D2.4 Technology Watch and Future Trends Plan I

Authors: Salomé Reíllo

Date: 31.10.19

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824478.

Full Title	**Promoting the international competitiveness of European Remote Sensing companies through cross-cluster collaboration**		
Grant Agreement No	824478	**Acronym**	PARSEC
Start date	1st May 2019	**Duration**	30 months
EU Project Officer	Milena Stoyanova		
Project Coordinator	Emmanuel Pajot (EARSC)		
Date of Delivery	**Contractual** M6	**Actual**	M6
Nature	Report	**Dissemination Level**	Public
Lead Beneficiary	AVAESEN		
Lead Author	Salomé Reíllo	**Email**	sreillo@avaesen.es
Other authors	Nico Thom (Evenflow), Peter Baumann (Rasdaman), Stasa Stojkov (Biosense), Emmanuel Pajot (EARSC)		
Reviewer(s)	Gediminas Vaitkus (Geomatrix UAB)		
Keywords	Technology Watch, Future Trends		

Document History

Version	**Issue date**	**Stage**	**Changes**	**Contributor**
0.1	08/08/2019	Draft	First version	AVAESEN
0.2	15/10/2019	Draft	Contributions received and new contents included by lead author	AVAESEN, EARSC, BIOS, EVRS, EVF
0.3	23/10/2019	Draft	Contributions received and new contents included by lead author	AVAESEN, EARSC, BIOS, EVRS, EVF
0.4	28/10/2019	Draft	Last comments received	AVAESEN, EARSC, EVF
1.0	31/10/2019	Final version	Comments from the reviewer included	AVAESEN, EARSC, EVF, Geomatrix

Table of Contents

Table of Figures

Table of Tables

Executive Summary

This deliverable comprises the first Technology Watch and Future Trends Plan of the PARSEC project. The purposes of the document are the following:

1. To identify a list of technologies to be analysed and monitored about the PARSEC focus industries: Energy, Environment, Food and Earth Observation and associated technologies (such as e.g. AI, Machine Learning or Big Data).
2. To give an overview of emerging technology trends in the PARSEC focus industries based on internal expertise.
3. To detail how the technology watch and future trends analysis is going to be updated through:
    - The monitoring of identified sources by specialist partner on the focus industries
    - Sessions at key industry events during the project
    - A web-based open consultation process

The contents of this document will help to the following profile of entities/stakeholders:

- To the potential beneficiaries of the project (start-ups, entrepreneurs or SMEs) to identify business opportunities
- To Big Corporates, industrial and end-users to see how to solve challenges or to propose challenges to be solved by potential beneficiaries

1 Technology Watch and Future Trends Plan Strategy

PARSEC will involve a broad range of stakeholders, from SMEs to investors and from policy makers to industrial end-users. All these stakeholders are part of an integrated ecosystem which can greatly benefit from Earth Observation (EO) as a key tool for evidence-based decision making.

EO-based services and products provide value across a wide range of application areas in Energy, Environment and Food sectors, including i.e. sustainable agriculture, climate change adaptation, forest management, renewable energy, pipeline monitoring, water quality monitoring.

This value is being increasingly appreciated and sought, owing to the technological developments in remote sensing but also in big data processing. PARSEC will set up a Technology Watch that will closely monitor the development of EO-capabilities and associated enabling technologies (e.g. Big Data cubes, Cloud resources) in support of the key emerging industries (food, energy, environment). It will also closely follow the evolution of the “tiered landscape”, which – especially through Copernicus Data and Information Access Services (DIAS) – will drive the development of EO services in Europe for the next decade.

To identify and prioritise future technology changes and innovations foreseen of potential benefit to SMEs in the cross-border and cross-sectoral ecosystem, PARSEC will:

(i) capitalise on the strong expertise within the consortium
(ii) exploit the strong links with key stakeholders from the EO sector (e.g. ESA) and the key emerging industries (e.g. Energy in Water ESCP-4i; WindEurope, OGEO, etc.)
(iii) systematically collect insights from the greater community. PARSEC will attend workshops and sessions of major industry events targeted at each of the three emerging industries (food, energy, environment) so as to gather the insights of their stakeholders and deliver the outcomes of the watch. Links will be established with other organisations that are developing relevant Foresight Plans (e.g. JRC on research needs for 2050 and safety & nutrition needs for 2050).
(iv) a web-based open consultation process will be held towards:
    a. fine-tuning the features of the Technology Watch and Future Trends Plan in accordance with the feedback by participants
    b. raising awareness across actors in different value chains.
(v) generate and share a wiki-style library of these technologies online via the project website, for access to PARSEC beneficiaries and other stakeholders.
(vi) in the wiki-style library we will includ the connection of challenges in Energy, Environment and Food Sectors with solutions using EO.

2 Analysis of Monitored Technologies based on expertise on the consortium

2.1 Trends, technologies and outlook in the EO sector and associated enabling technologies

The EO ecosystem can be defined as an interconnected set of 3 main layers:
- the Resources tier providing access to data and IT capabilities
- the Exploitation tiers providing access to tools to create added value products or services
- the Knowledge tier providing access to information to develop promotion and sales.

2.1.1 Resources tier

Resources tier is composed of the infrastructure and the EO data which will be consumed by users in order to create an added value service. Both showed significant changes within the previous years, opening up news capabilities for users.

Processing on DIAS instead of download is useful for large-scale services, besides there can be limitations on cloud-based production imposed by certain clients. Also cost-efficiency of DIAS-based services may be considerably lower. Local processing is an alternative to DIAS processing. However, with DIAS platforms, large-scale services based on Big Data became technologically feasible.

Data can be commercial or available under a free and open data policy (e.g. Copernicus, Landsat). On the commercial side, small (or cube or nano) satellites characterized by a low mass and size compared to traditional satellites are a potential game changer. A major player in this market is Planet Labs (US company) which, in September 2018, launched a total of 298 satellites called doves, of which 150 are still active ("Inside Planet Labs' new satellite manufacturing site". *TechCrunch*. 2018-09-14. Retrieved 2019-09-06.). Potentially designed for a specific onboarding a dedicated sensor, these small satellites may play an important role in the set-up of large constellations of several hundred unit to improving the revisit time between two acquisitions. In addition of these, few tens of traditional size satellite will be launched (e.g. 60 Worldview Legion by 2026).

While the deployment of the first generation of Sentinels is approaching its completion, the intense use and increased awareness for the potential of Copernicus have generated great expectations for an evolved Copernicus system (CSC Expansion programme). Emerging and urgent needs for new types of observations have been consolidated in a distinct set of requirements which are addressed by six new potential Copernicus Sentinel missions, so-called High Priority Candidate Missions (HPCM), as follows: Anthropogenic CO2 monitoring mission (CO2M), High Spatio-Temporal Resolution Land Surface Temperature Monitoring Mission (LSTM), Passive Microwave Imaging Mission (CIMR), Hyper

Spectral Imaging Mission for the Environment (CHIME), L-Band SAR Mission (ROSE-L) and the Polar Ice and Snow Topographic Mission (CRISTAL).

This tier is very dynamic and drastic changes occurred over the last few years. Copernicus and its related infrastructure highlight these changes. Further to the launch of Sentinal-1 in April 2014, and furthermore of Sentinel-2 in June 2015, Copernicus data were difficult to access. Several countries have set-up national platforms (e.g. CODE-DE in Germany, PEPS in France). Using the free and open data policy, new cloud providers, Amazon and Google, started to provide access to Copernicus data. In 2018, the European Commission has implemented the Copernicus Data and Information Access Services (C-DIAS). All these new ways to reach the data encourage the development of new applications supported by the digitalisation of our societies as well as business processes and impact the Earth Observation and Geo-Information sectors.

Borders between sectors have changed and may have disappeared. Crosscutting approaches are now sign of a new industrial/data revolution. As an example, Amazon is providing a Ground Station tool as a Service, allowing to reduce the number of interfaces to program, to reduce the cost, to acquire and receive a data on a specific area of interest. As much more tool, components will be available through online platforms a challenge will be interoperate access to platforms and to develop the trust of the user (service provider or end-user) on reliability, privacy, liability, usability and inclusiveness.

2.1.1.1 Example: MultiCloud

MultiCloud – rising trend of using and managing multiple Cloud services from more than 1 service provider. Companies that use multicloud approach do that for many reasons:

- Security
- Vendor lock-in
- Flexibility
- Data sovereignty
- Geographical advantages
- Financial reasons

A MultiCloud approach allows companies to more easily and quickly respond to vendor lock-ins. Thanks to this approach companies have more flexibility in choosing service providers, picking only those whose services suit company best. Certain laws require enterprise data to physically reside in certain locations, a MultiCloud approach can help solve this problem by choosing a service provider with data center locations complying with the law.

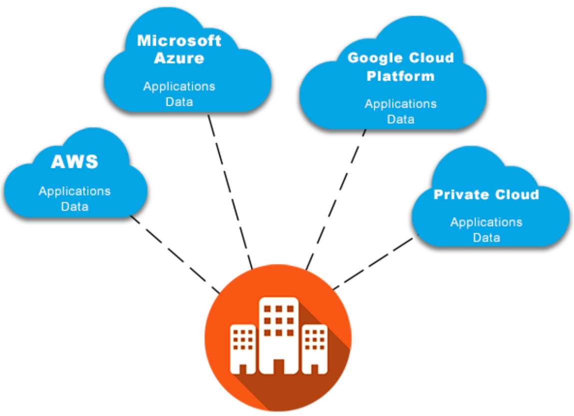

Figure 1: Example MultiCloud diagram

[img. https://avinetworks.com/glossary/multi-cloud/]

2.1.2 Exploitation tier

With a significant increase of potentially available EO data, users will have to manage its diversity (format, radiometric and geometric accuracies). Furthermore, to maximize its value EO data should be crossed with in situ data (e.g. sensors in fields, onboard equipment) having a drastic different resolution (spatial, time). New processing approaches are needed. Big Data and digital technologies, such as Artificial Intelligence (AI) or Deep Learning, as well as hardware and materials technology breakthroughs are foreseen to be key components of future capabilities to better connect infrastructures and users-ecosystems.

