THE CIRCULAR CITY

THE **TRANSFORMATION** OF **MODERN CITIES** FROM **LINEAR** TO **CIRCULAR MODEL.**

CONTRIBUTION FROM **TECHNOLOGICAL** PLATFORMS.

sensoworks
SENSING THE FUTURE

SUMMARY

1. INTRODUCTION

Cities are the places where the concept of civilization takes shape. They are the birthplace of creativity and innovation and play a fundamental role in the global economy. In fact, 54% of the world population lives in urban areas and is responsible for 85% of the global GDP.

Modern cities produce for over 70% of global anthropogenic emissions and 75% of the total consumption of natural resources, besides being the cause of 50% of global waste production and 80% of greenhouse gas emissions. Between 1950 and 2005, the level of urbanization grew from 29% to 49%, while global carbon emissions from fossil fuels increased by 500%. This highlights how resource consumption and environmental impact follow exponential trends associated with unmanaged forms of urbanization, construction inefficiency and poor infrastructure use (read more on this topic, here).

*For these reasons, **cities represent a great opportunity for the development of a new vision of circular economy.** They have primary economic drivers and, therefore, they represent the chief physical and political engine for the transition to models of circular economy.*

The goal of this white paper is to show how an IoT platform integrates with the founding principles of the circular economy to provide an excellent all-round solution for strategic drivers.

Sensoworks' IoT platform in particular, not only can communicate with smart devices across the installed network, but it can also trace all the incoming and circulating information back to the "City System", so as to optimize all its outputs.

Hence, this white paper works into a broader business strategy and will be followed by other similar resources and activities, all aimed at informing our readers about use cases and technological advancements on strategic industries and markets.

If this work of ours helps you and your company better understand what your organization needs and where to direct your efforts, we will have achieved our key goal.

sensoworks

2. CITIES OF TOMORROW

A) A LESSON FROM SCI-FI

In the world of science fiction, many authors envisioned all kinds of future as social and technological evolution. This evolution, this kind of future, never overlooks the places where society blossomed and how these developed the civil structures to integrate technology and living habits in the best possible way. Isaac Asimov is regarded as the father of science fiction. He is the first author to have elevated science fiction to a high level of literature.

In his works, we find future and reality merged together with a touch of "plausibility", which gives us the impression that his writings could become reality in the near future. In The Caves of Steel and The Naked Sun, Isaac Asimov writes about a series of thrillers taking place in cities that inherit the urban and social ideals the architects of the past envisioned. In The Caves of Steel, Earth is overpopulated and technology rules the human lifestyle in all its forms. Cities are "caves of steel", they are covered and develop below the surface of earth. Humanity took cover underground and became agoraphobic. Everything is guided by technology: communication is ensured through conveyor belts that allow transportation from a place to another, food production is on an industrial scale, there are only public toilets and having a personal space is a luxury.

City culture meant optimum distribution of food, increasing utilization of yeasts and hydroponics. New York City spread over two thousand square miles and at the last census its population was well over twenty million. There were some eight hundred Cities on Earth, average population, ten million. Each City became a semi autonomous unit, economically all but self-sufficient. It could roof itself in, gird itself about, borrow itself under. It became a steel cave, a tremendous, self-contained cave of steel and concrete. (Isaac Asimov, The Caves of Steel)

Earthpeople (as opposed to Spacers, who conquered the galaxy and moved away from their mother Earth) do not approve of robots, namely machines with anthropomorphic features, and think that opposing them means defending the last remnants of humanity left. In order to support this kind of society machines are at the base of production. If this had to stop for even one day only, society would fall.

As opposed to this kind of city model, in Asimov's novels we also have Planet Solaria, mostly populated by anthropomorphic robots. Robots are the basis of Solarian civilization. For each human there are millions of robots at their service dealing with whatever they need and much more. Solarians don't meet in person. They "see each other from a distance". They live in mansions so large that the mere thought of human contact became horrifying. That's why they now only meet remotely through holographic projections - in a similar fashion to our life during the pandemic. Humans hide in full isolation while machines rule their existence. Their social life is minimal, almost to the point of non-existence.

However, men are well aware of the danger constituted by robots. Thus, they create the "antibodies" to technology, the so-called Three Laws of Robotics:

- «A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.»

These are the laws governing technology and can be applied to all the human contexts. Only with these

laws humans can follow technological progress without incurring in the danger of technology overthrowing humanity. It's an incredibly topical argument we should all pay attention to.

