Cities of Tomorrow

Circular Cities

OCTOBER 2018

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Summary

Executive Summary

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The circular economy now stands out as a development model that combines competitiveness, innovation and sustainability: it is a new vision of the economic system and is taking on an increasingly central role in the agendas of governments, local institutions, associations and companies.

In cities, where the majority of the global population is gathering, where much of our produced resources are consumed and where environmental issues have particular importance, the circular economy plays a decisive role. Imagining a new development model for cities means imagining it for the entire planet.

The definition of a circular city responds to a holistic vision combining technological innovation and aspects directly correlated to it, resource and energy flows and production and consumption models into one single entity, considering their impacts in economic and performance terms as well as in environmental and social terms.

Imagining a new development model for cities means imagining it for the entire planet.

New Technologies: The Changing City

The city is increasingly becoming the preferred context for the passage from idea to reality: new technologies, developed in the last decade, are allowing for the **transformation of theories into practice**, systematically and on a large scale.

Technological innovation has initiated an overall transformation of the urban context. Mobility, energy, construction, tenders, even nutrition and healthcare are evolving.

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Until a few years ago, the solutions that are now taking shape thanks to new technologies were unimaginable. The list is getting longer and longer: ranging from information management with sensor technology, cloud computing, ultra broad band fixed and mobile grids, API marketplaces, Internet of Things, Big Data and artificial intelligence, to final applications like intelligent transport systems, smart public lighting with incorporated value-added services, smart grids, electric cars, renewable energy plants and storage batteries.

Common Goals, Sustainable Development

The awareness that the answers to the needs of civil coexistence and of business must lead to not just economic but also environmental and social benefits, reveals the **essential role of all stakeholders** and the importance of their involvement for creating shared value.

The circular economy has become a reference model partly due to the assertion of sustainable development as a paradigm and shared goal of companies, institutions and civil society.

The main international initiatives for the sustainable development of the planet are dually linked to the circular economy.

The **fight against climate change**, which received its greatest focus at the 2015 Conference of the Parties in Paris, requires rapid decarbonization. This objective is achievable only through a circular model based on renewable energy sources and the electrification of consumption.

The **Sustainable Development Goals** (SDGs) promoted by the United Nations, looking toward 2030, indicate 17 specific goals to shape a new paradigm for economy and development. The circular model is an enabling factor and the city is the best place to achieve this, to the point that several goals directly concern urban areas and one (SDG11) refers to cities specifically.

The Circular Economy: A Strategic Driver

Innovation and sustainability have been at the heart of Enel's strategy for several years. This choice comes out in many ways: from an open and inclusive approach to creating shared value, to the development of technologically advanced infrastructure and the constant growth of renewable energy and innovative solutions based on electric sources.

The circular economy is a strategic driver for Enel: it's one of the pillars of our approach and systematically extends to all areas of our business.

Some time ago, we initiated the transition toward an economic model based on renewable sources and technologies, marked by the optimized and increasingly efficient use of our assets, aimed at boosting products, plants and properties that are no longer competitive with initiatives to bring environmental benefits and business opportunities.

The path we've chosen provides a challenge that fosters innovation, pushing us to identify solutions with reduced impacts. This facilitates the identification of synergies, leading to strong transversal collaborations based on innovation along the whole value chain, reducing risks and costs, finding new solutions.

On the Open Road to Change

Cities see Enel at work in many areas: they are places of living where we bring renewable generation sources, solutions for electric mobility, innovative infrastructure (smart grids, fiber optics, smart public lighting), applications for consumers and companies and energy efficiency.

Our contribution to the circular city also includes projects like **Circular procurement**, for measuring the circularity of our suppliers, and **Futur-e**, for the conversion of thermal power plants that are no longer competitive for new purposes.

Our activities embrace a broad and diversified outlook, joined by Enel's vision and planning, inspired by the circular economy.

We've outlined our vision in terms of **approaches**, **KPIs** and **Group objectives**. These are clear and verifiable indications that form the foundation for our relationships and our continuous dialogue with institutions, customers, partners, associations, start-ups, communities and scientific institutions in all the countries where we work.

Thanks to this approach, we can set ourselves increasingly ambitious objectives and involve all the subjects in the ecosystems where we work as active players in the transition.

While a lot has been done, **the transition of cities toward the circular economy** is just getting started. This document provides an overview of Enel's vision and activities to open up even more to collaboration and discussion, which are characteristic of our way of interpreting and following the road to change.

The Circular City

The Circular City

We are witnessing an unprecedented transformation of cities. The exponential growth of the population and of resources used, the technological evolution of infrastructure and services, and the importance of environmental issues in the urban environment are signs of this epochal turning point.

This profound change has origins far back and has become faster and more radical in the last decade, giving cities a new, key role: urban centers can be a starting point for the transition to a new paradigm of sustainable development for the entire planet.

Some data to demonstrate the impact of the changes underway:

- between 1900 and 2015, the percentage of the global **population living in cities grew from 14% to 54%**, and forecasts predict it will reach 66% by 2050[1];
- cities generated about **1.3 billion tons of solid urban waste** in 2012[1];
- the materials consumed in cities will rise from 40 billion tons in 2010 to 90 billion in 2050[2].

[1] World Bank: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/0,,contentMDK:23172887~pagePK:210058~piPK:210062~theSitePK:337178,00.html

[2] UNEP, IRP 2018: https://www.iswa.org/fileadmin/galleries/Publications/ISWA_Reports/GWMO_summary_web.pdf

The Primary Challenges for the Cities of the Future

The changes underway directly affect citizens' quality of life.
Some of the main challenges:

Resource consumption

We are witnessing a structural waste of resources and capability, taking, for example, the fact that cars are parked 92% of the time, on average (and even when they are used, it is never to the maximum of their potential), that 31% of food is wasted along the value chain and that offices are used, on average, to only 35%-50% of their capacity, even during working hours.

