DIGITAL SUSTAINABILITY
APPLIED TO SMART GRIDS

think SMARTGRIDS

FRENCH SOLUTIONS FOR SMARTGRIDS

THE THINK SMARTGRIDS ASSOCIATION

The Think Smartgrids association federates an ecosystem of French stakeholders contributing to the decarbonization and efficiency of power systems: grid operators RTE and Enedis, the main French manufacturers and equipment suppliers in the energy sector, major digital services companies, numerous SMEs and French startups at the cutting edge of energy and digital technologies, as well as the academic and research ecosystem.

ASSOCIATE MEMBERS

OBSERVER MEMBERS

PARTNER MEMBERS

Universities, research centers and laboratories

EXECUTIVE SUMMARY

While smart grid technologies are essential to the energy transition and the decarbonization of our energy mix, the increasing digitalization of the power system raises questions about the environmental impacts generated by this explosion of sensors and data, which must then be transported, stored and processed. At a time when CO_2 emissions from the digital sector are increasing by 8 to 9% a year, i.e., doubling every ten years, and when these technologies use many critical metals and minerals, many smart grid stakeholders are reviewing their practices and implementing strategies to reduce the carbon and environmental footprint of their data projects.

At the same time, regulations are being tightened to combat "software obsolescence", impose new obligations in terms of hardware lifecycle analysis and digital eco-design, reduce the environmental impact of data centers, and encourage data sharing and interoperability.

A dozen smart grid stakeholders were interviewed about their vision, practices and recommendations for applying Green Computing principles to smart grid use cases. In particular, the focus is on data storage (and the hardware needed to store it), optimizing data flows, and pooling data and infrastructure.

Seven focus areas emerged from these discussions, and are illustrated in this white paper by several concrete initiative:

- **REDUCE THE FOOTPRINT OF HARDWARE** for data collection, storage and processing, as well as that of digital terminals. This involves both the eco-design of equipment, and a rethinking of "lean" sizing, or even the need to deploy new equipment.
- **REVIEW THE TECHNICAL ARCHITECTURE OF DATA COLLECTION** and processing infrastructures to optimize the volume of data stored, transported and processed, while meeting expected service levels.
- **PROMOTE OPEN DATA AND SHARED DATA STORAGE AND PROCESSING PLATFORMS** to avoid redundancy and use the same data for different purposes.
- **PROMOTE FRUGAL SOFTWARE DESIGN**, by designing software matching its uses and needs as closely as possible. In addition to energy and hardware savings, this software frugality will result in faster processing.
- **FAVOR USE CASES WITH VERIFIED ENVIRONMENTAL BENEFITS** and avoid the replication of existing projects.
- **DEVELOP A REAL GOVERNANCE FOR GREEN COMPUTING** to encourage all stakeholders to tackle the issue.
- **STRENGTHEN DATA STANDARDIZATION AND INTEROPERABILITY**, an essential prerequisite to facilitate the pooling and sharing of data and data processing. This standardization also optimizes data storage and processing, and helps combat technological obsolescence while reinforcing cybersecurity.

The white paper concludes with a discussion about the obstacles to be overcome, particularly in terms of quantifying the volume of data generated by smart grid use cases, and Green Computing challenges to guarantee the performance of smart grid business models.

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WHY THE NEED FOR A STUDY ON APPLYING DIGITAL SUSTAINABILITY TO SMART GRIDS?

THE EMERGENCE OF A DEBATE ON SUSTAINABLE DIGITAL

At a time when the number of data projects for energy is multiplying, the members of Think Smartgrids' Digitization Commission wanted to investigate the concept of sustainable digital, which they felt was becoming an unavoidable challenge for the development of new smart grid services.

Although digital technology currently accounts for only a small proportion of the environmental footprint of energy network development projects, its impact is set to grow significantly. With the energy transition, **the rise of intermittent renewable energy and the massive electrification of energy uses will require an increasing use of digital solutions** to optimize the management of power grids and make them more resilient.

On the one hand, smart grid technologies are helping to avoid greenhouse gas emissions, through energy savings, by controlling usage to smooth consumption curves and avoid the need for back-up thermal power plants, or by electrifying usage and integrating renewable energies to replace fossil fuels.

On the other hand, **with the widespread digitization of the electricity system and the increasing use of energy-intensive artificial intelligence algorithms, it is now impossible to ignore the various environmental impacts associated with digital projects**, however virtuous they may be for the energy transition. The Digitalization Commission of the Think Smartgrids association has therefore decided to tackle this issue.

But the concept of "digital sustainability" must first be clarified: does it mean developing solutions that consume less energy and, more generally, fewer resources, or should we go so far as to question the relevance of new products and services brought to market, in light of their environmental impact? At a time when the energy transition still requires numerous innovations, what CSR approach should be adopted to anchor sustainability in all digital project developments, without restricting innovation?

The definition of digital sustainability used in this white paper involves **designing digital services that are more resource-efficient, and moderating their use to minimize their environmental impact**. It encompasses, for example, energy efficiency, eco-design, pooling and optimizing the use of existing resources, and the reuse and recycling of hardware.

The recommendations and illustrations given here focus on **the environmental impact of energy data storage and processing**, but other areas of reflection are also considered.

Many of the companies surveyed have begun to think globally about reducing the carbon and material footprint of their digital products and services. For some, the approach has even become an essential dimension of their business model.