Now, we should stop a moment and ask ourselves: what is the best compromise between the two city models? Asimov answers us always considering the Three Laws:

«We have labored to produce a planet which, taken as a whole, would obey the Three Laws of Robotics. It does nothing to harm human beings, either by commission or omission. It does what we want it to do, as long as we do not ask it to harm human beings. And it protects itself, except at times and in places where it must serve us or save us even at the price of harm to itself. Nowhere else, neither on Earth nor in the other Spacer worlds, is this so nearly true as here on Aurora.» (Isaac Asimov, The Robots of Dawn.)

How to achieve this is still a subject of debate.

B) WHERE WE ARE TODAY

Today, many of the machines we find in old sci-fi movies are no fiction. We all remember the feeling of awe thinking about a potential future when we could control machines just with our voice - and they would even reply to us! Well, we don't need to remark how vocal assistants are real and in the house of many of us.

However, some of these technologies, applied to public services and utilities, can even amplify technological adoption to the whole community, rather than progressing individually according to pre-existing market conditions and philosophies. When this happens, we are in front of a new frontier: that of smart cities, a place where specific devices are able to detect and measure external stimuli and act accordingly.

Hence, a smart city could not exist without connectivity and data analysis. Fortunately, though, with technological progress, sensors became increasingly capable of collecting and generating incredible amounts of data, encouraging the market to further produce

faster and more innovative solutions related to connectivity, file storage and software platforms. For instance, devices can now not only connect among themselves, but they can also withdraw and deposit information from a secure virtual storage, namely the cloud. Humans and machines can securely upload and store files as they'd do with physical goods.

The same data are then analyzed by an advanced, central "brain" able to filter important information and even to learn from its own mistakes - thus further improving its performance through machine learning algorithms. This "brain", the data processing terminal, translates data into readable information for human operators, so that men still have full control over the algorithmic work of the machine, which notifies and alerts maintenance and security teams of everything that's going on.

Plus, these technologies are incredibly simple to use. Everyone can make the best out of it and start interacting with intelligent objects.

C) A CONNECTED NETWORK

Everything is connected. Everything generates information, communicates. This kind of network-shaped infrastructure allows the entire infrastructure to be sustainable (and not depending on a few scattered points) and secure (distributed information is the base of the blockchain theory). However, it requires worldwide broadband connectivity.

Given the strong technological advancement, we feel the need to unlock the potential of existing

and future technologies for our societies and communities. We think this is the reason that pushed us into talking about Circular Cities, a new concept of city, where things are not only improved and more efficient, but they are also connected to provide better services.

In the Circular Era, we all have the duty to redesign our spaces, environments and relations. Not through our technical expertise. But rather, with our imagination, sensibility and verve to develop tomorrow's successful applications.

3. ECONOMIC MODEL

A) LINEAR CITIES

In brief, the linear model of consumption is a type of economic system that follows the so-called "take-make-waste" pattern. That is, raw materials are extracted (take) to produce materials or goods (make) only to dispose of them when these end their lifecycle (waste).

The linear model's main goal, hence, is profit making. This channels the maket's efforts into mass production and, at the same time, into selling products at the lowest possible cost.

The key elements of this model are based on an input-output pattern, where the necessary inputs feed the production process (capital, labor, raw materials and energy) to produce the outputs to be sold on the market.

Thus, the main steps a linear model of consumption follows are:

- **TAKE:** extraction of raw materials
- **MAKE:** transformation of raw materials into finished products
- **WASTE:** disposal of the finished products (and production of waste)

A central role in the linear economy is played by the market and its strong competitiveness, which dictates the rules of both production and trade. The relation between supply and demand foresees an infinite linear model in that products in a linear economy soon become obsolete (planned obsolescence). This means that consumers will find it more convenient to buy new products - often according to transitional trends - rather than recycling or repairing old ones.

The linear economic system involves a series of consequences that are not always taken into consideration, such as the environmental impact and the limited supply of natural resources used for production.

B) CIRCULAR CITIES

According to the Ellen MacArthur Foundation a circular economy is:

"A generic term to define an economy regenerative by design. In a circular economy, there are two flows of materials types: biological ones, able to be put back in the biosphere, and technical ones, destined to be re-used without entering the biosphere"

The circular economy is therefore an economic system designed to reuse finished materials in subsequent production cycles and to minimize waste. The circular city is a strongly integrated concept that touches on many aspects of everyday life. This model cannot be applied to a single sector without involving others.