Environmental impacts

- *Air pollution:* about 80% of the Earth's cities have pollution levels above the limits set by the World Health Organization. This situation concerns most countries. In 23 of the 28 member states of the European Union, for a total of over 130 cities, air quality standards are not respected. In this regard, it must be considered that:
  - transport is almost completely based on diesel and petrol;
  - heating is still very linked to fossil and biomass fuels;
  - it is estimated that at least 75% of buildings are energy inefficient.
- *Greenhouse gas emissions:* over two thirds of the planet's energy is consumed in cities, which are responsible for roughly 70% of global emissions[3].
- *Waste:* waste reduction and management is one of the most critical issues, with significant health and environmental impacts.
- *Water pollution:* rivers, seas and aquifers present pollution levels that affect ecosystems and people.
- *Biodiversity and services for the ecosystem:* pollution and land consumption have various impacts on biodiversity, such as the interruption of migratory routes or the destruction of entire natural habitats.

Resilience

In cities, climate change is already causing problems and critical events that affect the safety of citizens, the functioning of infrastructure, economic activities, etc.

Economic opportunities and social inclusion

Many traditional economic activities have disappeared as they struggle to emerge again, causing significant employment and social issues. The development of a new economic model based on the circular economy can create new opportunities and new jobs. The focus on existing asset management and on associated services can generate new jobs that cannot be eliminated with automation or delocalization, unlike what is happening with many manufacturing activities. Plus, new technologies are opening up opportunities in the direction of so-called e-government: the availability of large volumes of data, profiled according to specific needs, allows for fast decision-making, prompt and proactive interaction with citizens and the transformation of the large quantities of available information into improvements to quality of life and competitiveness.

[3] Ellen MacArthur Foundation, 2017 https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Cities-in-the-CE_An-Initial-Exploration.pdf

The Most Relevant Urban Sectors

The classification set out by the **Ellen MacArthur Foundation** is effective in analyzing the challenges and opportunities of the cities of tomorrow. It highlights certain important areas:

Built-up areas with residential and industrial construction;

Energy systems, that is, heating/cooling, transport, energy supply;

Mobility, including public and private transport;

Bio-economy, including food and waste;

One further, fundamental sector should be added to these, because of its role in enabling the areas listed above:

Infrastructure and networks, like the electrical grid, public lighting, optical fiber, telecommunications, water, gas, ports.

New Technologies

The infrastructure and technologies available now have recently gone through a rapid and total evolution. Ultra Broad Band communication networks, the Internet of Things, Big Data and artificial intelligence allow for the introduction of control architecture and optimization algorithms that create extraordinary opportunities for both the use of existing assets and the development of new business models.

New technologies[4] can be imagined as virtual levels that overlap on the physical level, multiplying their potential. In this, we can define several levels:

Physical: this is the 'tangible' world, made up, for example, of infrastructure and products, both traditional and innovative;

Data driven - digital: new technologies for the measurement, transmission and management of data, such as:

- *Data collection:* smart sensors and smart technology for the final consumer;
- *Internet of things and connectivity:* solutions to make products, assets, smartphones and devices communicate with each other, with a centralized level of control, at high speed and reduced latency. This is the case of Energy Intelligence Software (EIS) for buildings and factories. This allows for the constant monitoring of the energy consumption of all the commodities involved in the production/life cycle, and to check if there are anomalies in consumption, to then correct them.
- *Big Data:* the real time availability of large volumes of data and the possibility of analyzing and processing it with evolved computational and algorithmic capabilities, in order to enable the development of new services and improve the performance of existing ones (for example, knowing the status of a vehicle, its location, and its availability are prerequisites for any car sharing application)

Adoption and use: it is the third level, correlated to the previous two, concerning new applications and new business models made possible by artificial intelligence and by decision support systems, like predictive maintenance, recycling and flow optimization, sharing solutions and demand-response systems associated to distributed assets.

[4] McKinsey Global Institute, June 2018: SMART CITIES: DIGITAL SOLUTIONS FOR A MORE LIVABLE FUTURE

Governance e Stakeholder

Every city is marked by its specific characteristics: location, history and all the factors that make it unique. For this reason, the vision of the smart city should always be determined and designed in a specific and accurate way, building consensus and above all fostering collaboration between all stakeholders so that everyone's needs and suggestions can be heard. For an effective circular ecosystem to be built, it is important that both 'bottom up' and 'top down' approaches exist.

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The framework offers a long-term vision, indicating intermediate goals along with the main areas and instruments of action, analyzing existing barriers and identifying the incentives to work on to develop the gradual adoption of transition solutions within the urban environment. In this stage, too, the close involvement of all the counterparts, from citizens to companies, NGOs and start-ups, plays a critical role.

Constant innovation transformation makes the management process of circularity dynamic and requires a flexible and open approach. This is in line with what happens at our company, for example, with the model of open innovation, where innovation no longer occurs in a planned and 'closed' way, but develops through the creation of an ecosystem where start-ups, tech partnerships and collaborations with research centers interact and lead to new solutions.

An essential role is also played by the spontaneous initiative of citizens, associations and companies. The potential of proposals from private or mixed private-public entities is extremely relevant. To make sure these contributions are not sporadic or isolated, an integrated approach is needed, one that allows these initiatives to develop synergies and collaboration in a systematic way. Circularity must become a forma mentis that every side can develop in its activities and choices, in private life as well as in the professional and public sphere.

The concurrent development of these two directions, 'bottom up' and 'top down', fosters the creation of a circular ecosystem, where everyone is in the condition to contribute, with ideas and actions, to the transition to a circular economy.

Some of the stakeholders involved in this are:

- **Local institutions:** fundamental to providing a long-term vision, intermediate goals, priorities, legislative measures and to monitoring changes in the process and promoting innovation. Institutions initiate the process, which includes defining priorities, setting up tenders, managing the tenders, to then create a virtuous cycle that leads the innovative ecosystem to find cutting-edge technological solutions and business models;
- **Citizens:** they have a central role, both by participating actively in determining vision and priorities and by contributing to change with their ideas, projects and daily actions;
- **Companies:** they can help accelerate the transition with their resources, both in terms of financial assets and managerial and technical skills;
- **Start-ups:** they are the creators and suppliers of new technologies and new

solutions. They can cooperate with large companies and local institutions to speed up implementation;

- **Universities, NGOs, research centers:** these are contexts that can raise awareness about the circular economy, create the theoretical and cultural context necessary to support the transition, help monitor and push for the achievement of results;
- **Investors:** they play an essential part in boosting the transition. For them, the circular economy can be an indicator of both lower risk and innovation. The development of new forms of financing, like crowd funding, is further expanding investment opportunities.