STUDY OBJECTIVES

This white paper had two main objectives:

- **Identify the factors** influencing the data storage and processing volumes required for smart grids use cases.
- **Formulate courses of action** to reconcile the development of smart grids and Green Computing.

While it is not possible to give a precise quantified assessment of the environmental impact of the smart grids sector, which was not the subject of this study, the research and interviews carried out have enabled us to define the areas of sustainable digital on which smart grids stakeholders should focus, and then to formulate a series of precise recommendations, based on the projects and feedback from the stakeholders interviewed.

STUDY METHODS

A series of 12 interviews were conducted with stakeholders from a wide range of backgrounds, to obtain a global view of digital sustainability applied to smart grids: energy data service providers, telecom and power grid operators, equipment and hardware manufacturers, researchers, data hosts...

During these interviews, the stakeholders were asked about their vision of Green Computing, the global policies, actions and best practices implemented by their organization, and their recommendations, in order of priority, for making smart grid projects more sustainable.

A review of the existing literature was also carried out to obtain a few figures and compare them with the information provided by the interviews, to begin to develop a global and factual vision of the various impacts of the digitization of the power system.

REGULATION: FROM THE DIGITIZATION OF THE ENERGY SECTOR TO THE NEED FOR A CARBON-NEUTRAL DIGITAL SECTOR

REGULATIONS HAVE STRONGLY ENCOURAGED THE COLLECTION OF ENERGY DATA

For over a decade, the regulatory framework in France has been a driving force behind the development of smart grids. After supporting the digitization of the grid, notably with the deployment of smart meters, it is now seeking to encourage the collection, access and sharing of the energy data needed to implement energy transition services.

Article 179 of **the French Law on Energy Transition and Green Growth** (LTECV) requires network operators to make local energy data available. Today, they also use this data to respond to changes in the electricity system: renewable energy production, self-consumption, electric mobility, etc. Grid operators have thus become true data operators.

The LTECV law and **the ELAN law** (Housing, Planning and Digital Development law) have also contributed to the increase in the overall volume of energy data, by introducing new obligations that local authorities and companies must meet to avoid penalties (with the "Décret tertiaire" setting energy saving targets for tertiary buildings and the "Building Automation & Control Systems (BACS) Decree"). Added to this are numerous standards (ISO 50001) and environmental labels (GRESB, GRI, EPRA). As a result, companies and local authorities have to rely on a growing mass of data to comply with the various reports that demonstrate their energy performance.

The law on energy and climate (November 8, 2019) known as the **"loi Energie-Climat"**, introduced a regulatory experimentation mechanism (known as a "sandbox") in the energy sector. The French Energy Regulatory Commission (CRE) can now grant exemptions to network access and use conditions for the experimental deployment of innovative smart grid technologies and services. This measure has helped to remove constraints on the use of energy data, and thus encouraged the proliferation of use cases.

REGULATORY FRAMEWORK EVOLVES TO ENCOURAGE GREEN COMPUTING

At the same time, the regulatory framework has also evolved to limit the negative externalities of this exponential development of energy data and associated use cases.

Smart Grids can manipulate personal data, notably on consumer behavior in terms of energy consumption and movements. **The General Data Protection Regulation** (GDPR) has created an initial legal framework that limits the collection, processing and storage of personal data, with in particular obligations concerning the collection of consumer consent, the minimization of collection to data strictly necessary for the purpose of processing, or limiting the storage duration of personal data.

The French anti-waste Law for a circular economy of February 10, 2020 then strengthened obligations to **prevent software obsolescence** and the impact of software on the lifespan of equipment (see Article 27).

Article 167 of the Finance Act for 2021 introduced an obligation for companies operating a data center to adhere to an **eco-design and energy consumption optimization program** that is "recognized by a public authority". It also introduces an obligation to carry out a cost-benefit analysis on the recovery of waste heat, notably through a heating or cooling network.

Finally, the Law to Reduce the Environmental Footprint of the Digital Economy of November 15, 2021, known as the "REEN Law", establishes, via Article 25, the creation of a general reference framework for the ecodesign of digital services (RGESN). The REEN Law inevitably impacts Smart Grids with, among other things, constraints in terms of **hardware LCA, digital eco-design, combating software obsolescence and limiting data-center consumption**. It also prohibits manufacturers from making it impossible to restore the full functionality of a repaired or reconditioned terminal, or from preventing users from installing the software or operating systems of their choice after two years.

At a European level, the provisions of the **Sovereign Cloud** (Gaia-X) and the Trusted Cloud (Bleu, S3NS) as well as the future **Data Act** and the **Data Governance Regulation** that will apply from the end of September 2023 will further facilitate the sharing and pooling of energy data, promote **interoperability** and impose limits on proprietary solutions for the development of IoT.

More generally, the European strategy for the digitization of the energy sector points to the need to accelerate the digitization of electricity grids, while dedicating a section to the carbon neutrality of the digital sector. The European "Digital Decade" action plan for 2030 adopted in December 2022 places digital sustainability among its main objectives in order to "ensure that digital infrastructures and technologies, including their supply chains, become more sustainable, resilient and energy and resource efficient, with a view to minimizing their negative environmental and social impacts (...), in line with the European Green Deal, in particular by encouraging research and innovation that contribute to this end, and by developing methodologies to measure the energy and resource efficiency of the digital space".

