic maturity, weak infrastructures, national political challenges, regulation or culture. Studies predict that there will be more connected objects than people by 2025, it is obvious that digital technologies will play an active role in this swing, enabling the reduction of obstacles and level the differences.

To move toward a shared goal, nations will need a common belief or similar constraints, following the example of The United Nations Framework Convention on climate change. An approach based on collective principles, the use of standard tools and processes, and the implementation of an infrastructure to support the technologies required for circularity, are likely required in addition to a regulatory framework to accelerate change. Different countries, municipalities, organizations and companies will be able to embrace the circular economy in their own way. This will require a multi-level governance to orchestrate the different layers of any society. Translation of global targets into local pathways will be mandatory. Indeed, the adoption of the circular economy will involve consistency on multiple levels (local, regional, national, international) to ensure a common trajectory. It is important to consider that the priorities of economic players (government, cities, sectors, companies, citizen) can result in multiple, at time incoherent, initiatives. It is necessary to connect such ventures but also to ensure convergence. This is the second challenge to solve. Governance will be a challenge as it must ensure alignment both bottom-up (for local agility) and top-down (for central consistency) and perhaps horizontality across governments to guarantee the integrity of the supply chain. Strong cooperation across and nations will be needed leveraging on best practices and mutualization of means: a pack could include guidelines, tooling, incentive schemes and set of laws could help driving the change. In addition, national policies should focus jointly on accelerating transition in a consistent timescale with climate challenges, natural resources scarcity, air and soil pollution and other environmental issues.

Digital technologies will necessarily be part of the tools to govern the adoption of the circular economy. In this respect, the market must be prepared to integrate new technical and functional requirements in connection to the circular economy (like the modularity of components in the FairPhone). Putting forward standards about water reuse, eco-design or lifespan of products could also support the shift to smarter practices. Digital technologies can facilitate the integration of new rules into the processes and certify compliance with directives or recommendations if needed.

> The circular economy's success is also based on the ability to introduce new common metrics leveraging analytical tools to monitor progress.

The circular economy involves setting new (non-economic) objectives, implementing new metrics like the Material circularity Indicator of a product[23] as well as adopting new instruments for measurement and control. Setting new key performance indicators will capture the main elements of a circular economy and allow supervising and guiding practice adoptions (like those suggested by Eurostat[24]). Digital technologies have already enhanced the ability to track resources and flows, enabling organizations to identify wasteful processes, to detect non-compliant materials along the supply chain or to spot non-authorized substances. This role will have to be dramatically reinforced. It is also about being able to collect, host and interpret huge volumes of data in many different contexts to support the decision making process, to optimize operations of the supply chain or bots' interactions, leveraging on the swarm computing capabilities for instance. The model will increasingly require measuring the use of infrastructure, products and resources (lifespan, preservation of scarce resources etc.), securing of raw materials and ecosystems.

Finally, and this is probably one of the most challenging aspects, governance should also include a large change management program. One of the most sensitive aspects of the circular economy is the transition phase, which requires the deep transformation of mind-sets as to govern and operate beyond personal interests. The capacity to promote and encourage circular practices relies on a set of tools that provide guidelines and to frame usage. If in certain contexts, a regulatory framework combined to adequate tax incentive pack could be envisaged, in all cases, raising awareness will be a cornerstone of the successful shift. The ability to broadly inform individuals, industrialize e-training, and develop new skills in all industries (in particular critical markets, such as agriculture, mobility, real-estate and energy) will be a key aspect for success. Digital technologies will be here again, a decisive factor in the shift toward the circular economy .

Conclusion

As the human population continues to grow on a planet with finite resources, sustainability is not a choice. At present the circular economy is our best bet to move toward a sustainable world. Digital technologies will necessarily be part of the solution. The challenge of building full circularity is massive, multifaceted and complex. The key will be our ability to undertake incremental and pragmatic steps toward a bold future. Current social, political, economic and business realities will need to be taken into consideration. More importantly, as markets, regulators and businesses address mid and long-term issues, these actors will need to provide or enable short and medium-term benefits to business, society and the environment.