The scope of actors involved is not limited to the inhabitants of individual cities, but can be extended to the rest of the world. The circular economy develops on synergies at both the local and the international level that often represent a unique asset to deepen experience gained in other contexts, acquire skills or develop additional profitable synergies.

Enel's Vision for Circular Cities

The economic model developed to date is based on a **prevalently linear paradigm**. Consequently, there is a huge capital of goods and infrastructure created for a no longer suitable model that exposes cities to significant issues in terms of environmental impact, resilience, economic development and social inclusion. This change cannot be overnight, but some stimuli to act on can already be identified.

Imagining its relationship with material and energy flows and the way it uses its assets and infrastructure in a new way, a 'circular city' can **improve quality of life** for citizens in many areas, like health, environment, development and social inclusion.

In Enel's vision, the interpretation of the Circular economy, based on the framework of the 5 pillars described below in Part C, has a very effective expression. Some examples of what we are already doing are highlighted below:

1 **Sustainable inputs:** focusing on a new paradigm based on renewable sources, storage and electric technologies makes it possible to shift consumption toward increased use of electricity powered by renewable energy. In achieving this integration, it is possible to use technologies like solar photovoltaic and thermal to produce zero-emission energy that is '100% green', which then powers extremely efficient zero-emission electric technologies, like heat pumps and electric cars. This is an effective fulfilment of the concept of circularity that allows us to shift the inputs used toward renewable sources, generating several benefits: renewable sources are now competitive, electric technologies have much greater efficiency levels than thermal alternatives, an electric system powered by renewables has no local or global emissions.

1

2 **Increased product life:** Enel achieves the maximum product life for its assets and guarantees their expected performance with solutions like modular design, drone monitoring and predictive maintenance. The Futur-e project is a clear example of this approach: the infrastructure of 23 discontinued thermoelectric plants is used as an opportunity for the community, a starting point to generate new business and a chance for close involvement with the local community and stakeholders. In this way, assets that would have been managed as costs to

minimize with a linear approach are instead given value, becoming opportunities for growth and employment for the community.

3 **Product as a service:** selling customers a service and not a product means providing them with only what they need and want, without transferring the ownership of the asset to them. In this way, multiple customers can use the same assets, leaving the burden of management and maintenance with the operator. An example of this is the network of electric car charging stations that Enel is installing throughout Italy: infrastructure to be used by all electric vehicle users, from a Product as a service (PAAS) point of view. The benefit of this approach is that the customer only pays for what he or she needs (the charging service) without having to purchase the product (the station). The latter remains the property of the company, which can better take care of its management and maintenance. Another example, still in the pilot phase, can be found in parked electric cars that can help regulate electrical grids with their batteries. In this case, the perspective is actually flipped: the customer supplies a service to the system.

4 **Sharing platforms:** creating smart microgrids shared by multiple users that can deposit energy, self-produced with renewables, and withdraw it for their consumption is an almost material interpretation of the concept of circularity. Sharing has the benefit of optimizing the use of goods and products through peer sharing, which goes beyond the relationship between customer and company.

5 **End of life:** salvaging the inherent value of discontinued assets is the final step in the circular economy model. One of the many possible examples is the installation of second-generation smart meters in the homes of 31 million Italians.

The replacement of first-generation smart meters is happening with digitalized management and includes the recovery of materials from the discontinued smart meters.

Infrastructure must also be mentioned as a fundamental enabler of the circular economy model, as it can be subject to applications of circular economy principles in its creation and management.

- **Smart electrical grid:** to actualize the possibility of a system based on renewable sources and electric technologies, it's necessary to manage the presence of many new points of input and/or output (electric vehicles, heat pumps, residential photovoltaic panels, etc.). Customers, now prosumers (producers and consumers), require continuous updating of the electrical grid to allow for the full use of all the new technologies, simultaneously guaranteeing grid stability.

- **Smart public lighting:** public lighting networks, in addition to becoming more and more efficient thanks to new LED technologies and advanced remote control systems, are becoming a form of infrastructure that can deliver new services linked to safety, environmental/local monitoring and connectivity.

- **Data transmission networks (optical fiber and wireless):** technological innovations for many applications of the circular economy require the transmission of much larger volumes of data than before, with much fewer latencies. Connectivity suited to new flows is a prerequisite of the European goal for a so-called 'Gigabyte Society' by 2025, allowing for new services for citizens and companies as well as for public administration. Current telecommunications systems in Europe, often based on copper networks, do not allow for the qualitative leap necessary for the development of new business models for the future of cities,

like e-government, e-health, e-learning, etc. and for the development of services required by the cities of the future, like Fiber-To-The-Home (FTTH).

- **Circular ports:** Another important form of infrastructure are ports. Generally integrated within cities, they represent a key part of them, both from an urban planning and economic point of view. Circularity can be applied here in several ways:
  - *Electric mobility* for all internal port transport;
  - *Renewable energy* for for all energy consumption, both electric and thermal;
  - *Cold ironing:* to power the moored ships with electricity from the dock and not with engines on board.

Conclusions

The challenges that cities will have to face in the coming years and decades are enormous and require a systemic vision to outline policy and action. The circular economy can be this vision. To do so, it must be turned into concrete priorities and consequent actions. This is the challenge that all players must accept and help implement.

Enel has placed innovation and sustainability at the center of its strategy – and the circular economy is a perfect combination of these two things.
Enel's approach to the circular economy has become a point of reference internationally, as it has concretely implemented it in every area of its business, from renewables, to electrification and infrastructure.
The guidelines for this transition to a new circular model are clear. The increased competitiveness obtained with innovation and environmental sustainability turns circularity into a benefit.

The use of renewable sources, the increased service life of assets and the promotion of the so-called *end of life* phase are actions that lead to benefits in terms of new solutions, innovation, cost and risk reduction.
Even in cases where this doesn't happen, because of an existing system that favors a linear approach, applications are already competitive and will become even more so, because of innovation and the growing importance of environmental issues.