“Big Data” refers to datasets whose size is beyond the ability of typical computer networks to transfer within a reasonable time frame and typical software tools to process, store, manage, and analyse. This definition is intentionally subjective and incorporates a moving definition of how big a dataset needs to be in order to be considered Big Data. Simply making such data more easily accessible to relevant stakeholders in a timely manner can create tremendous value. Big Data enables companies to create new products and services, enhance existing ones, and invent entirely new business models. It will allow the development of new opportunities for research, development, innovation and business. It is characterized by the so-called four V’s: volume, velocity, veracity and variety and may bring significant value (commonly referred to as the fifth V).

The combination of different EO data such as low resolution and high resolution or of satellite EO data with another kind of data (aircraft, drone, crowd, or in-situ measurements) will maximize the benefits. The combination of different data sources to develop services fitting the need of a customer is a complex topic. Each case is specific needing a significant level of R&D. New algorithms and approaches will be needed to support this trend furthermore if real-time is needed.

One of the biggest opportunities for the geospatial industry is Artificial Intelligence (AI) as a core asset for image analysis and information extraction. The new algorithms are enabling the effective processing of more and more data. Concurrently, there is a revolution in the business approach that is required to serve customers with the best results at the right cost and price.

Progress in AI will derive from more accurate algorithms, supported by specialised hardware solutions, that make AI systems explainable, fair, scalable to huge volumes of data (Big Data classification), able to tackle a wider range of problems and transfer knowledge from one task to another, adaptive in dynamic environments, and increasingly context-sensitive. As these processes become ever more accessible, more and more processing will be able to be achieved on instruments themselves, reducing up/download rates and allowing closer to real-time data access. Further investment in these technologies will be assured in the next years, including computing, communication, and sensor technologies, to make the results of research available in commercial applications and disruptive technologies.

Cloud applications are challenging traditional thinking about information technology (IT) infrastructure performance, as well as the availability and accessibility of information for key data management and delivery mechanisms. Cloud computing is designed to treat IT as a scalable service rather than an institutional infrastructure. Scalable services have the ability to dynamically increase or decrease capacity to match user demands, leverage shared technologies and hardware, and ultimately realize economies of scale. Service-oriented architecture is adopted in Cloud Computing and enables a reduction in business up-front investment in hardware, through development of a range of facilitating services, including Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). An increasing amount of data is today stored in the Cloud. There are several advantages, including the opportunity to access, adjust and share information more efficiently. This means that multiple users/services can rely on the same physically stored representation of data, reducing the' risk of old/corrupted local versions (inconsistencies) of data being used in data analysis processes, and increasing economies in data storage (e.g. by reducing redundancy). Storing and using data in the Cloud enables everyone to work under the same conditions, and to share the same information. Blockchain and other distributed ledger technologies that offer openness to users will increase in relevance and wide uniform (safety) standards for verification. Self-certification for products or services should be systematically favoured.

Data revolution needs coordination. The main challenge today will be increasing the robustness and reliability of advanced computing solutions, both when they operate in isolation and as part of integrated ecosystems, to increase citizens' trust and sense of participation in an EU-centred sovereign ecosystem of data and computing resources. Some technologies will directly impact geospatial standards and interoperability, others lead to new operational environments that will drive requirements and use cases. The trade-off between the benefits delivered through highly specialised data services and the data privacy concerns that come with these algorithms will come to the fore of societal discussion. Technology-powered companies that innovate for sustainability will prosper on the global arena, while open source-based technologies will create new models for growth to compete with commercial applications that can build war-chests for advertising and publicity.

2.1.2.1 Example: Containers technology

Containers are packaged applications that can be run isolated from other processes. Container orchestrators are applications that automatize the management / scheduling the work of containers for apps based on microservices. These orchestrators manage such tasks as: health check of containers and hosts, load balancing of service discovery, provisioning and deployment of containers; and many more. To the most popular container orchestration tools we can count Kubernetes, Docker and Helios. It's important to keep track of how the containers and tools to automatize management of containers evolve in the future.

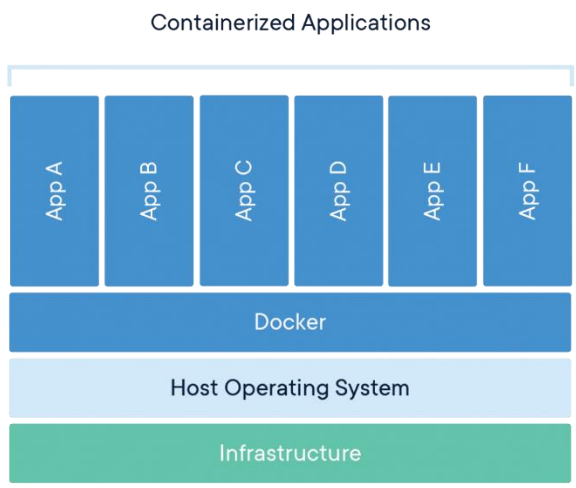

Figure 2: Docker container architeture

[img. https://www.docker.com/resources/what-container]

2.1.2.2 Example: Processing frameworks

Processing frameworks compute over the data in the system, either by reading from non-volatile storage or as it is ingested into the system. Computing over data is the process of extracting information and insight from large quantities of individual data points [1]. The most popular processing frameworks we include e.g. Apache Spark, Apache Storm, Samza, Google BigQuery and leading in popularity Hadoop.

Hadoop is an open source processing platform whose main purpose is management of data processing and managing storage of Big Data. One of Hadoop's advantages is that it's able to store and process data types (structured and unstructured) giving it's users more processing and analyzing flexibility than e.g. relational databases provide. Two main components of Hadoop are: 1) HDFS - distributed file system designed to run on commodity hardware. It has many similarities with existing distributed file systems. However, the differences from other distributed file systems are significant. HDFS is highly fault-tolerant and is designed to be deployed on low-cost hardware. HDFS provides high throughput access to application data and is suitable for applications that have large data sets. HDFS relaxes a few POSIX requirements to enable streaming access to file system data. HDFS was originally built as infrastructure for the Apache Nutch web search engine project. HDFS is an Apache Hadoop subproject [2].
2) MapReduce - software framework for easily writing applications which process vast amounts of data (multi-terabyte data-sets) in-parallel on large clusters (thousands of nodes) of commodity hardware in a reliable, fault-tolerant manner [3].

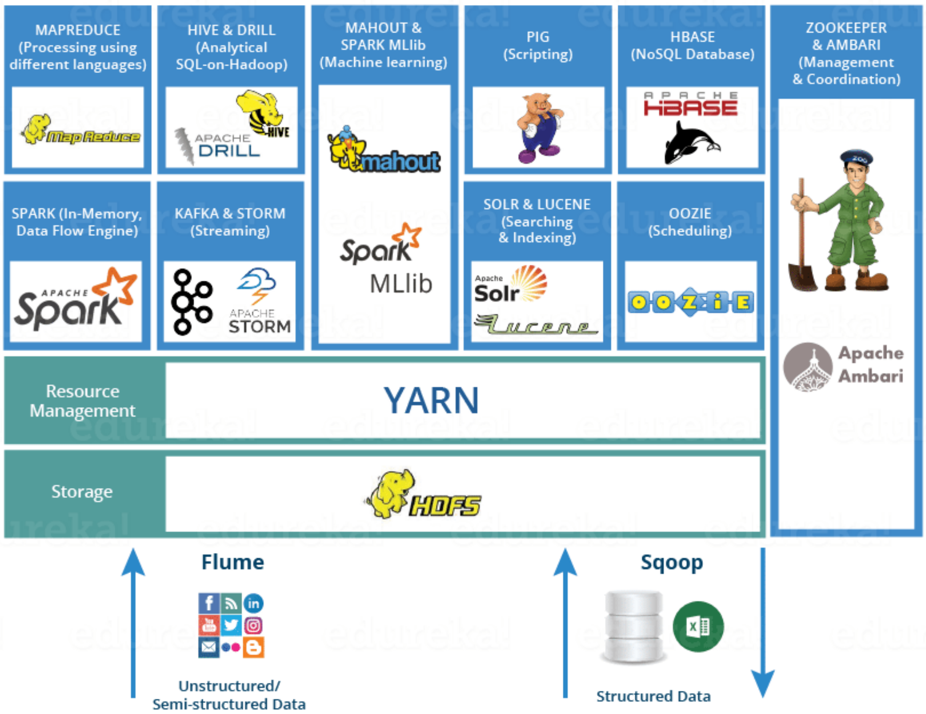

Figure 3: Hadoop ecosystem

[img. https://www.edureka.co/blog/hadoop-ecosystem]

2.1.2.3 Example: Clustering tools

RabbitMQ is a messaging broker - an intermediary for messaging. It gives your applications a common platform to send and receive messages, and your messages a safe place to live until received. This simple concept makes RabbitMQ an ideal tool for automated scaling simple processing tasks and complicated processing chains on cloud-based HPC platforms.

RabbitMQ is the most widely deployed open source message broker with tens of thousands of users from small start-ups to large enterprises. RabbitMQ is lightweight and easy to deploy on premises and in the cloud. It supports multiple messaging protocols. RabbitMQ can be deployed in distributed and federated configurations to meet high-scale, high-availability requirements.

Messaging enables software applications to connect and scale. Applications can connect to each other, as components of a larger application, or to user devices and data. Messaging is asynchronous, decoupling applications by separating sending and receiving data. RabbitMQ ships with an easy-to use management UI that allows you to monitor and control every aspect of your message broker.