> Sustainability and the circular economy is a business opportunity and will become a key driver of digital transformation.

In this white paper, we focused on three important aspects:

1. What are the key technologies that will help to shape the circular economy – those allowing intelligent supply chains to share information and collaborate in continuous improvement processes?
2. How significant can the circular economy be as a generator and driver of new business opportunities?
3. Why should a new governance be considered and how will data protection play a major role in the success of the project?

The circular economy will be implemented on a large scale only with the help of digital technologies. Connected objects, big data capabilities, deep learning insights, automation and robotization will be at the heart of this transformation. This change of model will necessarily be based on new governance, supporting by common national and international ambitions and political commitments. Regulation, and new tools including new indicators, should accelerate and anchor this transition. This change is expected to be a new source of value creation for companies and society at large and give opportunity to new industries to create new jobs. But a profound cultural change will be necessary to abandon a model that has served and shaped our societies for more than a century. However, numerous examples show that this transformation is already underway. It is therefore necessary to strengthen the role of digital technologies to accelerate the move, while considering seriously the increasing environmental footprint of digital industry.

At Atos, we place the circular economy at the heart of the solutions we design for our clients. But if we want to cope with the huge challenge we face, we will have to rely increasingly on collective intelligence and open innovation to imagine disruptive solutions able to make the change happen. The shift to a new model is more than a society challenge; it is about seizing the only chance we have to build an acceptable future for humanity. Mobilize this intelligence around a common destiny, in particular the digital brainpower, is part of the Atos' responsibility.

About the Atos Scientific Community

The Scientific Community is a global network which comprises 150 of the top engineers and forward thinkers from across the Atos Group, with a rich mix of skills and backgrounds. Their mission: crafting the Group's vision for the future of technology in business and anticipating the upcoming trends and technologies that will reshape businesses and society in the years ahead. By making this vision available to its clients, and by investing in areas related to the findings, Atos intends to help its clients make informed decisions regarding the future of their Business Technology solutions.

About the authors

			
Blanca Jordan	Head of Healthcare Sector at Atos Research and Innovation	blanca.jordan@atos.net	@jordan_blanca
Catja Frenzel	Head of Contract Management, Atos Germany	catja.frenzel@atos.net	@sunflower7169
Dominique Grelet	Head of Artificial Intelligence	dominique.grelet@atos.net	@DominiqueGrelet
Jose Esteban Lauzan	Head of Innovation, Atos Iberia	Jfernando.esteban@atos.net	@esteban_lauzan
Nigel Thorley	Head of Strategic Planning, UK&I, MTS Germany and Central Europe, Worldline	nigel.thorley@worldline.com	@nigelthorley
Ivo Luijendijk	Group Industry Director data analytics, IoT and Blockchain	Ivo.luijendijk@atos.net	@IvoOnPayments
Sophie Chambon-Diallo	Former Head of Global Sustainability, Atos		@ChambonSophie
Luis Lancos	Former Technical Director Payments, Worldline		@InnovatorRider

White paper

About Atos

Atos is a global leader in digital transformation with 120,000 employees in 73 countries and annual revenue of € 13 billion.

European number one in Cloud, Cybersecurity and High-Performance Computing, the Group provides end-to-end Orchestrated Hybrid Cloud, Big Data, Business Applications and Digital Workplace solutions through its Digital Transformation Factory, as well as transactional services through Worldline, the European leader in the payment industry. With its cutting-edge technologies and industry knowledge, Atos supports the digital transformation of its clients across all business sectors. The Group is the Worldwide Information Technology Partner for the Olympic & Paralympic Games and operates under the brands Atos, Atos Syntel, Unify and Worldline. Atos is listed on the CAC40 Paris stock index.

Find out more about us
atos.net

Let's start a discussion together

CT_190206_LPM_Circular_Economy_WP_en2