A circular economic model opens up new opportunities for social inclusion and job creation, fundamental aspects for the cities of the future.

Enel has placed innovation and sustainability at the center of its strategy – and the circular economy is a perfect combination of these two things.

To effectively achieve a circular model, in addition to business solutions, Enel believes the **Open Power approach** is also essential. In this approach, openness and inclusion generate discussion with all stakeholders and the development of skills and ideas coming from the entire ecosystem.

The transition to the circular city is still in its early stages, but the results achieved so far and above all the consensus and commitment to this vision that we are seeing, on an international level and transversally for all stakeholders, are a strong indication of the potential it represents.

Circular Economy and Indicators

Focus

Focus:
Circular Economy and Indicators

The circular economy can be defined as an ‘umbrella concept’: it brings together different approaches united by the fact that they promote an economic model based on sustainable solutions (renewables, reuse and recycling) and on the circular use of assets that involves the maximization of their use and their promotion in the *End of life* phase.

It is usually divided into the following five pillars:

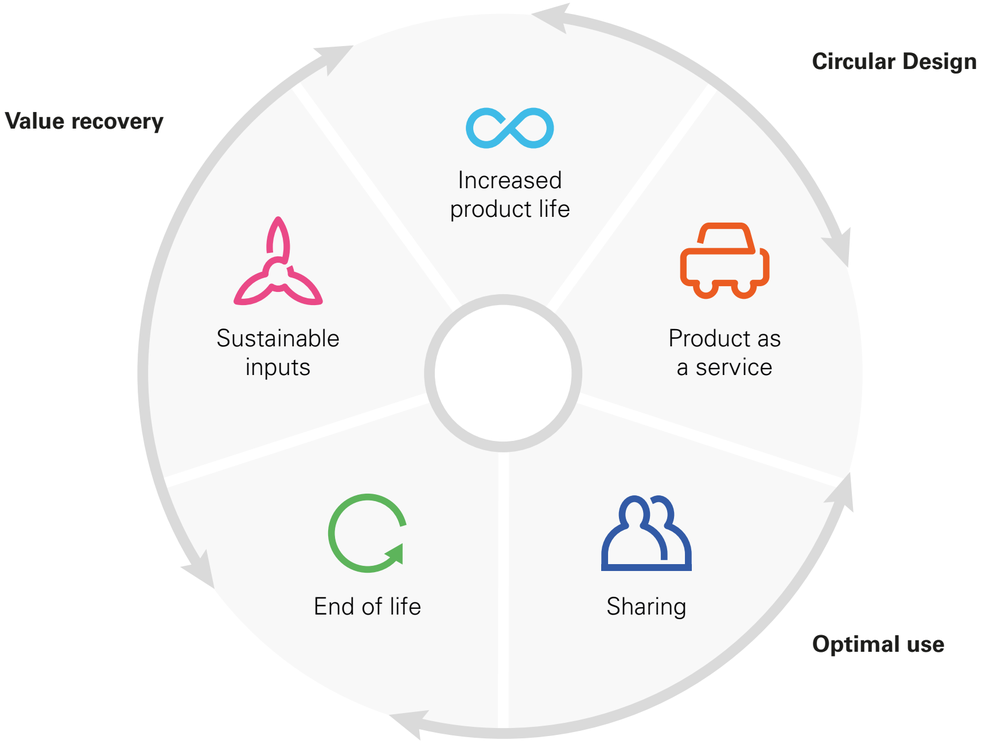
Sustainable inputs: the use of inputs from renewable sources (both material and energy) or from reuse and recycling.

Increased product life: every specific action designed to increase the service life of an asset and a product, through modular design, predictive maintenance, etc.

Product as a service: a business model in which the customer purchases a product in the form of a service, like car sharing, from the company.

Sharing platforms: platforms where private individuals can share assets between them.

End of life: every solution aimed at preserving the end of life value of an asset and reusing it in a new cycle through reuse, regeneration, recycling, etc.



The earliest theories of the circular economy emerged during the second half of the twentieth century, but a real acceleration in the implementation of this paradigm has happened in the last decade, especially thanks to two factors:

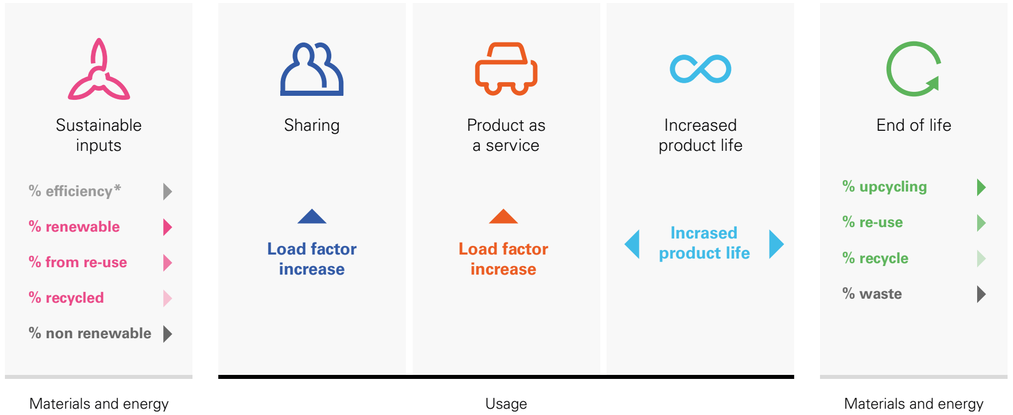
Technological innovation: new technologies[5] like Asset tagging, Geo-spatial information, Big Data Management and Connectivity have led to new opportunities in the management of assets and products. The spread of smartphones and the possibility of instantly knowing the position of an asset, its availability and its condition have made new business models possible. Technological innovation has also enabled numerous technologies, like those for the use of renewable energy sources and for the electric car, to become competitive.

Environmental awareness and institutional effort: the growing awareness about issues linked to environmental pollution, both local and global, has pushed the European Union as well as individual countries to develop their own strategies on these topics and to take action at the legislative level.