LEVERS FOR APPLYING DIGITAL SUSTAINABILITY TO SMART GRIDS

DATA GENERATED BY SMART GRIDS

The electricity system is undergoing radical change, due to the decentralization of electricity production and the rise of intermittent renewable energies, as well as the development of new uses such as electric mobility and self-consumption. At the same time, the European Union has set itself ambitious targets for decarbonization and energy savings by 2030, at a time of unprecedented tension on the energy system.

In this context, the development of Smart Grids and digital technologies is seen as a real opportunity to meet energy-saving targets by optimizing grid operation, while reinforcing its resilience.

Much of the data collected by smart grids, concerning mobility or energy consumption for example, provides information on the impact of human activities or can inform decision-making on the ecological transition, as emphasized by the 2020 roadmap on the environment and digital technology issued by the French National Digital Council (CNNum).

The data collected on smart grids is very diverse in nature: consumption data from meters, operational data on the behavior of equipment, data on the state of infrastructures, data linked to specific events (incidents, outages, etc.).

In addition to its diversity, Smart Grid data is characterized by its sheer volume, which is growing exponentially due to the multiplication of sensors, sampling frequencies and connected objects, right up to the edge of energy grids. Within the scenarios of the ARCEP-ADEM report (environmental impact of digital technology in 2030 and 2050), these sensors are identified as the main vector of growth in digital equipment. A global approach to the sustainability of digital solutions is therefore necessary to limit the environmental impact of smart grids, which are at the heart of the energy transition.

LEVERS FOR ACTION

The majority of Smart Grid stakeholders interviewed are already integrating sustainable IT principles into their activities, and implementing specific actions to limit their impact on the environment.

Acting on data storage

> "Data storage is a major issue, and we need to implement a frugal approach, with processes that only retrieve and store the data we need."
>
> **University of Lille**

Most of the environmental impact of data storage is concentrated on the hardware needed to store it. Increasing the lifespan of hardware and minimizing storage to reduce the amount of equipment needed is therefore a priority.

Then there's the question of reducing storage energy consumption, which is often very high. The simplest way to do this is to regularly delete non-useful data, but there are other optimization levers.

x9,4

The volume of data relating to the storage of electric vehicle charging stations will be multiplied by 9.4 between 2022 and 2030[1].

> "Local data management and the ability to power data centers with renewable production sources will be very interesting ways of reducing the environmental footprint of projects."
>
> **Energy Pool**

The eco-design of data centers is also a major lever for action. The operation of cooling circuits and the power supply to servers and all IT tools housed in data centers are particularly energy-intensive.

Leading market stakeholders, notably hyperscalers, are looking to use greener solutions by improving data center energy efficiency or planning to replace generators with low-carbon energy sources such as photovoltaics, wind power or "green" hydrogen.

1. Indicator calculated from information shared by IZIVIA.

BIOGRAPHIES

ROMAIN ROUVOY
Professor of Computer Science at the University of Lille

Romain Rouvoy is Professor of Computer Science at the University of Lille, and a member of UMR CRIStAL and GdR GPL. He is also a member of the Inria Spirals project-team and an honorary member of the IUF. His research interests lie at the crossroads of software engineering and distributed systems, exploring issues of sustainable development of current software infrastructures.

JEAN DOBROWOLSKI
Head of microgrid solutions - Energy Pool

After completing a PhD in 2017 on decentralized microgrids, Jean Dobrowolski joined the Zurich University of Applied Sciences (ZHAW) to focus his research on the stability of the European grid with the integration of numerous renewable energies. In October 2019, he joined Energy Pool as head of microgrid solutions; he is involved in the deployment of various connected and disconnected microgrid projects.

ARNAUD PHILIBERT
Director, Digital Solutions & Services Development - Itron

Arnaud Philibert is an instigator of Energy Management Strategy, thanks to his proven methodology as an energy consultant and his mastery of digital tools. He is currently involved in developing smart grid, Smartcity and alternative mobility solutions for Itron, one of the suppliers of Linky and Gazpar smart meters.

GUILLAUME BULLIER
Smart Grid Manager - CRE

An engineer with consulting experience, Guillaume Bullier has been in charge of smart grids at the French Energy Regulatory Commission since 2020.

FRANCK AL SHAKARCHI
Director of Strategy and Innovation - Entech

Franck Al Shakarchi became involved in the field of renewable energies, energy storage and sustainable development, after an initial experience in oil services. He then turned his attention to island energy issues and the development of innovative solutions for smart grids. In 2021, he joined Entech to head up strategy and innovation.

SÉBASTIEN HENRY
Executive Director R&D, IS & digitization - RTE

Sébastien Henry has worked for 25 years in the field of electrical systems, and more specifically in transmission networks. He led research teams for several years, notably as RTE's R&D Director, before taking responsibility for IT and digital systems.

BORIS DOLLEY
Digital Strategy Manager - RTE

With 15 years' experience in managing and directing IS projects, followed by experience in managing a purchasing team, Boris Dolley now manages a team of software designers and developers within the company. His team notably develops software for prospective supply/demand balance studies (Future energy pathways 2050) and network development.