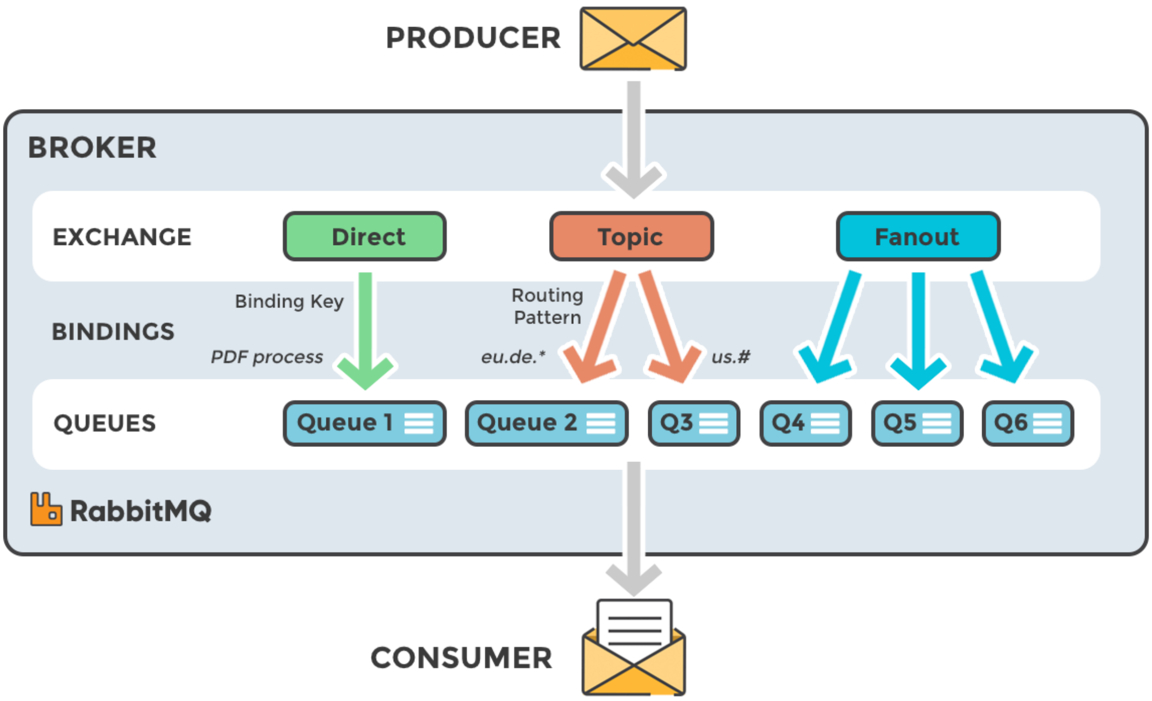

Figure 4: RabbitMQ brockering services

[img: https://www.cloudamqp.com/img/blog/exchanges-topic-fanout-direct.png]

2.1.2.4 Example: Jupyter Notebook

According to Project Jupyter, the Jupyter Notebook, formerly known as the IPython Notebook, is an open-source web application that allows users to create and share documents that contain live code, equations, visualizations, and narrative text. Uses include data cleaning and transformation, numerical simulation, statistical modelling, data visualization, machine learning, and much more. The word, Jupyter, is a loose acronym for Julia, Python, and R, but today, the Jupyter supports many programming languages. Interest in Jupyter Notebooks has grown dramatically. [5]

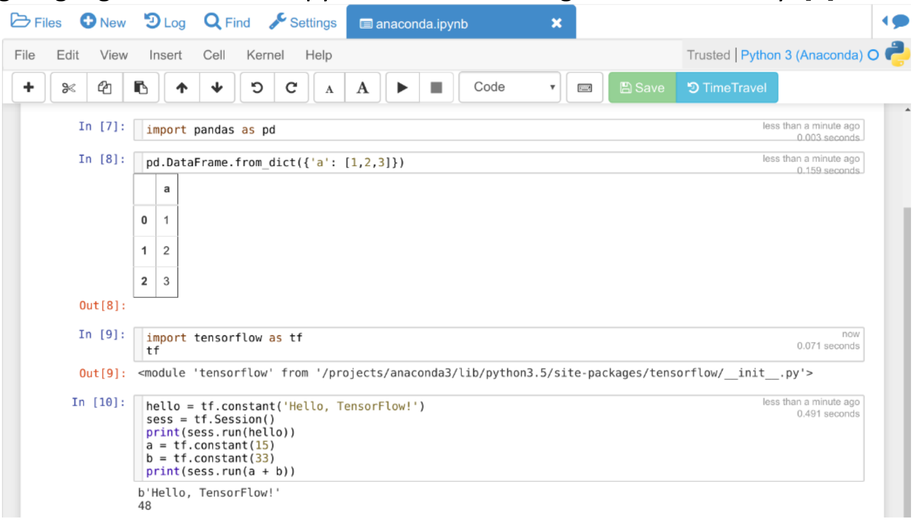

Figure 5: Example Jupyter Notebook dashboard

[img. https://cocalc.com/doc/jupyter-notebook.html]

2.1.3 Knowledge Tier

EO is traditionally a bespoke market having its specific process to be identified as a service provider, to identify a potential new customer, to collect needs which may open business opportunities. The development of an online market is changing this approach (see “Creating a European marketplace for EO services”, EARSC 2016). In 2016, online represented 5% of the EO market (i.e. 110M€) and was foreseen to reach 25% of the EO market in 2025 (i.e 1,3 B€). Even if only based on the processing and not the delivery model, current numbers confirm this trend. Pure bespoke services significantly decreased from 64% in 2016 to 26% in 2018 (2019 Industry Survey, EARSC 2019).

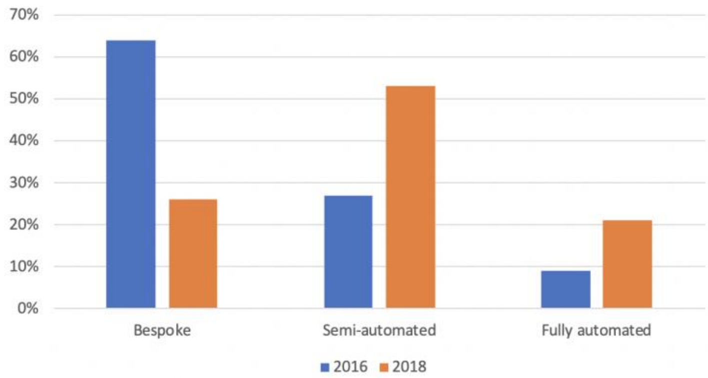

Figure 6: Evolution of bespoke vs automated services processing (EARSC, 2019)

Each company is facing the challenge to increase its visibility. If a few non-European platforms such as Amazon Web Service (AWS) or ArcGIS on-line (geo-Information as a service) are well known by users or potential users, there is currently no EO platform which is top of mind even if several players already exist (e.g. Airbus, cloudeo, Maxar, Geocento, Hexagon, Planet). In this context, it is challenging furthermore for young or small companies to use online services as a tool to develop. Or companies will have to acquire skills, internally or as a subcontract, which are not related to EO technology such as web-technologies, online customers behavior, online marketing or they will join a platform providing the information platform as a service.

EO is an ecosystem having strong technology needs and pushes. The integration of ICT in the different tiers is a game changer which changed the borders between the three tiers. It allows to move from a data/product to a service model, and to produce new layers of information.

2.1.3.1 Example: Analytics tools

Buisness Intelligece (BI) analytics tools are the type of software designed to retrieve, transform, analyze and report data. BI tools find information primarily by queries. They allow it’s users to create reports, dashboards and visualizations of data which can be helpful during decision making process. Most of currently available BI tools work best with data that is already structured, stored in data warehouses and data marts. Analyzing unstructured data straight from data lakes is a difficult task but we can see new applications and technologies emerge as the demand on such services rises and it’s important to keep track of them, because they could replace traditional BI tools.

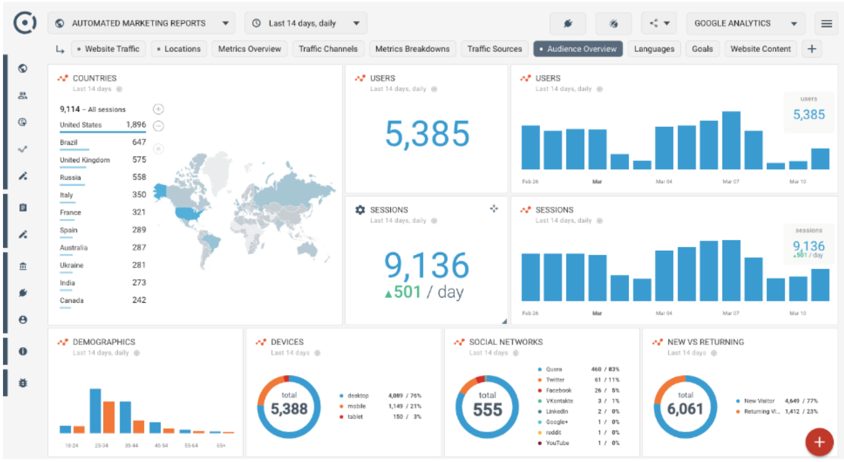

Figure 7: Example dashboard of analytic tool (Google Analytics)

[img. https://www.octoboard.com/reports/who-visits-my-website]

2.1.3.2 Example: Chatbots

A chatbot is an AI software that can simulate a conversation (or a chat) with a user in natural language through messaging applications, websites, mobile apps or through the telephone. [4]
A chatbot is often described as one of the most advanced and promising expressions of interaction between humans and machines. However, from a technological point of view, a chatbot only represents the natural evolution of a Question Answering system leveraging Natural Language Processing (NLP). Formulating responses to questions in natural language is one of the most typical examples of NLP applied in various enterprises' end-use applications.

Chatbot applications streamline interactions between people and services, enhancing customer experience. At the same time, they offer companies new opportunities to improve the customers engagement process and operational efficiency by reducing the typical cost of customer service.