The circular economy is also a great opportunity to obtain greater competitiveness through innovation, by imagining new solutions and reducing costs and risks at the same time. It is not an opportunity limited to the business sector, but is valid for all application areas: for cities, too, the circular economy is an extraordinary opportunity to increase competitiveness.

One of the main challenges associated with the Circular Economy is the definition of circularity indicators that can allow us to move from qualitative and generic considerations to considerations that are more exact and quantitative. The difficulty in evaluating 'circularity' comes from the fact that, while some aspects – like the share of renewable inputs or the share of outputs reused – are more easily measurable, other benefits are harder to measure – like increased service life and asset sharing. Also, the interaction between indicators linked to materials and indicators linked to use is not always easy to define.

Enel has developed its own model for measuring circularity (CirculAbility model@), which keeps track of all five pillars of the Circular Economy, categorized with certain indicators:



*Applicable only to selected cases

[5] CITIES IN THE CIRCULAR ECONOMY: THE ROLE OF DIGITAL TECHNOLOGY, 2017

Our CirculAbility Model lays out a single circularity index, calculated from two components:

Circularity of flow, which keeps track of all the material and energy components in the phases of:

- *inputs* (whether renewables, from recycling, from reuse, etc).
- *outputs* (for recycling, reuse, landfill).

Circularity of use, which takes the use factor of materials into account through:

- increased product life
- increased load factor, through Sharing and Service as a product (SAAP).

The circularity indexes of the two components are calculated with many specific indicators.

Enel's Activities for Circular Cities

Enel's Activities for Circular Cities

Enel's vision is articulated in a series of activities, which represent the contribution of a utility to the transition to a Circular City, and involves all areas of the Group's business:

1. Energy services

a) Residential

b) Industrial

c) Mobility

d) Public infrastructure

2. Smart Grid

3. Urban regeneration - Futur-e project

4. Circular Procurement

1. Energy services

In 2017, the Enel X division was created, with the goal of incorporating all of Enel's business that is not linked to the sale of commodities and developing innovative solutions with a strong focus on the circular economy. Enel X business includes four areas: e-Home, e-Industries, e-Mobility, e-City.

Enel X's strategy is represented through several lines of action:

- Understanding customer needs and satisfying them with new technologies and a new business model, overcoming any barriers (economic, for instance) that may prevent its adoption;
- Developing synergies and collaborations with other stakeholders and companies that share the Group's Open Power approach;
- Communicating and spreading opportunities and benefits linked to the transition to circular models based on renewable energy, smart electrical technologies and platforms on all levels;
- Supporting citizens and stakeholders in contributing to the transition from linear to circular models, to improve quality of life and the urban environment.

1.a Residential

In the residential context, our task is to offer a variety of products and services in the realm of energy, where Enel is a leader, while helping spread a culture closely linked to the efficient use/consumption of energy and to the circular economy, where everything revolves around transitioning from a system of waste to one of continuous reuse. This involves the development of a regenerative model that deals with environmental priorities, reducing our impact on the ecosystem around us while also improving the performance and competitiveness of our products, using innovation to stimulate development and economic growth.
Technological development plays a key part in the transformation toward new models based on the PAAS approach. Innovation has on an important role within the value chain of products and services linked to sustainable inputs.

Starting from this premise, the e-Home portfolio includes numerous solutions that belong to the following macro-categories:

- **Photovoltaic and storage systems:** to capture sunlight, convert it into energy used to power the home, meet daily needs, and also store excess energy produced to be used later.
- **Solar thermal systems:** to convert solar energy directly into thermal energy for the production of sanitary hot water, without producing pollutants.
- **Systems of heating, ventilation and air conditioning (HVAC):** considered a necessary part of the strategy for long-term improvement of energy efficiency at a country level. It is based on the promotion and spread of highly efficient systems, like smart heat pumps to guarantee summer and winter temperature

control with the greatest efficiency and without harmful emissions. The benefits gained – both in environmental and economic terms – are perceptible, quantifiable and assessable by the client-consumer as well.

- **Smart Home:** smart household utilities and smart home systems for heating/cooling require the presence of an 'orchestrator' to allow for their optimal use, making customers aware of their consumption and improving their habits without compromising their comfort. Enel X's smart home aims to become the future enabler and orchestrator for services to develop smart home assets (including photovoltaic panels and storage systems).

These solutions are part of the new energy model based on renewable energy, electric sources and technological applications that can contribute to a rapid transition to the circular model. This represents the first step of a road map where a sustainable approach, PAAS business model and development of a product's end of life phase are essential points.

1.b **Industrial**

Current industrial development, associated with the so-called Industry 4.0 model and implemented with a vision of the Circular economy, can provide a significant contribution in terms of innovation, competitiveness and corporate sustainability.
A growing number of companies are opting for circular business models to increase opportunities, reduce costs, innovate and be more environmentally sustainable. The effects of changing consumption models, with a different approach to product ownership, is playing a role in the transformation.

The role of e-Industries is to support the entire industrial and commercial sector in reaching its circularity objectives. Our contribution includes offerings like PAAS and Energy as a service with a wide range of solutions on the platform, installation of distributed renewable and high-efficiency technologies paired with storage systems, installation of behind the meter batteries, etc.
Thanks to new technologies - like Machine Learning, Big Data and Blockchain – we are witnessing a transition from asset-based to service-based models, where the PAAS model takes on increased importance.

The e-Industries portfolio covers the main stages of the value chain:

- **Advice:** energy audits and advisory services to analyze performance and historical energy expenses, defining procurement goals and risk management strategies, etc. Specific products for multi utility and multi-site invoicing, with systems like Utility Bill Management (UBM) and Sistema de Gestion Preferente (SGP), and procurement platforms to identify the most suitable supplier based on consumption.
- **Supply:** design of solutions and 'turnkey' installation of equipment, control and distributed generation systems. The solutions here range from CHP cogeneration and photovoltaic plants and storage systems to lighting systems, industrial equipment and optimization systems like solutions for Heating, ventilation, and air conditioning (HVAC).
- **Optimization:** advanced monitoring, verification and optimization of client sites and loads to direct their behaviors toward energy and cost savings. Energy Intelligence Software (EIS) and energy efficiency are the main services.