2,4%

This is the estimated share of data centers in France's electricity consumption in 2021, i.e., 11.59 TWh[2]. This is almost twice the 6 TWh consumed by the national railway company SNCF, France's largest industrial electricity consumer. The IEA estimates this figure at 0.9 to 1.3% worldwide, without taking cryptocurrency mining into account[3]. It should be noted that servers and cooling systems account for over 80% of the electricity consumed by a data center, with data storage itself representing only a marginal share of this consumption.

Acting on data flows

> "One action is to minimize the volume of data uploaded to the cloud from operating facilities, while continuing to meet processing needs: only relevant data should be selected and transmitted with the coarsest possible temporal sampling compatible with the desired processing."
>
> **Entech**

Data flows can be optimized by adapting the place where data is processed to its intended use. In some cases, centralization in the cloud proves to be the best option. Cloud solutions offer new computing capacities and data processing modules that cannot be replicated locally.

What's more, data processing in the Cloud is often simplified, as it avoids redundancy and limits maintenance and development, as these actions are centralized.

Nevertheless, this centralization requires data to be moved to the place where processing takes place. These data exchanges consume energy and should therefore be optimized as far as possible. To achieve this, it is possible to widen the time step for data transmission, to meet only the final need. Another approach is to use Edge computing technologies to carry out certain processing locally, as close as possible to the data sources, particularly when the high processing or computing power offered by the Cloud is not required.

> "We use AI systems in layers, processing locally to avoid Big Data processing and centralization when possible."
>
> **RTE**

2. ADEME-ARCEP Study - Evaluation de l'impact environnemental du numérique en France et analyse prospective - (19 janvier 2022) - volet 2, p.86
3. https://www.iea.org/reports/data-centres-and-data-transmission-networks

Sharing data and infrastructure

> "We try to reuse current infrastructures as much as possible by sharing infrastructures with partners. This collaborative mindset is key to a more responsible digital future."
>
> **ORANGE**

Developing data interoperability and standardization are essential prerequisites for minimizing heavy processing on data shared by smart grid stakeholders.

Some stakeholders, such as Enedis and RTE, have also opted for Open Data, so that their data can be used by others to develop new energy services. This pooling of data avoids the multiplication of storage spaces and data redundancy. Open data also avoids the need to develop new tools and processes specific to each platform, making it easier to exploit data for a wide range of uses, and providing real leverage for the development of new smart grid services.

In addition to data sharing, infrastructure pooling is a major lever for optimizing the use of existing infrastructures and avoiding duplication. As 80% of the environmental impact of digital technology occurs at the hardware manufacturing stage, this pooling must be a priority.

Optimizing developed solutions

> "Today, efforts are focused on energy savings in hardware, cloud and infrastructure, but still very little on software, even though it is the software that drives the infrastructures. Efficient hardware is not enough: efficient use of that hardware is just as important."
>
> **University of Lille**

Digital technologies and software are playing an increasingly important role in the operation of energy infrastructures, and new possibilities are emerging thanks to artificial intelligence (anticipating energy production and consumption, preventing breakdowns, etc.). However, these artificial intelligence models can be cumbersome and energy-intensive, and there is little transparency about their environmental impact, particularly during the learning, re-training and adaptation phases. They must therefore be used wisely, with the right balance between the initial need and the level of technology used.

8,08 TB

This is the annual volume of data required to run a digital twin for a warehouse of 5,000 units[4]. This is equivalent to downloading over 2,000 HD movies.

NICOLAS PERRIN
Head of CSR - ENEDIS

Nicolas Perrin began his career in the field of local economic development, then went on to manage teams in all the technical areas of the DSO Enedis. A member of several standardization committees (CEN - IEC), he complements these activities with international assignments (EDF International Networks) and teaches at ESTP Cachan and IAE Paris Sorbonne Business School.

GILLES SABATIER
Director of Co-innovation and Ecosystems, Major Customers Division, Orange Business Services - ORANGE

Gilles Sabatier develops co-innovation projects with major French companies, activating Orange's technological innovation capabilities and putting them to work to meet our customers' business challenges of tomorrow.

MICHEL GIORDANNI
Head of the Sustainable Regions research program at Orange Innovation – ORANGE

Michel Giordani conducts research aimed at harnessing the transformative power of digital technology to meet the environmental and societal challenges facing regions, with a particular focus on smart grids.

NICOLAS BIHANNIC
Expert of the Orange "Networks of the future" community - ORANGE

Nicolas Bihannic analyzes the business and technical opportunities offered by 5G and Edge Computing technologies. His work is carried out in co-innovation for the sectorial markets of smart grids, rail, medical and industry of the future.

4. Indicator calculated from data provided by Amazon Web Services: https://aws.amazon.com/fr/iot-twinmaker/pricing/?nc1=h_ls

GEOFFRAY BRELURUT
Data Scientist in Quantmetry's Trusted AI department

Quantmetry's expertise deals with aspects linked to the reliability, robustness and ethics of AI. Geoffray Brelurut works on the aspects of interpretability from the design stage and model frugality, in order to reduce the environmental impact of AI.

SÉBASTIEN MEUNIER
Vice-Chair Institutional Relations - ABB France

Sébastien Meunier works on the digital convergence of energy and services in technical infrastructures, on both operational and marketing levels. A contributor to the building, industry, mobility and energy sectors, Sébastien has been with ABB France since 2012 and is active in GIMELEC and Think Smartgrids.