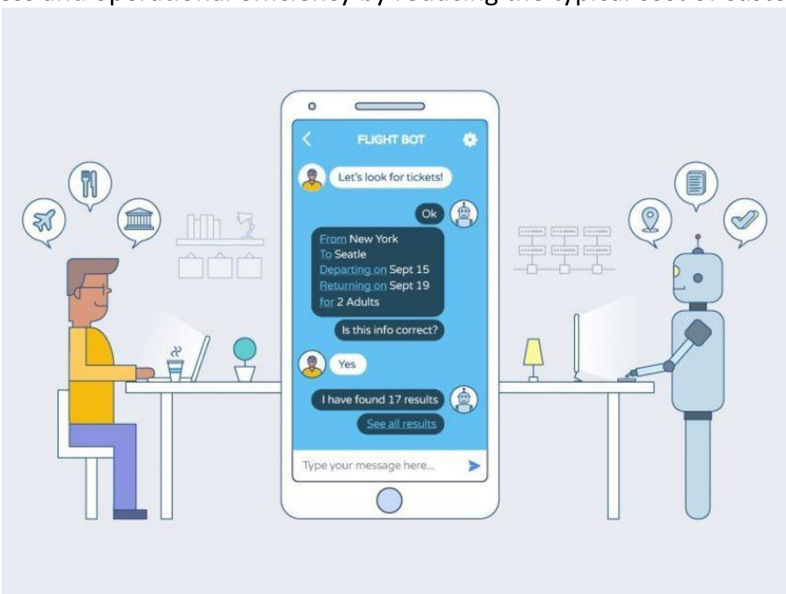

Figure 8: Example chatbot interaction

[img. https://www.ecommerce-nation.com/chatbots-advantages-and-disadvantages-of-these-tools/]

2.2 Trends, technologies and outlook in the Energy sector

Energy systems around the world are going through rapid transitions that will bring important changes to the way we fuel our cars, heat our homes, and power our industries. These trends will have widespread implications for businesses, governments, and individuals in the coming decades.

The McKinsey report on Global Energy Perspective 2019 finds three important tipping points in the energy landscape that will come within reach in the next few years:

1. As the cost of renewables has come down further, many countries will reach a tipping point in the coming five years, where new-build solar or wind capacity is cost-competitive with the fuel cost of existing conventional plants. As a result, we will see a further acceleration of the ramp-up of renewables.
2. Similarly, as the cost of batteries continues to decline, within the nest 5-10 years, many countries will reach the point at which electric vehicles are more economic than internal combustion engine vehicles. This is true for passenger cars but also for most truck segments.
3. For the first time, a peak in global carbon emissions is projected, despite the continued economic growth and a growing global population. Triggered by a drop in global coal demand and flattening oil demand, carbon emissions are expected to start to decline by the mid- 2020s.

Cities are at the leading edge of low-carbon innovations and efforts to avert global warming. Big data and IoT (Internet of Things) continue to offer energy efficiency gains for buildings and transportation. Electric and autonomous vehicle technology is leading to advances in grid storage and reduction in emissions. Energy transformation is being modelled in cities, with lessons for regions and nations. Energy companies will partner at the city level to advance smarter, cleaner energy.

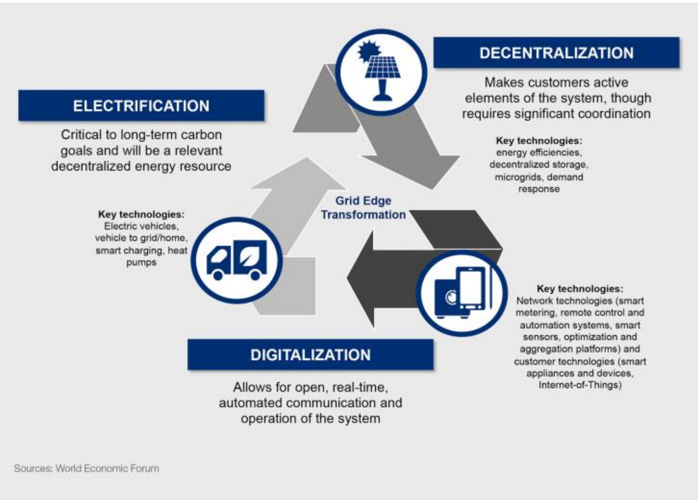

Figure 9: Electrification, decentralization and digitalization are the driving forces behind the transformation of energy systems and act in a virtuous cycle. (Source: World Economic Forum).

Several developments and technology advancements in the energy transition have shown further acceleration. These technology advancements will facilitate the achievement of the global climate strategies and challenges that are driving a global shift in energy systems.

Hereinafter we examine the main technologies related to energy sector, focusing the watch in the following fields: renewables, energy efficiency, smart cities (water cycle and waste management and waste management), smart grids, energy storage and self-consumption technologies.

The following table represent an overview of the different challenges and associated enabling associated technologies in energy sector.

FIELD	CHALLENGES	ASSOCIATED TECHNOLOGIES
Renewable energy: photovoltaic, wind, etc.	•Technological innovation for more efficient photovoltaic and wind energy •Cost efficiencies •Increasing consumer demand. • Universal access to energy • To transitioning to 100 percent renewables • Grid Parity And Falling Costs	Energy Storage Microgrids and AI Energy Blockchain And IoT Automation Advanced materials and manufacturing Weather forecasting technologies
Energy efficiency	•Cost efficiencies •Climate change •Reduce CO2 emissions	Data collection and analysis Improved controls and automated systems Advanced manufacturing Innovative building design Heat Pumps or 'geoexchange' technologies Electric vehicles Electric appliances Solar and wind technologies Storage technologies
Smart cities: water cycle and waste management	•Smart Builing •Energy Efficiency in Street Lighting •Balancing objectives between promoting recycling and protecting consumers against harmful chemical substances in recycled materials • Insufficient data collection; quality aspects related to recycling • Energy recovery of waste • Waste prevention	ICT Big Data IoT Augmented and virtual reality Artificial intelligence Apps Blockchain
Smart grids	• Transforming diverse energy sources management, supply chains and energy management processes • Shifting from one-way power flow to two-way, with consumers becoming producers • Fostering reliability, availability, accountability and efficiency of the energy industry • Enabling efficient transmissions of electricity and rapid restoration of power • Achieving cost efficiency and lower electricity rates • Facing the emerging security threats to the power grid from cyberspace, geospace and space • Total automation, from power generation to distribution and service management	Machine Learning Plug-and-play Intelligent appliances Smart power meters Smart Substations Super conducting cables Integrated communications Phase Measurement Units

Self-consumption	• Integrating variable renewables onto the grid and lowering overall costs through load shifting • Enhancement in storage and demand response solutions facilitating larger share of self-consumption and lower additional costs arising from integration • Application of information and communications technology solutions and smart-battery charging algorithms to the transition to active prosumers • Improved energy policy • Integration of intermmittent power sources , due to disparity between power generation and demand	Improved VRE forecasting technologies Technologies for grid reinforments and strengthened interconnections Improved information and control technologies Electricity storage devices Demand response technologies Energy-system integration
Energy storage	•Technological innovation to meet everyday energy needs • Managing the power supply while creating a more resilient energy infrastructure and bringing cost savings to utilities and consumers • Increased reliability, output, density, unlimited operational lifespan • Creating a more robust and adaptable energy grid • High- tech materials, cutting-edge computer control systems and innovative designs to make feasible systems to the real world applications • Increasing capacity and efficiency	Batteries Thermal energy storage Mechanical Storage Hydrogen Pumped Hydropower

Table 1 Energy sector technologies

2.2.1 Energy production

2.2.1.1 Renewables (wind and solar) technologies**.**

Technological innovation, cost efficiencies, and increasing consumer demand are driving renewables—particularly wind and solar—to be preferred energy sources. We examine seven trends that are driving this transformation.

New technologies involving automation, AI, and Blockchain, as well as advanced materials and manufacturing processes, can accelerate the deployment of renewables. The technologies range from those streamlining the production and operation of renewables (automation and advanced manufacturing) to those optimizing their use (AI in weather forecasting), improving the market for renewables (Blockchain), and transforming the materials of solar panels and wind turbines (advanced materials). These technologies support the previous two trends by helping to further decrease costs and facilitate integration.

Automation is dramatically cutting time and costs for solar and wind production and operations. First Solar automated its US manufacturing plant last year and tripled the size of its panels at a cost that undercut its Chinese competitors by 30 percent by transforming production from a hundred-step, multiday process to one that takes just a few steps and hours. Automation also has significant operational implications for offshore wind, which accounts for more planned maintenance outages per installed GW than any other generation technology. In July, the world’s largest offshore wind farm deployed fully automated drones and cut the inspection time from two hours to 20 minutes. Looking ahead, crawling robots currently under development will enable automated microwave and ultrasonic inspections of the internal structure and materials in solar panels and wind turbines.

Manufacturers are heavily investing in these new technologies because they anticipate growing demand for solar and wind power.

2.2.1.2 Self-consumption technologies

In a context of increasing energy prices, households and businesses using solar electricity rely on a power source the cost of which will remain fixed for the decades to come. Self-consumption does not only provide cheap electricity to people; it also protects them against volatile energy prices. Energy self-consumption increases retail competition and helps market transformation and makes consumers active players of the energy transition, a key objective of the Energy Union. Because it leads to concrete economic benefits, making the best use of on-site generation, self-consumption is considered a key driver for demand-side flexibility with the development of solutions such as storage, smart appliances and more flexible contracts for consumers.

Individual self-consumers are the final consumers entitled to consume and store the electricity they have produced within their premises and to sell this electricity. Renewable self-consumers are limited to producing electricity from renewable sources, whereas the definition of active customers also explicitly includes activities beyond energy generation such as the participation in flexibility or energy efficiency schemes.