- **Flexibility:** thanks to technological innovation, there are now solutions to minimize energy consumption and share the 'potential' of managed assets, which are no longer simple points of consumption but are able to provide grid balancing services and create economic benefits and energy for the entire ecosystem. These flexibility services go through a client's aggregation platform that uses the flexibility offered by demand (load), capacity (batteries) and production (e.g. photovoltaic rooftop) associated to assets that are distributed and aggregated to each other. The aggregation platform is the real technological content of this innovative process and is the interface toward the TSO on one side and toward the customer on the other.

Besides the economic and balancing benefits associated with the services above, it is possible to enable the customer's assets behind the meter through on-site control systems - Energy Management Systems – that interface with the flexibility platform described above. An example is Demand side management that involves, for example, cutting peaks and shifting loads with batteries and demand-response solutions in order to consume energy when it costs the least.

1.c **Mobility**

Enel's role is to support the transition to electric mobility through direct customer involvement, technological leadership, efficient management and an open approach both in terms of business and innovation.
Considering that mobility now represents about a third of energy consumption, the transition to an electrical system that has no local emissions, is highly efficient and

integrated with renewable production is one of the main challenges for the transition to a circular model.

e-Mobility is committed to making electric mobility the best choice from all points of view, combining innovation and sustainability. Furthermore, e–Mobility provides the customer with an effective and interoperable charging system, with a sharing platform that uses charging stations designed for an extended service life. The business model is open to other operators, providing products and services to the final customer and to mobility service providers that are based on the Enel charging ecosystem.

e-Mobility's portfolio includes many countries and types of customers, including solutions in the following main categories:

- **Public charging infrastructure** to enable an open business model for electric mobility, promoting electricity as transport carrier, reducing so-called range anxiety and indirectly encouraging the use of renewable energy. Enel X is investing to create public charging infrastructure for Italy, with the aim of installing 14,000 charging stations by 2022;
- **Private charging infrastructure** designed for the customer, easy to use and compatible with every kind of vehicle and environment, including fast charging and Vehicle to grid (V2G);
- **Platforms for integrated technologies** where all charging solutions are interconnected and integrated by flexible platforms that manage the process end-to-end. This allows for reliable service, effective maintenance, integration between activities and the possibility of providing flexibility to the grid.

1.d **Public infrastructure**

Enel X works in the urban context, in close contact with city governments, to provide products and services to Public Administrations that improve efficiency in cities and develop and support sustainable solutions for urban life.

That's the case for public lighting solutions, which use innovative technologies and reliable management and operation models to provide cities with solutions that improve the quality of urban life and safety: e-City provides lighting as a service, which is a key step toward circular cities.

Furthermore, light poles can be used as urban hubs, allowing for the implementation of value-added services, like video-analysis services for safety and planning, optimization of mobility flows, environmental monitoring, connectivity, smart parking, etc.

In the future, new services will be provided to urban stakeholders using platforms powered by large volumes of urban data, allowing for a more efficient use of infrastructure.

Promoting electric solutions in cities is another pillar of e-City's strategy: the electrification of cities is the most promising strategy in terms of urban sustainability, because it reduces local pollutant emission in the short term and provides a significant contribution to reducing global emissions in the medium term. Consequently, buildings and transport are key areas for guiding the electrification of cities in line with the transition to renewable energy.

Nowadays, cities have to face and adapt to a rapid transformation process daily, identifying solutions that concern very different fields and topics, like mobility, data

management and safety. In this context, e-City proposes solutions based on Enel's skills in the fields of energy and infrastructure. New solutions involve, for example:

- **Smart public lighting**

  Enel X offers solutions that strongly innovate the traditional public lighting system. Enel X uses LED lighting systems, with significant energy savings. This is integrated with other advanced systems, based on customer needs, like:

  - *Remote control systems*, for the timely monitoring of each light;
  - *Technologies to enable adaptive lighting*, to adjust the light intensity based on vehicle traffic flows, weather conditions and luminance to increase street safety and make the system's consumption more efficient.

  The solutions listed above primarily concern the street system, safety services and local monitoring. There is another area, linked to the city's artistic heritage, where Enel has gained notable experience: artistic lighting of monuments and historical sites – such as city centers, porticoes, churches, individual monuments, historical gardens, buildings, fountains. In these projects, the efficiency of LED and advanced technological standards come together with the aesthetic aspect of the art, opting for more natural light choices that enhance the characteristics of the artistic treasure.

- **The smart city and value added services**

  Public lighting is also the basic infrastructure on which further citizen services can be developed. e-City is developing new solutions for security, mobility and transport, environmental monitoring, connectivity, digital signage and many others. A few examples:

  - *Integrated video-analysis and/or sensor solutions* for services aimed at increasing the efficiency of road/city safety practices (detection and alerts for dangerous events, accidents, road violations…) and to support the monitoring of the area (vehicle traffic analysis, pedestrian flow analysis, environmental monitoring …);
  - *Connectivity solutions:* per fornire connettività WiFi ai cittadini e/o per incrementare le coperture delle reti di telecomunicazioni ultra-broadband fisse o mobili;
  - *Digital communication systems:* to allow Administrations and private companies to transmit informational and marketing content to citizens (LCD/LED panels, integrated holoprojectors, etc).

  There is then another level, even more general: the large quantity of sensors scattered around cities generate a continuous informational flow that could be a great opportunity for cities, if it is properly archived, processed and analyzed. So-called Urban management platforms can integrate data from many sources to generate analysis and suggestions, vital as support for the decisions of urban stakeholders, like institutions, citizens and the economic sector.

- **Energy efficiency services**

  Enel X's experience in energy efficiency technologies and services can also be applied to public administration buildings. In this area, e–City provides local institutions with national innovative solutions completely based on electric sources. This provides significant energy savings and reduced emissions and makes goals possible by increasing flexibility with solutions like demand-response and others at the same time.

2. **Smart Grids**

The cities of the future will have to combine economic growth, environmental protection, social inclusion, energy efficiency, digitalization and new technologies.
In the last century, energy distribution infrastructure was the most important technology for cities, allowing them to extend urban services, from cooking to lighting, from heating to mobility.

Today, smart grids are the main stimulus for the modernization of the electric system, with self-repairing design, grid automation and remote monitoring and control.