1507 kWh

This is the energy required to train the BERT model[5] just once. BERT is very widespread in AI but also very computationally-intensive. Reducing the size of a model and the number of its parameters will optimize resource consumption and training time. This can be done without compromising accuracy (see the DistilBERT model, 40% smaller and 60% faster, retaining 97% of BERT's language comprehension).

The energy efficiency of hardware and the eco-design of algorithms must also be considered when choosing computer architectures. Some architectures are natively more efficient than others. Micro-service architectures, for example, optimize lines of code by subdividing the infrastructure, thus considerably reducing software energy consumption. However, their potential "**rebound effect**" must also be monitored.

It is therefore in the interest of solution developers to optimize these models by finding a compromise between environmental impact and solution performance, to make their solutions sustainable. The environmental impact of solutions must be considered right from the design phase, by encouraging development teams to find solutions that incorporate the notion of sustainable digital.

> "Making AI solutions that address a need in tomorrow's world means accepting to downgrade certain dimensions to find a better balance between performance, robustness, ethics and environmental impacts."
>
> **Quantmetry**

5. MIT, "Training a single AI model can emit as much carbon as five cars in their entire lifetimes", 2019.

SEVEN FOCUS AREAS FOR ACTION: CONCRETE SOLUTIONS AND INITIATIVES

Interviewees were invited to share their solutions and actions on seven themes that contribute to sustainable digital and reduce the overall environmental impact of Smart Grids.

Focus area 1: Hardware and equipment

Although this study focuses primarily on Green Computing principles applied to the data of smart grids use cases, **terminals account for 65 to 90% of the various environmental impacts of digital technologies**[6]. The eco-design of hardware and a careful analysis of equipment sizing, or even of the need to deploy new equipment, are therefore major prerequisites for a sustainable IT approach.

This first area covers all the equipment needed to collect and process energy data for Smart Grids use cases. This includes devices for data collection (sensors, concentrators, meters, drones, etc.), data storage and processing (servers, disks, processors, etc.), as well as the digital terminals associated with these use cases.

Numerous parameters need to be considered to assess the environmental impact of different equipment and materials. For example, the volume of data emitted by a sensor says nothing about the environmental impacts generated during its design, production and maintenance. A sensor that transmits data in a "smarter" way will not necessarily be more environmentally friendly. The energy consumption of storing a terabyte of data may also vary depending on the quality of the hardware (server) on which it is stored. The carbon footprint of this storage also depends on the energy mix of the country in which the data is hosted.

Finally, digital infrastructures, and data centers in particular, have a "spatial" impact. In 2019, the ADEME-funded ENERNUM research project pointed to data centers as "a potential factor in the imbalance of local energy systems". In particular, it called for datacenters to be better integrated into both energy and urban planning, for preference to be given to the conversion of existing buildings over the construction of new ones, for infrastructures to be pooled to avoid redundancy, and for the recovery of waste heat and the development of renewable energy microgrids to power these datacenters[7].

Focus area 1: Illustrations

- **Some data storage centers are already integrating the notion of environmental performance:**
  - Qarnot Computing deploys its servers directly in existing buildings **with a decentralized approach to avoid building new datacenters, but also to be able to recover heat close to where it is produced.** Qarnot recovers 96% of the waste heat from its servers using direct water-cooling technology, with water at over 60°C that can meet the needs of urban heating networks, including older ones, without the addition of heat pumps, as well as those of aquatic centers or industrial heat consumers. The company also promotes the use of reconditioned equipment and seeks to maximize processor lifetimes.
    At the end of 2022, Qarnot initiated a project with Inria, supported by ADEME, to evaluate and optimize these decentralized "edge" infrastructures. The PULSE challenge (for "PUshing Low-carbon Services towards the Edge") will seek to model, measure and optimize the energy consumption of distributed computing infrastructures.

6. ANCT, "Évaluation de l'impact environnemental du numérique en France : les terminaux, premier vecteur d'impacts environnementaux".
7. Impact spatial et énergétique des data centers sur les territoires - ADEME.

- Another example is the EU-funded BodenTypeDC (BTDC) project in Sweden, which has built, tested and validated a data center designed to be the most energy-efficient in the world, while minimizing costs. Powered by renewable energies, its intelligent cooling system adapts to workload, ventilation and temperature, using free-air and evaporative cooling technologies, without the use of refrigerant gases. Its energy efficiency or "power usage effectiveness" (PUE) is 1.02, very close to 1.00, which is the theoretical maximum efficiency level, while other European data centers have a PUE of over 1.5. Building materials were sourced locally and are low-carbon. The project is now looking to replicate this first prototype elsewhere in Europe, recovering waste heat in countries with less favorable climates.

It's also worth noting that the tech giants were among the first to sign up to **Power Purchase Agreements (PPAs)** to source electricity directly from renewable sources, notably for their data centers. Google was a key pioneer, and in 2020 invested in Electricity Maps to reduce the carbon impact of its data centers, by modulating the calculations made there according to the CO_2 content of the electricity at any given time. Google has undertaken to share its methodology and results once the tests are completed.

- **Several labels have been introduced by the industry.** Schneider Electric's "Circular Certified" label guarantees extended product life through maintenance operations, re-use of parts and raw materials, product reconditioning and metal recycling. Siemens' "blue" label is applied to some of its Smart Grid products in compliance with a series of constraints and transparency measures, such as the implementation of recycling mechanisms, the absence of fluorinated gases, the publication of LCAs for products, and the expectation that they will operate appropriately for more than 40 years. Published documents comply with certain reporting standards to enable comparison between different market solutions.