The principles of this model are:

- **Sustainability**
- **Sharing**
- **Extension of service life**
- **Recycling**

These principles can be applied to every organization or entity.

Sustainability refers to the ability of a system to self-feed, as shown in the Grassman diagram below where you can see how the output is reused and reverts into the system. This way, the system becomes totally sustainable. Here, we can also apply fundamental industries and concepts such as renewable energy and energy efficiency.

INPUT
raw materials

System of consumption

OUTPUT
raw materials

Sharing means that each product is intended as a service. A clear example is car sharing, an already widespread phenomenon in the main European and global cities. Sharing a service means that the life of

each asset is extended and spread proportionately, guaranteeing greater sustainability to the whole system and production chain.

Extension of the service life aims at the optimization of consumption so that products can have a longer life than usual. Here, we find all the monitoring and tracking systems designed to improve the durability of products.

Recycling is the foundation of the circular economy. It involves the re-use of raw materials into a new production cycle at the end of the product's life. What was mere waste in a linear economy, in a circular model becomes new raw material to give life to new products. Recycling also involves concepts such as waste separation and management, limiting waste production and making scraps and trash a new resource for a whole new - circular - design of the production chain.

This way, we can move away from all the principles of linear economy - that is the maximization of profits, the minimization of production costs and the exploitation of (limited) available resources - to
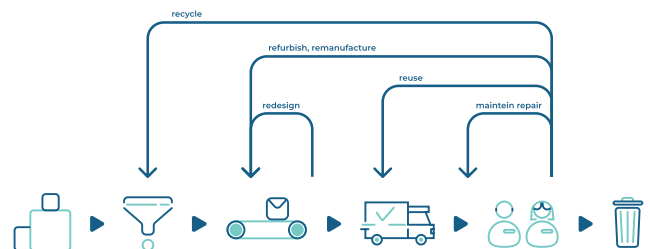
introduce an ecological transformation in all the production stages with an eye to resource, energy and waste management.

In a circular model of consumption, everyone has a role: from consumers who will have to dispose of waste in a way suitable for recycling, to those who manage waste and to companies, called to invest in and carry out a process of innovation and technological development - with high margins of margins in the long run too.

4. TECHNOLOGY ENABLERS: SENSOWORKS PLATFORM

The great tech developments at the IT (new software programs for data processing, incredible speed for internet data transfer) and technical levels (data storage, manufacturing of miniaturized sensors to be installed in the most peculiar contexts) allowed for the development of technological solutions we could not even imagine just 10 years ago.

Sensoworks is an IoT platform entirely developed by us which can monitor and communicate with any smart device and quickly process the collected data through advanced algorithms increasingly depending on machine learning to train independently. Moreover, the platform provides our customers with extremely precise answers, pointing out the exact point in need of attention and maintenance.

Sensoworks allows for the definition of classes of devices, empowering the users with global monitoring capabilities and to define their KPIs to measure the main parameters of their ecosystems. Adding new modules or classes is as flexible as it gets. The scalable design of Sensoworks' IoT Platform allows users to always add new settings at a later time.

However, going back to our main argument: what is Sensoworks' position in the transition scenario? What is the added value it can bring to this economic-cultural transformation?

Sensoworks' platform can be applied in both the economic models (linear and circular). We see this as our chance to prove that a circular model of consumption is more sustainable than a linear economic system and that companies would benefit from the former in terms of money as well.

Sensoworks has a key important feature in today's technological landscape: it acts as a systems integrator. It allows a large number of different tech systems and devices to collaborate, scaling up the whole ecosystem and making it universal.

A) SMART DEVICES

Smart devices are all those electronic instruments capable of bidirectional communication with Sensoworks' platform. Bidirectionality consists in the device's capability to receive and transmit information.

Under this definition, everything can become "smart" by means of appropriate sensors and a PLC (Programmable Logic Controller). The PLC must be able to process and send raw data to the platform.

Data transfer exploits connectivity technologies since data is sent to the cloud system where Sensoworks works.

A trash bin can become a smart device in an IoT ecosystem. With sensors we can always know, for example, its location or weight and send all these necessary data to the process terminal.