Today, smart grids are the main stimulus for the modernization of the electric system, with self-repairing design, grid automation and remote monitoring and control. They also inform consumers of their energy use, costs and alternative options, to give them independent decisions on how and when to use electricity and fuels. Finally, they provide safe and reliable integration of renewable and distributed energy sources.
Smart grids combine the use of traditional technologies with innovative digital solutions that make the management of existing distribution networks more flexible, through a more effective exchange of information. Electrical grids are renewed to better manage flows of electrical energy from all sources, optimize flows, enable the most modern technologies (like the electric car) and allow for active participation in electrical demand.

From the *Internet of Things to the Internet of energy*, where digitalization and convergence significantly improve the quality of the electricity supply service. These networks, based on the analysis of large volumes of data, increase innovation, connectivity and resilience.

The management of smart grids, efficient integration of distributed generation, active customers: Distribution System Operators (DSOs) can act as market facilitators and grid optimizers, thanks to the efficiency potential of their processes and activities. This is the main challenge for DSOs linked to the energy transition: to become Information Hubs and main agents of change for the modernization of technological networks.

For customers, it's a completely new experience: thanks to smart meters and digital communications, they can experience energy differently than before, using new products and services powered by electric sources, and have a key role in a more comfortable and sustainable lifestyle. Smart grids are key to the success of a new vision of the city – evolved, shared, sustainable and where customers can be main players in energy markets.

3. Urban Regeneration

In recent times, the industrial sector has seen numerous transformations and many production sites have been decommissioned because they are no longer competitive. This situation is a key challenge because of its economic, environmental and social implications. This is a topic that concerns the urban context directly, given that, especially in recent decades, many production sites have been built within city limits or have been incorporated in them.
This transformation naturally concerns the energy sector as well. In recent years, Enel - started the decommissioning of 23 thermoelectric plants for an installed capacity of roughly 13 GW.

Enel decided to manage this transition from a circular economy point of view by launching the Futur-e project to manage the decommissioning of this 23-plant portfolio in an integrated way.

The goal is to come up with new purposes for these sites, besides the production of electrical energy, that can create value for local communities, in line with the potential and priorities of the territory they belong to.

From the beginning, the Futur-e project was managed openly and transparently, with extensive - engagement with all local stakeholders. We launched competitions for ideas and projects, which were open to all, and we involved local and expert stakeholders in the evaluation phase. Only projects that are geared towards circularity and respect certain economic, environmental and social requirements make it to the final selection stage.
This circular approach to assets that are generally considered waste allows for the generation of economic benefits by developing infrastructure, buildings and manufactured goods, prolonging their lives and generating thousands of new jobs. The re-use of industrial assets also avoids the use of new land and reduces the use of new resources, to the extent that existing assets are reused, like buildings, connections to the electrical grid and gas, etc.

4. Supply Chain

Within *Global Procurement*, the evolution towards a circular approach requires a profound knowledge of material flows in terms of components, environmental impacts and recyclability of products. The Environmental Product Declaration (EPD) project fits into this context. The goal of these declarations, made voluntarily, is to quantify and objectify data related to the entire life cycle of our supply by referencing life cycle analysis on products.

The EPD is an effective instrument to highlight a company's commitment to reducing the environmental impacts resulting from its production cycle in relation to an asset or the provision of a service.

In addition, the supply chains considered by EPD, there are also actions that impact the urban environment, like the installation of charging stations for electric cars and optical fiber or the work on medium and low tension lines. Only with a structured and correct synergy between local public administration and Enel can we call for 'circular' agreements and protocols on the correct use of resources, waste management and the reuse of components from these activities.

It will be necessary to involve all the stakeholders (citizens, administrations, suppliers) for the promotion of virtuous and shared processes of the circular economy on the local level.

Examples of Enel's Circular Projects

Renewable Microgrid

New York (Stati Uniti)

One particularly significant example of renewable inputs is the Marcus Garvey project, developed in New York: a system based exclusively on the use of renewable energy and optimized to maximize the use of what is available. It's a cutting-edge project because it is **the first self-sufficient energy system in New York**, obtained through the creation of a smart microgrid, and demonstrates how, even in a metropolis, we can build a grid controlled in a smart, digital and distributed way, which increases the resilience of the system and transforms the energy supply chain.

An integrated system of photovoltaic panels and batteries will guarantee the **energy supply for 625 apartments in the Village**. Thanks to microgrid optimization software, it is estimated that consumption can be reduced up to 15% and will thus reduce greenhouse gas emissions. The system is also designed to have an emergency energy supply, in order to increase its resilience. The Marcus Garvey Village Apartments Microgrid project won the prestigious ESNA Innovation Award for its distributed storage.

Smart Public Lighting

Merida (Spagna)

This project is a case where we can extend the service life of assets by using new technologies and predictive maintenance.
In Spain, Enel runs **17 street lighting projects** equipped with remote control systems that manage about **70,000 light poles** with this system. Specifically, in the town of Merida, a street lighting project was created with LED technology and remote management with almost 14,000 lights.
The lighting apparatuses are connected to the management system with wireless RF (Radio Frequencies) communication, with an open communication protocol. Enel – which also holds the related IPR (Intellectual property rights) – developed the software that is used in the management system, called WeLight. Because of its technical characteristics, the system is a key instrument to optimize preventive and corrective management of public lighting networks.

Main advantages

- Visualization of georeferenced devices;
- Management of energy savings;
- Programming for lighting devices;
- Planning for control and maintenance;
- Detection of malfunctions;
- System reports (periodical reports);
- Backup of historical information.

Electric Mobility

Orbetello (Italia)

This project is an example of a product turned into a service, as customers can simply pay for their use to travel the distance they need to travel instead of purchasing a product (cars, bikes).

The sustainable mobility system includes the Isola del Giglio, Monte Argentario and Orbetello. The three towns, together with citizens and operators working in the area, will adopt an innovative plan that aims to create a system of alternative and eco-friendly transport for the first time.

The European Commission gave the green light to finance the implementation of the **Life for Silver Coast project pilot**, as part of the 2016 call for proposals concerning LIFE, the European Commission's program for the environment and climate action. The plan, with an estimated cost of over 5 million euro, is based on the use of electric vehicles that will make areas that are not covered by public transport easily accessible, especially for tourists.