The development of a sharing economy in the recent years has led to an increased interest in direct sharing of electricity between producers or self-consumers and other final customers. This collective self-consumption has been already recognised in certain national legal frameworks such as France and Austria or within pilot projects, but the concept is still formally being recognised in the EU-level legislation.

Additionally, there exists the concept of Energy Community, which has been already introduced into the European legislation, differentiating between Citizen Energy Communities and Renewable Energy Communities. These energy communities are entities set up as a legal person that are defined by their structure and effectively controlled by their shareholders or members. The primary objective of the energy communities is to provide environmental, economic and social community benefits rather than financial profits. Renewable Energy Communities are limited to renewable energy technologies while citizen energy communities are technologically neutral. Renewable energy communities can be active in all energy sectors for the production, consumption and selling of renewable energy. In the case of citizen energy communities, their activities are limited to the electricity sector and are dedicated to electricity generation, distribution and supply, consumption, aggregation, storage or energy efficiency services, charging services for electric vehicles, etc.

The technologies needed to increase self-consumption are available today but have been developed in their own silos. Few integrated solutions exist in the market, combining technological solutions to produce, storing and share energy from renewable sources. Among these technologies and approaches, the following allow putting energy back in the national grid:

- **Improved VRE forecasting**, thanks to modern ICTs such as cloud-based computing, improved mathematical models and artificial intelligence, together with big data, cloud-imaging technology, sensors, etc.
- Use of **shorter system dispatch intervals**
- **Grid reinforcements and strengthened interconnections** thanks to new high-voltage technologies as well as the connection of remote energy resources. Also use of digital smart-control technologies
- **Improved information and control technologies for grid operations**. These devices include phasor measurement units (PMU) for transmission; automated capacitor banks and feeder switching for distribution; and advanced metering infrastructure for customers that provides new capabilities
- Co-ordination and trade of electricity supply across larger balancing areas
- **Electricity storage devices** such as thermal energy storage or battery storage technologies
- **Demand response**
- **Energy system integration** (coupling of electricity, H&C and transport sectors)

All the previous would not be possible without the energy infrastructure beyond the building connection to the electricity grid, including components such as smart meters, the power distribution network, the district heating and cooling, the EV charging infrastructure, the NG network, etc.

2.2.2 Energy Storage

A wide array of storage technologies has been developed so that the grid can meet everyday energy needs. Since the discovery of electricity, we have sought effective methods to store that energy for use on demand. Over the last century, the energy storage industry has continued to evolve, adapt, and innovate in response to changing energy requirements and advances in technology.

Energy storage systems provide a wide array of technological approaches to managing our power supply in order to create a more resilient energy infrastructure and bring cost savings to utilities and consumers. To help understand the diverse approaches currently being deployed around the world, we have divided them into five main categories:

- **Batteries** – a range of electrochemical storage solutions, including advanced chemistry batteries, flow batteries, and capacitors
- **Thermal** – capturing heat and cold to create energy on demand or offset energy needs
- **Mechanical Storage** – other innovative technologies to harness kinetic or gravitational energy to store electricity
- **Hydrogen –** excess electricity generation can be converted into hydrogen via electrolosis and stored
- **Pumped Hydropower** – creating large-scale reservoirs of energy with water

2.2.3 Energy Distribution & Usage

Energy distribution technology is any human-made system capable of transporting energy in the form of fuels like gasoline, or flows such as electricity. They are the backbone for the energy sector, as they allow energy to be transported globally in order to provide essentially any location with their energy needs, in effect driving the economy. When energy is produced in the form of electricity, gasoline, liquefied natural gas, or any other, it requires transportation to where it can be made useful. Distribution technologies make this task achievable, and in some cases are very efficient.

As far as Energy reduction is concerned, it is very important to monitor energy distribution technologies and energy efficiency technologies in the usage of energy.

2.2.3.1 Smart Grids technologies

For any nation, the energy ecosystem is fundamental to its progress and development. Since the energy industry drives economic growth, the power grid has always had a profound impact on a nation’s economic survival, security, and sustainability.

Now, supported by advances in emerging technologies like artificial intelligence, blockchain, internet of things and more, the growing digitization, automation, communication, connectivity, and decentralization are on their way to fundamentally transform the way nations manage diverse energy sources, supply chains, and energy management processes. As a result, each individual nation is now able to lay the foundation of an intelligent, integrated, democratized, and decentralized energy market which can work for consumers, have diverse energy sources, and which ensures that energy supply can always meet demand. Individually and collectively, this will likely lay a foundation to bring sustainability to national economic engines.

As the technology transformation intensifies, the evolution in the grid is on its way to both allowing energy to keep flowing where and when it's needed and allowing all energy sources to be used efficiently. So, as nations witness transformative changes to the way electricity is produced, transmitted, managed and used, it is essential to understand and evaluate the emerging trends in technology that could transform the grid further.

2.2.3.2 Energy efficiency technologies.

Energy efficiency simply means using less energy to perform the same task – that is, eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level.

Data collection and analysis: Enables companies to better understand where energy is being used, and to identify opportunities for improvement.
Improved controls and automated systems: Technologies and software that allow equipment to run faster or slower depending on the demand; remote control and automation of equipment, improving accuracy, efficiency and removing human error.

Advanced manufacturing: As is true of any industry, the report notes that "the use of new materials and manufacturing techniques could offer breakthroughs in production that could significantly reduce the inputs of energy and materials required for production and transportation of goods and provision of services, while driving innovation."

Innovative building design: As was noted in a recent Rocky Mountain Institute blog, buildings consume an estimated 40 per cent of total global energy (along with 25 percent of water, and 40 percent of other resources), so present great opportunities in energy and emissions reduction.

Heat Pumps or 'geoexchange' technologies: These clever technologies can drastically reduce the amounts of energy required for heating and cooling by drawing heat or cold from outside or underground and pumping it into the conditioned environment.

Electric vehicles: Electric cars cost less compared to conventional gas vehicles each year. ... In almost every way that counts, an electric car costs significantly less to run and maintain than a gas-powered car. There is no gas to buy, no oil changes, no smog tests, and fewer moving parts to break or wear out. Multiple studies have found that electric cars are more efficient, and therefore responsible for less greenhouse gas and other emissions than cars powered solely by internal combustion engines.

Electric appliances: In this case, ClimateWorks is talking about technologies that replace non-electric appliances in the home with electric alternatives, such as electric induction cooktops – which deliver the same energy output as gas burners, with about half of the energy input – and high efficiency electric water heaters.

2.2.3.3 SmartCities

A smart city is a designation given to a city that incorporates information and communication technologies (ICT) to enhance the quality and performance of urban services such as energy, transportation and utilities in order to reduce resource consumption, wastage and overall costs.

Smart Buildings

Smart buildings provide new services to enhance occupant comfort and empower people to take charge of their energy management. Smart buildings are an integral part of the smart city concept. It's about seeing the bigger picture to promote more intelligent, eco-friendly urban development.

Smart buildings leverage new digital solutions to optimise energy consumption. They are a vital string to our bow in the bid to tackle climate change. In France, for instance, the buildings sector is the leading source of energy use.

Energy Efficiency in Street lighting

Energy-efficiency has been gaining more and more importance in the past few years, and today it is considered essential, in order to optimize the use of energy resources and to assure environmental and economic sustainability. Regarding street lighting, there are several solutions for achieving energy efficiency, raising opportunities for improvement and innovation, and allowing a rationalization in consumption. Although these benefits are clear and significant, a specific challenge arises, namely the acceptance of these solutions by citizens, as many of them affect their perceptions and feelings regarding their own security and their quality of life in the public spaces of cities

Water Cycle in SmartCities

The water sector in the urban hubs has continued to evolve, using available tools and technology to adapt to the new challenges posed by water availability.

With the technological revolution that defines the 21st century and which we call 'Industry 4.0', we have the tools necessary to meet the challenges and make a smart use of water, in order to maximise economic and social well-being without compromising its sustainability. It is an undeniable and tangible reality, where the barriers between the physical and the digital world dwindle, to support an ever more complex integrated water cycle management.

Waste Management in Smart Cities:

From densely populated cities to smaller rural communities, waste management systems keep our homes and communities free from unwanted clutter. Although these waste management services exist in nearly every community, the industry’s current operating standards have proven inefficient and highly resource-intensive. This inefficiency is largely due to outdated manual collection methods and logistical processes which lack efficient data-driven solutions.

The waste management industry is beginning to develop and implement IoT-related solutions to these problems. From waste bins equipped with fill-sensors, to data-based management and logistics platforms, the industry is shifting into a cleaner, more efficient part of modern life.

Enabling technologies:

- ICT (Information and Communication Technologies), a key element of sustainability
- Big Data, the great ally in energy, waste and water management
- IoT (Internet of Things), the brain of Smart Cities
- Augmented and virtual reality, a 360º vision
- Artificial intelligence, an X-ray image of needs
- Apps, direct communication with users
- Blockchain, the strong link

2.3 Trends, technologies and outlook in the Environment sector

The opportunity to prevent global warming rising beyond 2C is diminishing – highlighting the urgent need for faster deployment of low carbon and climate adaptation solutions. Current efforts remain insufficient to change our course towards dangerous climate change. A rapidly warming climate and failure to adequately reduce greenhouse gas emissions underscore the urgent need for greater focus on resiliency measures. Rapid, large-scale investment in effective solutions is needed to prevent global warming from reaching potentially catastrophic levels.

Falling prices for both renewable energy and natural gas have resulted in modest emissions reductions amongst heavy emitters such as Europe and the United States. However, none of the four largest global polluters (China, the United States, the European Union and India) are currently on track to do their part in global efforts to reach the Paris Agreement goals.

Experts report that global greenhouse gas emissions rose by an estimated 2.7 percent in 2018, reaching an all-time high. This represents the second year of notable increases after a brief period of relatively stable emissions due to slowed economic growth. The latest IPCC report highlighted the severity of impacts we are already experiencing at 1C warming and stated that 2C of warming is now considered highly dangerous. Countries have agreed to report on their emissions every two years starting in 2024, in accordance with the new Paris Agreement rulebook agreed at COP24 in December 2018 in Poland.