B) CONNECTIVITY

Connectivity is essential in urban areas connected to an IoT system. The connection between devices and the cloud is divided into two main types:

Cable, where the data travels inside a physical cable (copper coaxial cable, optical fiber, etc.);

Wireless, where data travels in the shape of electromagnetic waves.

These two kinds of data transmission are not mutually exclusive. The signal can be converted

without loss of information, for instance with FWA technology (Fixed Wireless Access).

In recent years, many cities adopted optical fiber connectivity, allowing a greater amount of data to travel at a higher speed through cables. At the same time, wireless technology such as FWA is common in digitized environments. With these technologies, we'll be able to exploit 4G and 5G connectivity very soon.

When 5G will be available, we'll also be able to stretch the IoT concept to the extreme. The amount and speed of transmissible data will allow the automation of many daily actions such as autonomous driving or smart parking, together with many other applications we will entrust to artificial intelligence, all supported by Sensoworks.

C) BENEFITS

Why use Sensoworks in the transformation from a linear to a circular city?

First of all, to change the greater we need to start from the smaller. Communal services, domestic or office utilities, all the way to more complex activities regarding schools, buildings, the public administration and collective communities and neighborhoods.

People want to see the potential benefits of a change before this happens. That's why we think it's necessary to provide our community with a platform that simulates the behavior of the new economic system and compares it to the current situation. To do so, we need to analyze the current circumstances of the system, such as energy consumption, sustainability and technological adoption.

Sensoworks does this and more. It takes a snapshot of the system before designing an alternative and compares it with a before-and-after approach.

Furthermore, Sensoworks can also integrate different technologies and platforms that speak different languages. Meaning that Sensoworks can retrofit every system with its built-in tools.

5. SENSOWORKS: PROJECTS & USE CASES

The following case studies offer an overview of how Sensoworks can be applied in the various industries of a circular city.

A) SENSOWORKS AND WASTE MANAGEMENT

Waste management consists of all those actions aimed at waste collection and segregation. This case study is addressed to all the organizations dealing with such activities.

Sensoworks Waste Management solution employs a series of sensors that allows the waste management company to monitor in real-time the status of the bin and its content. Below, a rendering of the smart device installed inside a waste container.
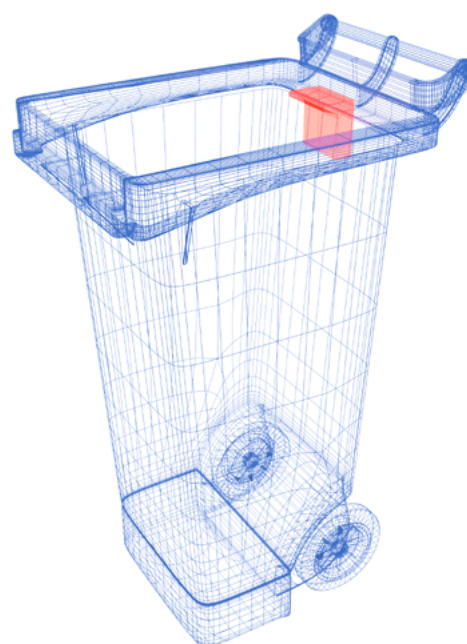
The device is installed on the inside of the container's lid so that Sensoworks can detect:

- Volume of contained waste;
- GPS position;
- Potential overturning;
- Shock, fire and damages of different nature.

Data is sent to Sensoworks' platform in real time where it is elaborated and shown on a dashboard the end users can configure as they prefer. When received the data, Sensoworks provides the following services:

- It shows the volume of contained waste;
- It notifies the user of potential overturning;
- It notifies the user the presence of fire;
- It calculates the best collection route for garbage trucks;
- It notifies the user of potential overturning;
- It generates statistics of produced waste per area

The services proposed by Sensoworks work in line with the principles of a circular economy. It guarantees waste collection efficiency and cuts the cost of energy and effort needed to ensure the service, besides tackling vandalism with immediate alerts on fires and damage to the containers.

This system can be upgraded with tracking and monitoring solutions for street sweepers and garbage trucks with the following services:

- Monitoring of vehicle consumption;
- Calculation of the best route to follow;
- Monitoring of the volume of waste contained in the truck;
- Statistical analysis and calculation to optimize the costs of the waste collection service.

Being an all-round, end-to-end solution, Sensoworks touches on the many aspects of an IoT solution, not only from a technical point of view, but also with an eye on cost saving and energy efficiency.