Overall, the project calls for:

- Integrated systems for car/bike sharing: Electric cars, bikes and scooters, infrastructure for electric charging, service support IT platform;
- Electric shuttle service to connect Orbetello's train station to the center of the city;
- Virtual community for travelers that want to share their smart mobility experience on the lagoon;
- Electric boats to connect Orbetello with the two beaches of Giannella and Feniglia and to sail along the coast of part of the Isola del Giglio and Monte Argentario;
- Innovative hubs for electric bike deposit and charging.

Enel contributes to this project by providing vehicles, bicycles and scooters (all electric and shared), electric minivans for public transport, charging infrastructure and an integrated mobility platform.

Life for Silver Coast received financing from the LIFE program as part of the grant agreement No ENV-IT-000337. The project will have significant environmental impact: thanks to the new mobility system, **a reduction of roughly 1,200 tons of CO_2** is predicted. Significant results are also expected in terms of service usage: the plan calls for the **involvement of over 285,000 users** during its fulfilment and more than 350,000 after the test phase.

Demand-Response

An important example of sharing is the demand-response (DR) solution, where Enel, through the creation of a platform, allows the aggregation of consumption and/or generation resources from multiple clients to provide their services of reserve capacity or balancing to the electric system, able to generate value for those who own assets and increase the efficiency of the entire system.

A modulation event is typically characterized by the following steps:

1. The grid operator predicts a grid stability problem and sends the balancing notification to Enel, which acts as an aggregator;
2. Enel receives the balancing order and distributes it (by using implemented optimization algorithms) among the clients in its portfolio in order to reduce or increase energy consumption;
3. The designated Enel client adjusts its consumption and/its generation either automatically or manually;
4. The load modulation is made available to the grid operator;
5. Following a verification of the successful supply of the service, the Enel client receives the compensation agreed upon in the negotiation phase.

DR Italy

In Italy, Enel has - received **119 MW of flexibility** from its own industrial and commercial customers, demonstrating itself as one of the main players in the development and spread of new advanced energy services.

Leveraging on Enel X North America's experience and in continuity with what we are doing in other countries, we began in Italy with the construction of a capacity portfolio to implement demand-response mechanisms, with the goal of contributing to support grid stability through consumption modulation. With this new experimentation phase it was also possible to test the reliability of new demand-response services from Terna. Thanks to the intermediation of subjects like Enel X, several commercial and industrial customers received balancing orders to stabilize the grid, based on their availability to perform the service.

DR Ireland

At the Dublin airport, even energy travels safely. The Dublin Airport Authority (DAA), relied on Enel X's expertise to guarantee **flexible, sustainable and resilient energy management** to the Irish hub.

Ireland is paying attention to renewable sources, moving full speed ahead toward the goal of **producing 40% of energy generated in the country from green sources** by 2020. Last April, the Irish electric system set a world record, recording 65% energy from non-synchronous and intermittent renewable sources at all times of the day.

To balance energy supply and demand, grid operators rely on other flexibility sources, like demand-response programs, where customers with significant energy levels are compensated if they reduce their use during peak hours or in phases of frequency instability of the electrical system.
In perfect harmony with best practices in environmental sensitivity, the Dublin airport, since 15 May of this year, is participating, through Enel X, in the DS3 program called by the public operator EirGrid.

DS3 is a new program for ancillary services for large clients that quickly make available the flexibility of their own distributed generation assets in cases of frequency instability of the electrical grid. The DAA will contribute to providing more than 11 MW overall of flexible capacity, taking part in both the EirGrid program of ancillary services – launched in recent months – and in the future capacity market for Ireland and Northern Ireland (I-SEM), planned for next October.

Futur-e

Bari (Italia)

One example of giving value to an end-of-life asset is the Futur-e project, and one of its most representative applications in the urban environment can be found in the case of a former Enel plant in Bari.
The plant, in the capital of Puglia, was built in the 1950s in the neighborhood known as Stanic, in the southwest part of the city. Located in an area between center and the industrial zone, it takes up an area of about 7 hectares and is characterized by three groups of gas production. The plant stopped functioning in 2013 and was then included in the Futur-e project.
The plant is located in an urban environment and as such, is a case where the fate of an asset can be an opportunity for urban regeneration.
In 2016, **a consultation phase was performed with local stakeholders** to decide on priorities and needs, together with a context study carried out by the Milan Polytechnic.
In April 2017, **a project contest** was launched, open to whoever had projects to propose for the area. The contest came to an end in June 2018. Three proposals were selected, which will now be evaluated by a commission that includes Enel and several stakeholders. The proposals involve uses ranging from research, tourism, residential to commercial and food. One of the evaluation criteria, besides quality, sustainability and innovation, is also specifically 'circularity'.
In this way, an industrial asset that is no longer competitive will be transformed into an example of urban regeneration to redevelop the area and create new opportunities, of employment and quality of life, for the community.

End of life - Open Meter

(Italia)

An important example of enhancing end of life is **managing the replacement and recycling of first-generation smart meters**, also known as smart or electronic meters.
E-Distribution launched a massive replacement campaign for first-generation electronic meters, to be replaced with second-generation meters, called Open Meters. Started in 2017, the campaign covered **1.8 million smart meters** in the first year and is expected to reach about **31 million in the next 7 years**.
The meter is made up of roughly 65% plastics, with the rest mainly iron (12%), copper (7%) and electronic circuit boards (7%). These materials, when correctly recovered at authorized plants, become resources that are reusable in other production cycles.
Plastics are reused in various sectors, such as the production of accessories for the automotive industry, headlights, electric appliances, switches and specific electronic apparatuses. Of the metal components, iron is melted down and used in construction, copper is reused in the refinery, mainly to produce brass bars. From the circuit boards, finally, gold and copper are taken: the former is reused in jewelry, the latter goes to the refinery for brass production.
These virtuous behaviors allow us to **extract residual value from decommissioned meters** and reuse their components in new production cycles, saving them from the landfill and avoiding the waste of valuable resources.

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Cities of tomorrow

Circular cities