International media focus continues to remain on emissions from electricity generation, where the greatest progress is being made. But agriculture and transportation are also major contributors and only limited attention is being given to these sectors and other smaller emitters. The European Union has struggled to maintain emissions reduction momentum, in large part due to Germany failing to transition away from coal. Meanwhile US carbon dioxide emissions rose by 3.4 percent in 2018, the biggest increase in eight years.

China continues to heavily invest in renewable energy, electric vehicles and energy storage, but its total emissions are predicted to continue climbing until 2030. India’s emissions are anticipated to peak in 2033. Air pollution related to consumption of fossil fuels remains a major global issue. More than 3 billion people are breathing deadly smoke in their homes from using polluting stoves and fuels.

We expect to see billions of dollars of additional damage and many more lives lost due to extreme weather events. Resilience, adaptation and liability regarding infrastructure that is ill prepared for increasingly extreme weather will be front and center for both governments and business. Companies will accelerate action to increase climate preparedness in both direct operations and their supply chains. Geoengineering technologies could see greater investment from the private sector and renewed discussion at the policy level.

WHAT THIS MEANS FOR BUSINESS.

1. Prioritize investment in climate resilience and adaptation.
2. Companies need to increase the resilience of their supply chains and direct operations. This will require investment in climate risk assessments and scenario planning.
3. Shape policy and lobby governments for more climate action

4. Companies need to play a more active part in national and global efforts to implement the Paris Agreement and exert greater pressure on governments to limit global warming. This means advocating for actions like a price on carbon, aggressive deployment of renewables and electric vehicles, and climate smart agriculture solutions.
5. Increase Collaboration Efforts to Scale Low Carbon Economy Solutions
6. Rapidly reducing greenhouse gas emissions and increasing the resilience of infrastructure will only be achieved through multi-sector collaboration. Companies need to work with corporate peers, governments, NGOs and others to leverage the diverse skills required to scale low carbon economy solutions in all industries.

Hereinafter we examine the main technologies related to environment sector, focusing the watch in the following fields: Air quality, Climate change, Forest, Marine resources.

The following table represent an overview of the different challenges and associated enabling associated technologies in environment sector.

SEGMENT	CHALLENGES	ASSOCIATED TECHNOLOGIES
Air quality	•Removing pollutants from the air •Switching to less polluting cars •Air Quality Monitoring	Gas to Liquids Hydrogen Fuel Additives Autonomous vehicles Liquid air Photo-catalytic materials Air purification Big Data
Climate change	•Reduce CO2 emissions •Reduction greenhouse gases •Reduction Earth temperature	Carbon fixation technologies Waste valorisation technologies Renewbable / compostable materials
Forest	•Biodiversity •Sustainable forest management •Wood and energy •Forests as a Renewvable materials Source	ICTs Biotecchnology Laser measurement for precision forest inventory and monitoring Nanocelulose extration and valorisation technologies
Land Monitoring	•Land changes by climate change • Land Administration and Mapping correctly	Inland water Monitoring of snow Monitoring of the land change and biodiversity Land use Topography Built environment
Marine resources	•Expanding aquaculture production around the world •Global population is expected to reach 9 billion by 2050 •The sector needs to be far more efficient in utilizing productive resources. •Pollutans in the marine food chain •Biodevirsity	Ocean quality and productivity Monitoring marine habitat Coastal management Metocean Fishery Monitoring and detection of ship Ice monitoring

Table 2 Environment sector technologies

2.3.1 Climate, atmosphere, meteorology

2.3.1.1 Air quality technologies.

There is a growing sense of urgency about the need to clean up air pollution. For this aim, there exist many key technologies to tackle air pollution, including lower emission vehicles (including electric, hybrid and LPG), car sharing and lower emission sources of heat and power. Whilst the role of these technologies in reducing air pollution is generally accepted, there are also numerous other emerging technologies that could also be interesting.

It is the case of **gas to liquids**, for example, switching to alternative fuels. Electric and LPG offer separate fuel systems, but there are other options offering the potential to clean up the existing diesels. One example is the new synthetic gas to liquid (GTL) fuel developed by Shell, derived from natural gas. The use of GTL in heavy duty vehicles has proved to reduce the NOx emissions by 5-37%. Another example is the natural gas converted into dimethyl ether (DME), able to reduce NOx emissions by around 25%. DME is less straightforward to implement than GTL in the sense that it requires some engine modification. In any case, manufacturers such as Ford and Volvo are investigating the potential to bring DME fuelled vehicles into the market.

The use of **hydrogen fuel additives** can also allow reductions in emissions. For example, CGON developed a technology that fed small amounts of hydrogen into the vehicle air intake such that it creates a more efficient burn, increasing fuel efficiency and reducing emissions. Related to vehicles, one of the mega-trends in the automotive sector are the **self-driving cars**, able to improve fuel efficiency by 15-40% and reduce emissions of local pollutants as well as greenhouse gases, as well as improve safety and decreasing congestion. For example, Volvo has launched plants to trial driverless cars.

New technologies are also being developed to address very specific sources of pollution. For example, a growing source of pollution in cities comes from refrigerated vans and trucks. Whilst trucks are subject to emissions standards, the auxiliary engines used to power refrigeration units are largely unregulated and are highly polluting. Technological company Dearman is developing an alternative system based on the use of **liquid air**, which produces zero emissions on the road.

An alternative to cleaning up emissions from vehicles directly could be to deploy **technologies which remove pollution from the ambient air**. For example, a number of companies are developing **photo-catalytic treatments** which remove pollutants from the air in the presence of sunlight. These treatments can be applied to a range of surfaces, for example roofing tiles, roofing felt or even the surface or roads. Similarly, developers are also looking at other ways of cleaning air in urban environments. Studio Roosegarde, a Dutch design company, has developed a smog free tower consisting of an **air purifying tower** which sucks in pollution and expels clean air. The extracted pollution is, somewhat bizarrely, turned into pieces of jewellery.

2.3.1.2 Climate change technologies.

In many cases people will adapt to climate change simply by changing their behaviour, but often they will employ different forms of technology, whether hard forms such as new irrigation systems or soft technologies such as crop rotation patterns. Nevertheless, as with any form of technology, there is always the risk that adaptation measures will be more accessible to wealthier communities. The first step in design strategies for adaptation is to collect information. There are multiple methods of data collection, including many types of equipment, from **tidal gauges** to **satellite remote sensors**. There are also more ways of analysing and presenting this data using **sophisticated computer graphics programs**, known as **geographic information systems (GIS)**.

Technological innovation gives ways to solve environmental challenges. An example could be the **new approaches to measuring and reducing emissions** of methane, which are responsible for a quarter of all the warming the environment is experiencing today. Researchers use a range of technologies, including **sensors mounted on drones, airplanes and even Google Street View cars**, to measure emissions every link in the supply chain. Through reliable, low-cost sensors, remote monitoring and oilfield internet-of-things, energy companies could reduce their emissions and eliminate waste of saleable gas at the same time. In this sense, companies such as Shell and Equinor are testing **continuous monitoring technologies**, and others such as Stanford University and ExxonMobil look at **mobile detection technologies** to be used in aircraft and drones.

Advanced sensor technologies help creating a healthier environment, for example Google cars mapping air pollution and its health effects or the wearable bracelets designed to track the daily chemical exposure. Elsewhere, retailers and consumer brands are using **blockchain technologies** to improve accountability and sustainability across extensive supply chains. For example, sensors are used to help farmers reduce the amount of chemicals on their fields. Pushing the envelope even further, emissions could be also detected and measured by means of sat**ellite-based approaches** that can continuously map and measure emissions with exacting precision almost anywhere in the planet.

2.3.2 Land use/land ecosystems

2.3.2.1 Forest technologies.

Technology has been relied on in the quest for sustainable forestry. Biotechnology has been used for the genetic improvement of forests and plant cloning, while biomass conversion technologies have been used to turn biomass into energy. However, its impact on the forestry sector still has not been fully investigated, probably because forest researchers are not so tech-savvy.

Within these technologies, it can be found the **Geographic Information System**, a computer system used for mapping and geographical analysis by capturing and displaying data related to positions on Earth’s surface. It can make use of any information containing location, improving the process of decision-making as well as communication, so it is widely used across multiple industries. In the case of forestry sector, the data collected can help to discover the location of endangered species and habitat classification, the size of the forest area and the forest cover type. The GIS relies on Global Positioning System (GPS), making it suitable to operate with location data such as latitude, longitude and altitude, used in forest management.

Nanotechnology has also been increasingly used in the forestry sector to improve its products and make them more competitive to the market. There have been attempts to use a wood-based nanomaterial to produce clear reinforced glass with the hope to reduce greenhouse gas emissions. Another example is the extraction of cellulose, a biosynthetic product from plants, animals and bacteria. Nanocellulose refers to cellulosic materials with defined nano-scale structure dimensions, used in many applications in thermo-reversible and tenable hydrogels, paper making, coating additives, food packaging, etc.

Furthermore, **phytoremediation** implies the use of woody plants to clean the environment by decontaminating it. In this approach, plants are used to accumulate toxic metals and organic pollutants from contaminated soils and waters for clean-up purposes, being less invasive than traditional methods as landfilling. The most commonly used forms of phytoremediation are phytoextraction, which removes toxic metals by accumulating them in the biomass of plants, and phytodegration, which uses plants to degrade the pollutants.

Also **remote sensing technologies** are being used in the forestry sector. Different devices and approaches such as synthetic aperture radar, aerial photography or satellite images are able to measure objects by use of a photogram without touching them, providing much more detailed images. Their efficiency and scope can be improved when combined with Geographic Information Systems and GPS data.