That is why we can't see the end of the Sensoworks' possibilities in its many applications.

B) SENSOWORKS IN WATER LEAK DETECTION

Knowledge of the availability of resources is fundamental to sustainable management. Automatic measuring instruments, measurement techniques based on satellite observations and mathematical models, allow us to know the availability of water resources, to identify stress conditions and to intervene in a conscious way.

Sensoworks aims to dynamically and continuously identify structural anomalies in the monitoring of a water system. Specifically, it uses machine learning algorithms for leak detection.

The objectives are:

- Leak detection on cast iron and/or plastic hoses.
- The development, aggravation, of the rupture affecting groundwater discharges.
- Setting up a system of dynamic thresholds to report abnormalities following a loss with optimization of false positives.

The water loss from a pipe is normally caused by corrosion due to stray currents, by a failure of the pipe of a physical nature, by a incorrect welding of the pipes or by a physical failure of the pipes; the leakage of water from the hole produced by

rolling produces a noise that may have different qualitative and quantitative characteristics due to different variables, the main of which are:

• Working pressure
• Material
• Type of fracture
• Distance from listening spot to loss
• External environment

The noise (frequency) caused by the leakage of water propagates towards the surface of the ground and along the pipe itself, therefore the medium of propagation of ground and pipe noise will be fundamental for the qualitative and quantitative transmission of the same.

The implemented algorithms apply the method of mutual correlation, based on the analysis of the noise generated by the presence of leaks and transmitted by the pipe itself, captured by sensors placed in contact with the pipe (accelerometers) or intrusive directly in contact with water (hydrophones).
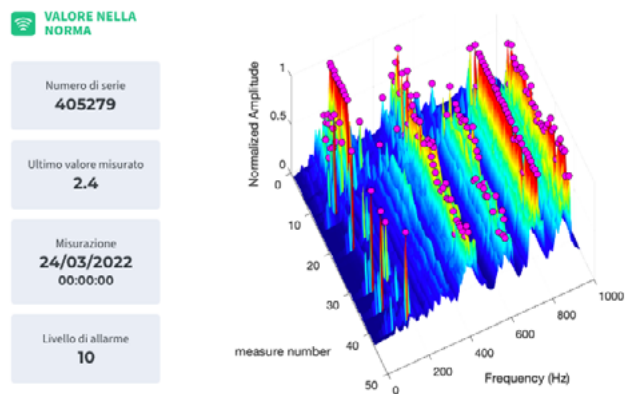
C) SMART MOBILITY

In 2020 alone, 14 milions cars were scrapped in the USA, 8 millions in Europe and 500,000 in Italy. Each year, end-of-life-vehicles generate between 7 and 8 million tons of waste in the European Union. These numbers should give us an idea of the problem's dimension when it comes to car scrapping.

The number of vehicles, indeed, is exponential if we consider it in individual terms. Virtually, to be free to move around the city, every citizen - or every household - should have a car. Just imagine what this means for highly dense city centres such as capital cities and metropolises!

However, as usual, for every problem there is a solution. In this case our solution is smart mobility. This is a sharing strategy in which a means of transport is shared with the community.

It answers people's need to move within an urban center without having to necessarily buy a new car.

Sensoworks supports smart mobility. Our platform tracks and manages the fleet of vehicles (which, in this case, constitute the intelligent element) for sharing and leasing companies. With vehicles we intend not only cars, but also motorcycles, bicycles, scooters and every means of transport that allows users to move inside the urban and extra urban context.