- **Orange has developed several programs to reduce the environmental footprint of its equipment.** The Green IT-N (N for Networks) program aims, among other things, to replace energy-guzzling equipment, to measure all consumption in order to reduce it wherever possible, and to use AI and Data to optimize infrastructure deployment, operation and sharing. Green IT-N also seeks to promote the passive air-conditioning of data centers and the activation of "standby" modes on its networks, thanks to innovative architectures. Orange also has several programs for recycling and reusing equipment: "OSCAR" is a platform for reusing equipment in subsidiaries, and the "RE" program aims to develop the recycling of customer terminals. Lastly, Orange has launched a project to develop a methodology that will enable it to take into account the overall LCA of its products and services, and to measure their positive impacts as well as their potential rebound effects, based in particular on the work of ADEME (the French Environment and Energy Management Agency).

- **Manufacturers are studying ways of drastically reducing the power consumption of the sensors** needed to implement Smart Grids use cases. In its white paper "Low-Power Sensing, Energy-efficient power solutions", NXP Semiconductors presents 3 approaches to reducing power consumption: integrating a shutdown mode and an ultra-low-power operating mode into the sensor, adding "smart sensing" to enable the sensor to manage its own power consumption, and enabling the sensor to use the local computing capacity of the microcontroller (MCU). This approach has been used in accelerometers, pressure sensors and magnetometers. French company TCT Magnetic Core and Component also offers battery-free sensors, known as "e-green sensors".

- **More and more companies are turning towards product-service system models rather than buying the equipment itself**. A Product-service system, which sells the service provided by a piece of equipment rather than the product itself, has many co-benefits: it promotes more durable equipment, repair and re-use (the manufacturer, who remains the owner of the product, has every interest in extending its life), enables savings (by extending the product's life) with the possibility of sharing benefits between the supplier and the customer, but also increases quality as the supplier guarantees a **service or performance rather than a product**. This may involve IT hardware, vehicle batteries or mobility services, but also innovative services such as contracts guaranteeing a volume in m^3 of compressed air supplied rather than selling the air compressors themselves, or a level of lighting rather than streetlamps and bulbs. The provision of the product is generally accompanied by other services (maintenance, training in the correct use of equipment, collection and recycling of end-of-life products, etc.).

Focus area 2: Technical architecture

The digital sustainability of smart grids then involves looking at the technical architecture of the infrastructures required for data collection and processing. Frugal architectures must **optimize the volume of data stored**, The digital sustainability **transported (flows) and processed**, while meeting the expected level of service (performance, security, functionalities, service continuity...).

Let's take a fictitious example of a collective self-consumption use case. The technical architecture will influence the volumes of data stored, transported and processed. If we opt for a totally centralized architecture, all the data linked to the operation (notably production/self-production/surplus load curves and consumption/self-consumption/supplement load curves) are sent to a central server at 30-minute intervals. If we estimate 10,000 collective self-consumption operations (12 consumers and 2 producers), this implies the transport of 755 Gigabytes per year to the central server.

An alternative to this centralized technical architecture could significantly reduce the volume of data transported by, for example, equipping the various nodes with local processing capabilities to send only surpluses and complements at 60-minute time steps, and thus divide the volume of data transported to the central server by 6.

Focus area 2: Illustrations

- **The use of an event-driven software architecture model:** this is a model in which microservices react to changes in state, called events. With this architecture model, each microservice operates independently, and the architecture only functions when an event occurs. Data processing is thus optimized, and the agility of this type of architecture enables upgrades to be carried out while optimizing development. This type of architecture is notably offered by hyperscalers such as Microsoft and AWS.

- **Discontinuous reception (DRX)** saves energy consumed by a system communicating in LTE by only activating the reception (or sending) of data during defined periods. This option is particularly useful when data sharing is not required for real-time or high-performance processing.

- **Clustering machines** on the same site also helps to reduce system energy consumption, by better compressing data packets, pooling processing capacities so that one or more of them can run at low power during off-peak periods, and coordinating the sending of data over the LTE network to avoid the peak load associated with simultaneous sending.

- **Inter-device communication** (device-to-device), or communication partially assisted by the LTE network, helps to reduce the network's energy consumption.

- **To size its network as closely as possible to actual needs**, Orange has implemented a policy of prioritizing flows, in consultation with customers and users: certain services, such as remote protection, will require real time, but for lower-priority services, lower priorities are granted at network node level, thanks to prioritization algorithms.

Focus area 3: Shared platforms for energy data storage and processing

Shared platforms for energy data exchange and processing make it possible to **avoid the redundancy of energy data linked to different use cases** by pooling as much data and processing capacity as possible.

Let's take the example of a use case linked to electric vehicle charging session data. Several market operators want to process this data to develop targeted pricing offers. This data will represent around 550 Gigabytes of data per year by 2030. If each of the market operators wishing to exploit this data replicates it to process it and deliver its service to the market, this volume of data, and the storage and processing capacities required, will be multiplied by the number of operators. The idea, then, is for a shared, optimized storage and processing platform to enable these operators to provide their services without having to replicate the data locally.