Regarding the **ICT development** for the global forest sector, the demand for graphics paper products will be lower than it would be without the ICT development. The impact will be of major significance. Paper consumption will be reduced, having this negative impact to the prices and profits. Pulp and paper industry companies would be not only competing against other paper companies, but also against the electronic media. However, at the same time, ICT can help to boost productivity and creation of new products. The convergence of print and electronic media is also creating new products, such as radio-frequency identification (RDIF) tags and intelligent packaging products.

Biotechnology has also many applications in the environment. Plants can be multiplied by clonal propagation, giving identical offspring. Gene transfer of valuable genes has been conducted for the genetic improvement of forests. The challenge is to get products that are ecologically friendly and that will function well in changing environmental circumstances. Fast –growing plantations permitting lower costs, higher product quality and reduced use of both chemicals and energy are needed, and biotechnology has significant potential to help the forest products industry overcoming these challenges. For example, through clonal propagation, large numbers of genetically identical plants can be produced. Techniques such as somatic embryogenesis have several advantages over other propagation systems, including high multiplication rates and the potential for scaling-up and delivering via bioreactor and synthetic seed technologies.

Precision Forestry is achieved through **Advanced Laser Measurements**. The most fundamental contribution these bring is to provide means to more accurately, more objectively and more efficiently measure and monitor the quantity and quality of the forest biomass. Precision forestry can then be used to increase the efficiency and information basis of existing national forest inventories and operational forest management planning. It also allows certification of wood origin, since the location of every stem is recorded by forest inventory and logging machines, and updated to maps. This more detailed information on forest resources also brings new points of view to forest science and can be utilised in more detailed development of models to be applied in analysis of scenarios of global climate change studies.

2.3.2.2 Land monitoring

Land Administration and Mapping are significant domains of activity, consistently growing worldwide and evolving continuously for the sustainable benefits of citizen, state and business.

Geo-information has long been a necessary data source for mapping and it continues to play a crucial role in supporting key decision-makers by turning the latest geospatial data into reliable information.

Some examples of technologies/applications related to land monitoring are shown below:

- Inland water monitoring– Sentinel 2 and 3, combined with in situ data for calibration and validation, allow to assess the temporal and special water quality dynamics. Historical data enable modelling to forecast water quality.
- Monitoring of snow
- Monitoring of the land change and biodiversity
- Land use – illegal activities, assessment of human activities on land
- Topography
- Built environment – monitor the urban areas and surroundings, mapping and monitoring of the infrastructure
- Monitoring crops and farming practices
- Monitoring natural hazards (drought, flood, forest fires)
- Monitoring desertification and soil productivity
- Monitoring natural succession processes
- Monitoring protected areas

2.3.3 Marine ecosystems

Maritime Surveillance has become a huge challenge over the past few decades, specifically in regions where maritime traffic represents the major economic interest, potential threats or source of illegal activities such as smuggling, illegal immigration or piracy.

The great maritime nations consider that they do not have the capacity to monitor the entire Exclusive Economic Zone (EEZ) using only traditional means. Satellites extend surveillance capacities from coastal areas to open seas and provide information in order to optimise operations at sea.

Examples of marine resources technologies are:

- Ocean quality and productivity – monitoring of pollution (water quality)
- Monitoring marine habitat
- Coastal management
- Metocean – meteorology of ocean (current, wind, waves, etc.) – impact on the shipping
- Fishery – illegal fishing, map fish shoals
- Monitoring and detection of ship
- Ice monitoring on the sea

2.4 Trends, technologies and outlook in the Food sector

In recent years, food has gained increased importance in the society we live in. On one hand, nutrition and health have become an important aspect for people when selecting everyday meals.

Simultaneously, the availability of different foods and ingredients has opened up doors to new cousines, tastes and flavours and created a movement of people interested in exploring what this field has to offer. In this way, food is no longer just a means to satisfy hunger, but has also become a medium for exploring new cultures, cousines, traditional recipes with modern twists, meeting people and exchanging experiences. Yet, with the rising need to feed a growing population in the face of climate change and environmental degradation, food plays a key role in building a sustainable future.

In this complex landscape of challenges and potential, the farm-to-fork value chain arises as a field where innovation is essential as a way to meet the future ahead. While agriculture still is the least digitized of all major industries, we constantly witness new technological advancements in the sector. With the value chain surrounding the food sector spanning a range of areas from seed monitoring and farming to retail and restaurant business, this section gives an outlook in the newest technological advancement across the whole value chain. While information in this section was compiled through a comprehensive desk research and analysis of multiple sources, one of the most important sources has been AgFunder and its reviews of the newest technology trends.

Technology's increasing role is notable in different industries including food and agriculture. With agrifood being "a $7.8 trillion industry, responsible for feeding the planet and employing well over 40% of the global population"[1] the potential technology has on increasing the productivity of the sector must not be neglected. In the face of global challenges imposed by climate change, population increase, environmental degradation and others, technology solutions in the agrifood sector address a broad range of challenges such as labor shortages, food safety and traceability, farm efficiency and profitability, drought, CO2 emissions, food waste, health and sugar consumption, unsustainable meat production etc.

Another specific characteristic of the agrifood sector is its wide supply chain that covers the whole farm to fork starting from farming, logistics, over to wholesale distribution, processing, retail distribution and finally arriving to the consumer. Covering such a lengthy value chain, AgFunder gives a useful classification of technology in this sector as:

1. **Upstream**: producer side of the value chain; from the farm until the retailer
2. **Downstream**: consumer side of the value chain
3. **Upstream + Downstream**

Based on the field where technology is applied, a detailed classification includes 14 categories:

[1] https://research.agfunder.com/2018/AgFunder-Agrifood-Tech-Investing-Report-2018.pdf

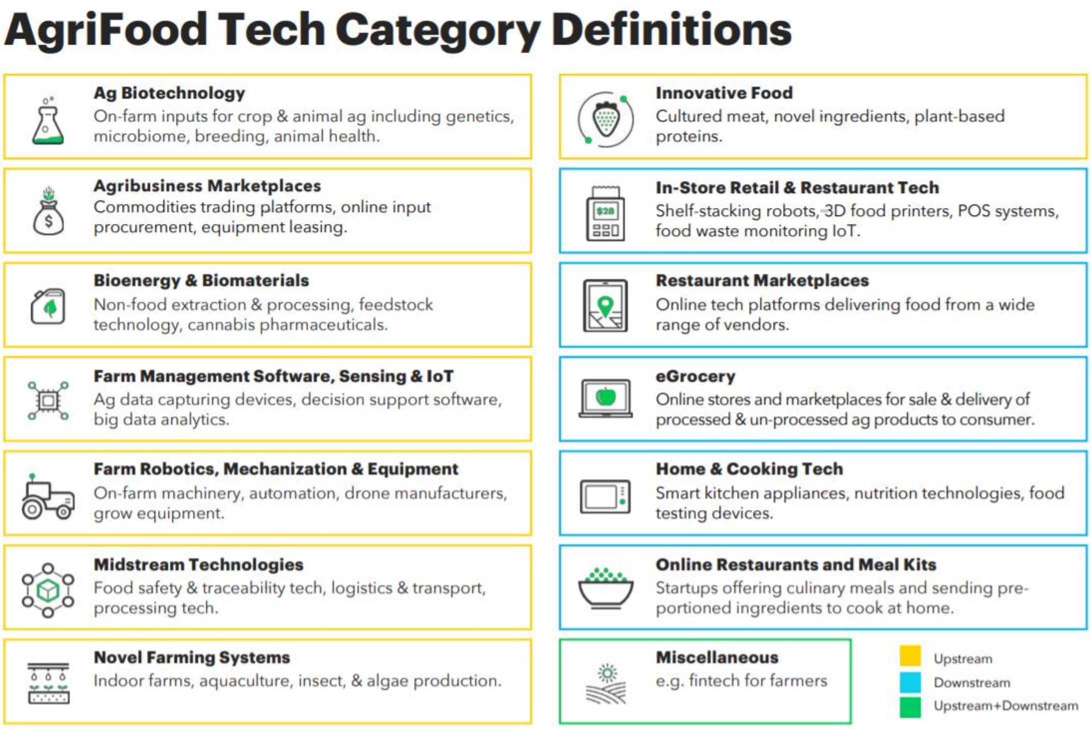

Figure 10: AgFunder AgriFood Tech Categories

2.4.1 Food production

Ag Biotechnology is a field that includes technology in the field of biological and chemical tools that are used on a farm. Research and science in the field of breeding, genetics, microbiome research, synthetic chemistry and animal health all contribute to new advancements of this technology. When it comes to companies, they are developing new solutions for plant breeding, gene editing, biologicals, microbiome research etc.

Bioenergy and Biomaterials field focuses on processing and extraction of non-food products, as well as products that can be used for animal feeding.

Farm Robotics, Mechanization and Equipment consists of three large categories: spraying and weeding; harvesting; and controlled environment agriculture. Technology in this field varies in maturity and capacity, however, it is pre-harvest field that is currently most developed. This includes different autonomous machines for weeding of row crops, inter-cropping cultures and meadows. When it comes to technology deployed during harvesting, solutions are emerging, and the field is expected to offer innovative solutions as the costs of labor and energy rise.

Novel Farming Systems revolve around technology deployed to enable indoor agriculture, aquaculture and insect farming.

2.4.2 Food Transformation

Farm Management Software and IoT includes technology focused on capturing and analysing data relevant for the agrifood sector, big data analytics, integrated farm management systems etc.

Innovative Food encompasses new food formats that offer sustainable dietary solutions. Alternative proteins, healthy sugar replacements, algae, sell-cultured and plant-based meat are some of the technology solutions in the field. Burgers grown in a lab and sugar molecules with health benefits are only a few of the current breakthroughs.

2.4.3 Food Distribution (Marketplace)

AgriBusiness Marketplace is a field where technology connects farmers with their suppliers, resolves challenges they face with leasing equipment, payment procedures etc.