Furthermore, Sensoworks produces customized statistics on each means of transport in order to optimize maintenance and, therefore, to extend the service life of the vehicle. Thanks to predictive algorithms, it can notify the service manager in advance whenever there's the need for ordinary and extraordinary maintenance.
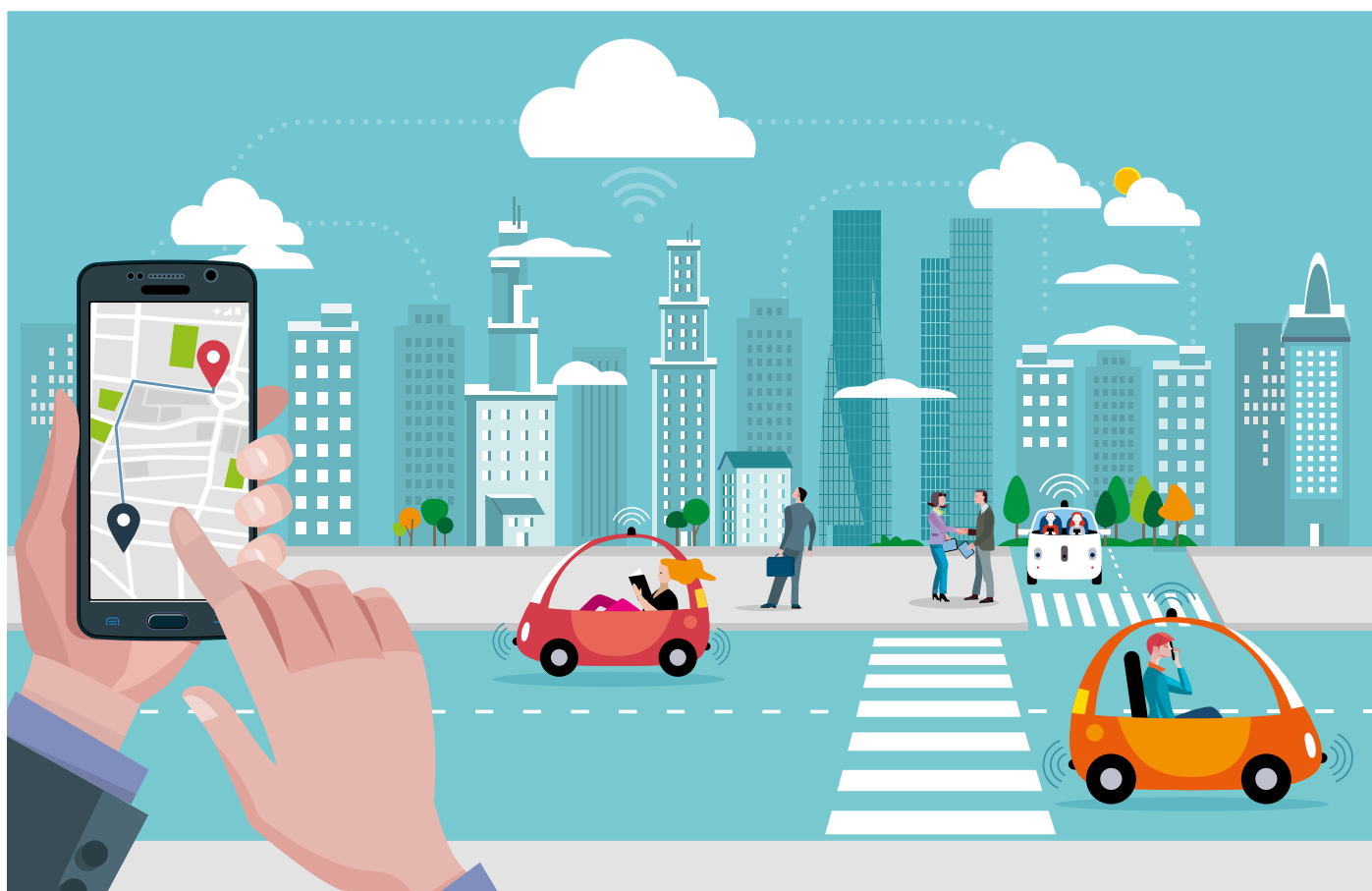
D) HOUSEHOLD APPLIANCES

Sharing one's own appliances might sound strange at first, but in reality is an efficient way to improve the service life and the energy consumption of household appliances.

The idea was born out of two main reasons: the fact that each family has an average of 20 to 30 appliances in their house, which are left turned off for about 67% of their life cycle and that, although only 5% of electronic waste is disposed of on a global scale, this often happens through illegal practices of transportation and disposal in poorer countries.

The way this kind of sharing works is through the provision of appliances such as washing machines or tumble dryers by a third party - manufacturers or resellers - to buildings or communal residential areas. The providing company will then take care of maintenance and disposal. This latter, in particular, will be handled more efficiently and sustainably than in the case of private, individual use.

On the other hand, families and users will be provided with an electronic card to access the shared service in exchange for a fee - such as a laundry service fee, for instance, which is cheaper than buying and running a washing machine individually.

Sensoworks supports this new sharing frontier with the possibility to track and monitor domestic appliances constantly and in real time. Here, predictive maintenance algorithms will also work to extend the service life of the shared machines. The platform, indeed, will notify the managing company in case of maintenance needs.