The emergence of these platforms raises a number of questions, particularly in terms of security, governance and architecture, but represents an undeniable avenue for the sustainability of smart grid solutions and data accessibility.

Focus area 3: Illustrations

- **"Open data"** is a first step towards the emergence of these shared platforms, and benefits from strong regulatory incentives, both in France and in Europe, which have led to the creation of numerous platforms. These include the European Energy Data space and the World Bank's Energy Data Platform. It's worth noting that the data space can help overcome a certain reluctance to share data, as it enables data to be shared while retaining ownership, unlike the centralized architecture of the Data Lake.
  In France, the Agence ORE (Energy Grid Operators Agency) federates all the stakeholders involved in electricity and gas distribution, to offer a global vision of distribution, thanks to a unique, free data platform.
  The ODRÉ (Open Data for Energy Grid) platform provides stakeholders with access to data linked to the themes of "Production", multi-energy "Consumption" (gas and electricity), "Storage", "Mobility", "Territories and Regions", "Infrastructures, "Markets" and "Meteorology", the result of the joint expertise and know-how of GRTgaz, RTE and Teréga, founding members of ODRÉ. They have since been joined by AFGNV, Weathernews France, Elengy, Storengy and Dunkerque LNG.

- **Pooling data platforms and avoiding redundancies** is also an important issue. RTE has eliminated its own open data platform and switched entirely to ODRÉ, thus avoiding duplicated data sets. A merger of the ORE and ODRE platforms would, in the same vein, eliminate further duplication.

- **The Open Subsurface Data Universe (OSDU™) is developing an open source, standardized and technology-agnostic data platform** to stimulate innovation, industrialize data management and reduce the time to market of new energy data applications. Beyond Open Data, OSDU™ enables developers to develop applications directly on the platform, benefiting not only from the available data but also from increased processing capacities.

- **The emergence of shared energy platforms will depend heavily on the ability of governments to develop trusted clouds** to take advantage of the performance of international cloud services (mainly American) while protecting their country's data by making up for the lack of international regulation. As some energy data is considered personal data in France, initiatives have recently been launched, notably with Bleu (Orange, Capgemini and Microsoft) and S3NS (Thales and Google), to deploy trusted clouds as the basis for shared energy data platforms.

- **In 2021, the Flexgrid program completed the experimentation of a shared "Energy Data Platform"** with the objectives of (1) an experiment in shared governance and the valorization of Smart Energy Grid data, (2) a digital platform for territorial data, (3) the development of Smart Grid Service Operator activities. This work has led to the creation of a technological demonstrator available online. Two use cases are currently being finalized (the territorial energy dashboard and smart EV charging). Future use cases will be identified and validated by a steering committee comprising the Région Sud, Orange, Capenergies and partners such as Enedis and RTE.

Focus area 4: Software

Software design also plays an important role in IT sustainability. **Ensuring that design is as close as possible to user needs, optimized and easy to maintain** saves energy and hardware. This is a highly complex area, as it lies at the crossroads of a number of disciplines, each with its own field of investigation (requirements management, functional and hardware mutualization and rationalization, algorithms, development standards and technologies, etc.).

The way in which an algorithm is developed, for example, can have a major impact on the speed with which it processes large volumes of data, and on its energy consumption.

But even before algorithmic performance, the way in which needs and requirements are defined, and therefore **the functional scope of an application, modifies the environmental impact of software solutions**. Take, for example, an application with 10 functions. Two are used regularly, three occasionally and five never. Even if five functionalities are never used, they have an environmental footprint, because they need to be developed, integrated, tested and deployed in the same way as the other five. However, they are of no interest to the end-user and therefore create no value. This attention to software design, known as "software eco-design", has become particularly important with the advent of artificial intelligence and digital twins, which are particularly demanding in terms of computing capacity and data.

The challenge is also one of skills and **providing appropriate support to developers** on eco-coded software design and assessing the environmental impact of their development.

Focus area 4: Illustrations

- **INRIA Lille has developed the "Power API" tool**, which enables the energy consumption of a system process to be measured without having to use any consumption measurement tools (wattmeters or others). This enables designers to accurately measure the resource consumption of the software they develop. The use of this solution is in line with a global approach to software eco-design. Similarly, **software libraries are emerging to assess the energy consumption of programs** and their carbon impact. These include the "Carbontracker" and "Code Carbon" Python libraries for AI algorithms.

- The use of Artificial Intelligence algorithms for the operation and maintenance of smart grids is growing rapidly, which raises serious concerns, as the amount of energy and resources required to train models, collect data and drive these algorithms is significant. In response, initiatives are multiplying to give substance to the concept of **"Green AI"**.
  In an article on the energy consumption of AI use ("Consommation énergétique de l'utilisation de l'IA"), the CNRS reports that **emissions linked to training neural networks range from 18kg eqCO_2 to 284T eqCO_2**. For a standard model, without any specific parameterization, this figure can reach 652kg eqCO2, or the equivalent of a round trip by plane from Paris to the North Pole. As with other green IT disciplines, the development of Green AI relies on a combination of best practices and tools to measure results and impacts. **A first lever is to promote the reuse and reproducibility of AI algorithms**, for instance with pre-trained AIs serving as the basis for other algorithms. **Open-source sharing of AI algorithms is also fundamental**, so that stakeholders can focus their efforts on optimizing algorithms rather than starting from scratch with trial-and-error cycles that have a high carbon impact.