Midstream Technology is focused on solutions positioned between producers and consumers in the agrifood value chain. This includes solutions focused on traceability and food safety, transport and logistics etc. Grain monitoring and testing and robot delivery technology are some of the newly developed solutions in this field.

In-store Retail and Restaurant Tech includes solutions that reduce food waste, enable better store management, provide robotic solutions for stacking and other daily tasks, offer 3D printing possibilities etc.

eGrocery offers tech solutions for online marketplaces, ordering and delivering of different agrifood products to various customers.

Restaurant Marketplaces is a common denominator for online platforms that offer customers the choice of online ordering from multiple vendors.

Home and Cooking Tech is a field at the very end of the downstream technologies mostly based in the homes of consumers. It encompasses smart kitchen appliances, timers and sensors that enable easier cooking and meal preparation, nutrition technologies etc.

Online Restaurants and Meal Kits is a field focused on preparing everything a consumer needs online and shipping the necessary ingredients ready for cooking to the customer.

Miscellaneous comprises of tech solutions that bring together different industries such as agrifood and fintech with solutions for farmers, or agrifood and logistics that provide better transportation solutions and easier traceability.

3 Procedure for updating contents by partners, PARSEC ecosystem and links with stakeholders

Each partner will monitor regularly the identified sources in this first version of the deliverable. The update of the content will be reflected in the Wiki-library and it will be done at least every four months.

The main sources to be facilitated are:

- internet publications (listed in Annex 1)
- expert opinions
- stakeholder opinions: links with stakeholders will be identified to update the scope of the Technology Watch and Future Trends Analysis.
- events: partners will attend and observe events of different sectors
- scientific publications
- patents
- conferences

4 Web-based open consultation process

A web-based open consultation process will be managed through PARSEC website in order to ask PARSEC stakeholders and potential beneficiaries about the contents of the Technology Watch and Future Trends contents.

A query/survey similar to the one used for user needs will be launched through stakeholders. They will be asked about technology trends, technology challenges to be solved or market challenges that could be solved using Earth observation.

A query similar to the one used for user needs will be launched to potential beneficiaries of the PARSEC Accelerator and will me mandatory to fulfil to beneficiaries in order to know which kind of information they would need in order to update the Technology Watch and Future Trends Wikipedia.

5 Technology Watch and Future Trends Plan Wikipedia

All the static contents of Technology Watch and Future Trends deliverable will be included in a Wiki style environment hosted in PARSEC Web page and combined with the Market Observatory.

The content structure for each Technology in the "Wiki" will be the following as a first proposal. It could be modified through the results of the web-based open consultation process:

- Technology Title
- Technology Description
- Application fields (PARSEC sector)
- Keywords
- Main stakeholders doing R&D
- Main stakeholders in the market
- Patents
- Challenges
- Links to EO

A mockup on how technology information could be displayed in the Technology Watch / on the PARSEC website is the following:

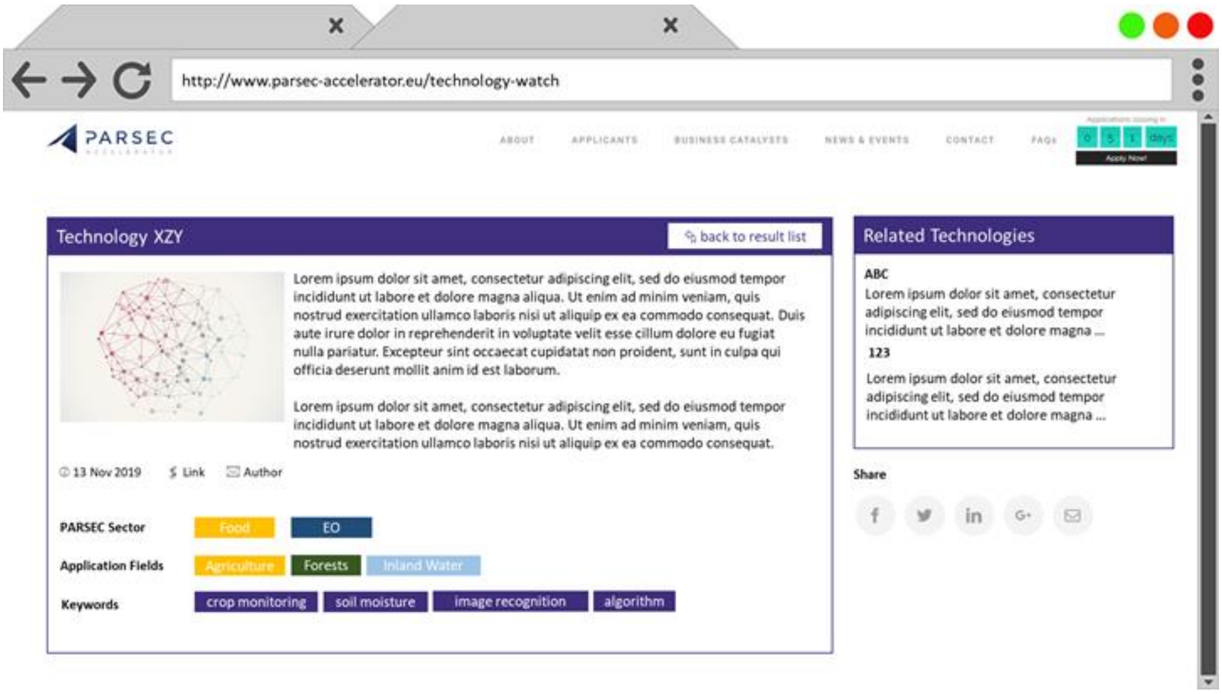

Figure 11: Mockup Wiki-style Technology watch

The "Wiki" content will be edited only by PARSEC partners at any moment.

ANNEX 1

Energy:

https://trends.sustainability.com/energy-utilities/

Global renewable energy trends (Deloitte):
https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/global-renewable-energy-trends.html

6 Renewable Energy Trends To Watch In 2019 (Forbes)
https://www.forbes.com/sites/jamesellsmoor/2018/12/30/6-renewable-energy-trends-to-watch-in-2019/#2bae18f44a1f

Top 5 Renewable Energy Trends in 2019 (Greentedtalk):
https://www.greentechtalk.com/top-5-renewable-energy-trends-in-2019/

Top 10 technologies to double energy efficiency, deliver zero emissions:
https://reneweconomy.com.au/top-10-technologies-to-double-energy-efficiency-deliver-zero-emissions-65210/

https://www.google.com/search?q=smart+cities+waste+management+technologies&oq=smart+cities+waste+management+technologies&aqs=chrome..69i57.15431j0j4&sourceid=chrome&ie=UTF-8
https://smartwatermagazine.com/news/smart-water-magazine/smart-water-technology-future-here

https://www.forbes.com/sites/cognitiveworld/2019/04/04/the-evolving-energy-ecosystem-smart-grids-to-smart-energy/#4694488e584b

https://energystorage.org/why-energy-storage/technologies/

Environment:

https://trends.sustainability.com/

6 New Technologies Which Could Improve Urban Air Quality:
https://policyexchange.org.uk/6-new-technologies-which-could-improve-urban-air-quality/
Air Quality Strategies and Technologies: A Rapid Review of the International Evidence

10 Startups Working to Fix Climate Change With Technology:
https://www.inc.com/jessica-stillman/10-startups-working-to-fix-climate-change-with-technology.html

The Way Forward: Four Major Challenges to and Opportunities for Forest Sector Policy in Europe:
https://www.foresteurope.org/docs/SoEF/reports/Future_Challenges_and_Opportunities_for_Forest_Policies_in_Europe_State_of_Europes_Forests_2011.pdf

9 Implications of Technological Development to Forestry:

FISH TO 2030: Prospects for Fisheries and Aquaculture.
WORLD BANK REPORT NUMBER 83177-GLB

EO sector (and associated enabling technologies (e.g. big data cubes, cloud resources))

Gurusamy, Vairaprakash & Kannan, Subbu & Nandhini, K. (2017). The Real Time Big Data Processing Framework: Advantages and Limitations. INTERNATIONAL JOURNAL OF COMPUTER SCIENCES AND ENGINEERING. 5. 305-312. 10.26438/ijcse/v5i12.305312.

https://hadoop.apache.org/docs/r1.2.1/hdfs_design.html

https://hadoop.apache.org/docs/r1.2.1/mapred_tutorial.html

https://www.expertsystem.com/chatbot/

https://medium.com/@GaryStafford/getting-started-with-pyspark-for-big-data-analytics-using-jupyter-notebooks-and-docker-ba39d2e3d6c7

Food:

https://research.agfunder.com/2018/AgFunder-Agrifood-Tech-Investing-Report-2018.pdf

https://globalnetwork.io/perspectives/2016/09/inside-bayer-monsanto-mega-merger-and-what-it-means-global-agriculture

https://www.greeneuropeanjournal.eu/food-security-at-stake-what-the-bayer-monsanto-merger-means-for-europe/

https://eit.europa.eu/our-communities/eit-food

https://agfundernews.com/the-state-of-agrifood-tech-startups-in-europe.html

https://research.agfunder.com/2018/Europe-AgriFood-Tech-Funding-Report-2018.pdf

https://research.agfunder.com/2018/AgFunder-Agrifood-Tech-Investing-Report-2018.pdf

https://research.agfunder.com/2018/AgFunder-Agrifood-Tech-Investing-Report-2018.pdf

https://www.forbes.com/sites/maggiemcgrath/2017/06/28/the-25-most-innovative-ag-tech-startups/#59cce6b84883

https://www.agprofessional.com/article/five-trends-shaping-future-farming

https://www.rliland.com/future-agriculture-look-like/

https://www.forbes.com/sites/danielnewman/2018/05/14/top-six-digital-transformation-trends-in-agriculture/#2f543520ed2e

PARSEC
ACCELERATOR

Our Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824478.