When it comes to sharing, Sensoworks knows no limits.

E) GREEN AREAS

Lhe management of Municipal green areas requires the use of appropriate techniques to avoid waste of resources and, above all, damage to an irreplaceable environmental heritage.

The Green Monitoring and Management Programme is aimed at the care, conservation and protection of the city's plant heritage, with the main objective of increasing its effectiveness and efficiency, reducing as far as possible the energy inputs required for maintenance and the production of waste and waste resulting therefrom.

Sensoworks is an application software solution for managing the monitoring of public parks and green areas.

The platform provides surveillance, video security and maintenance services, managed through a web portal that enables integrated usage.

The monitoring is generally implemented through the use of IoT sensors of different types, useful for the evaluation of parameters such as soil humidity, air quality, temperature and vegetation status, etc.

This information, integrated with satellite data, allows to extend the point data and to have a more extensive view.
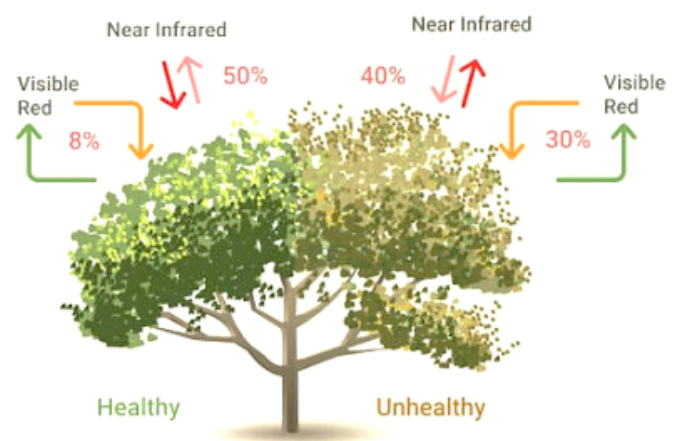
Sensoworks supports the following activities:

Identification and digitalization of the geometry of monumental trees within a municipal area.

Cataloguing according to tree type. Creation of a Geographic Database for data storage. Any other cartographic elements of interest (delimitation of parks, identification of roads and buildings) can be inserted in the Geodatabase.

Identification of vegetation indicators using satellite data. Subsequent allocation of the tree's Vegetation Index.

Service for detecting recurrent changes through automated analysis of changes in vegetation indices.

Recurring Change Detection service through automated analysis of changes on satellite images to identify any changes in the dimensions of the tree crowns.

6. CONCLUSIONS

This white paper wants to introduce the opposing concepts of linear and circular cities and economies, stressing on the reasons why circular cities are the only way to reach a truly sustainable world.

Just a few years ago, circular cities were abstract, utopical, something we could only write books and comics about. With the advent of new data transmission technologies, such as wi-fi and the optical fiber, the speed of data transmission increased exponentially and favored the development of 3G, 4G and, soon, 5G technologies. In these conditions, Sensoworks' IoT Platform finds fertile ground.

Before illustrating the applications of the Sensoworks platform, linear and circular consumption and economic models were described:

Linear cities represent the old economic model based on the exploitation of resources for mass production and production of massive quantities of waste.

This model must be replaced by the new circular model, based on sharing, optimization of consumption and recycling of waste. Sensoworks can play an important role for the organizations involved in this transformation.

How does a tech company like Sensoworks can support in this scenario?

Today, people want to know the benefits of a transformation, of an investment. Otherwise, why should they change the model they're accustomed to? Public opinion has become increasingly sensitive to the problem of climate change precisely because the effects are increasingly evident.

Sensoworks makes the benefits of this economic and cultural transformation tangible, both in economic and environmental terms. Using appropriate sensors and through simulations and real time graphs, Sensoworks shows the convenience of this change.

Sensoworks works as a magnifying glass for every organization that follows a linear economic model but wants to convert to a circular model. It not only shows the final results, but constantly monitors the KPIs of every organization, so as to adapt to every environment and take corrective action when needed.

The modularity and flexibility that distinguishes Sensoworks makes it an ever evolving platform. Indeed, Sensoworks can act as a system integrator with a wide range of technologies, architectures and devices, and as an enabler for new, innovative city services.

Today, we still don't know the limit of its applications.

Contact us to learn more about how to implement circular projects, and a free, custom demo

info@sensoworks.com

sensoworks

SENSING THE FUTURE