- **AFNOR periodically publishes a collection of best practices**[8] designed to provide guidelines and concrete recommendations for all organizations, both public and private, in this eco-design approach to digital services. Its recommendations cover the entire software lifecycle (expression, definition and prioritization of needs, design, production, use and operation, maintenance, decommissioning)..

8. AFNOR SPEC 2201, Éco-conception des services numériques.

Focus area 5: Use cases

The aim here is to avoid the inflation of energy data use cases by prioritizing those likely to really create value, and by asking the question of **the environmental impact/benefit ratio** of implementing a use case. To achieve this, it is essential for a Green Computing policy to be deployed in a coherent and harmonized way across all departments and entities of a group, with an objective to select only relevant use cases and to avoid the same use case being replicated several times by different entities.

Furthermore, as the Shift Project reminds us in its report "Déployer la sobriété numérique" (Deploying digital sustainability), Smart Grids are now an integral part of a true "digital system", and their deployment must take into account all the externalities they can generate: their overall consumption of energy and resources, their real eco-contributions compared with non-connected technologies, and the indirect effects of their deployment (need for maintenance and for new infrastructures, etc.). More generally, the question is whether a less energy- and resource-intensive approach could deliver the same benefits.

Focus area 5: Illustrations

- **The French Energy Regulatory Commission (CRE)** supports and encourages the evolution of electricity and natural gas networks towards smart grids. To assess the relevance of smart grid use cases, the CRE observes and supports experiments carried out by sector stakeholders. Numerous "**demonstrators**" have been set up, with an estimated budget of more than €600 million over the past 10 years, to test and demonstrate the relevance and viability of innovative solutions before considering scaling them up. **Incorporating the environmental impact of digital technology into these experiments** and future demonstrators would enhance the quality of the assessment.

- **The think tank The Shift Project** has developed the STERM model (Smart Technologies Energy Relevance Model), **which assesses the energy relevance of connected solutions according to use cases** (for example, connected lighting for tertiary buildings vs. housing). Implemented in Python, with open-access code, the model is intended to be used by public and private stakeholders to develop operational tools tailored to their decision-making processes.
  The think tank also proposes to develop tools to assess the "energy relevance" of use cases, by quantifying the net reduction or increase in energy consumption following the introduction of a connected layer - taking into account the energy cost of the production phase and the consumption of connected equipment in operation.

- The 3rd part of the ARCEP-ADEME study on the environmental impact of digital technology in France, published in March 2023, identifies green IT as one of the main levers for action, "which begins with a questioning of the scale of development of new digital products or services and a reduction or stabilization of the number of pieces of equipment"[9]. For example, ADEME's "Repairing Promise" scenario, which maximizes the use of digital technology to decarbonize other sectors, increases the carbon footprint of digital technology fivefold, and more than doubles the consumption of materials (minerals, metals, etc.) compared to 2020, which "calls into question its sustainability". ADEME and ARCEP are calling for **the systematic eco-design of terminals, infrastructures and digital services themselves, the development of equipment reconditioning and repair, and end-user awareness-raising**.

9. ADEME, ARCEP, *Évaluation de l'impact environnemental du numérique en France*, 3e volet.

Focus area 6: Governance

Integrating sustainable digital issues into sector governance would also help to ensure that they are taken into account in general policies at national, European and international level.

This governance brings together all state players (ministries, supervisory authorities, etc.), as well as all professional organizations (think tanks, sectoral unions, associations, etc.).

This area also includes all initiatives aimed at encouraging consumers to reduce their energy consumption and avoid the rebound effect in deployed use cases.

Focus area 6: Illustrations

- As part of its "**Digitizing the energy system**" action plan, the European Commission has decided to launch a **"European Energy Data Space" to ensure governance of the sharing and use of energy data**, the preparatory phase of which should be completed in 2024. A "Data for Energy" group bringing together member states and private and public stakeholders should be set up in 2023 to contribute to the development of this new European framework for sharing energy data. The aim is to develop a portfolio of high-level European use cases for data exchange, covering (1) flexibility services for energy markets and networks, (2) smart, bidirectional charging of electric vehicles, and (3) smart, energy-efficient buildings. This action plan will also include support for grid operators to create digital twins of the electricity grid.

- **The Institut du numérique responsable** (INR) is a French ssociation created in 2018 and bringing together companies and organizations that share and promote experiences for an environmentally-friendly, inclusive, solidarity-based and ethical digital. The INR institute has published a **responsible digital charter**. This charter summarizes the digital commitments made by the signatory, whether a company, an association, a startup/SME or a public stakeholder, and is structured around 5 main themes:
  - Optimization of digital tools to limit their impact and consumption.
  - The development of service offerings that are accessible to all, inclusive and sustainable.
  - A commitment to ethical and responsible digital practices.
  - A commitment to making digital measurable, transparent and legible.
  - A commitment to fostering the emergence of new behaviors and values.

  In 2021 and in partnership with the French Ministry of Ecological Transition, ADEME and the WWF, the Responsible Digital Institute also built the reference framework for the Responsible Digital label. This is based on 4 focus areas and 14 principles of action for the Responsible Digital label. The first focus area concerns strategy and governance, and aims to integrate the responsible digital strategy into the organization's overall strategy, define a responsible digital policy and deploy it within an organization.

- **The French Ministry of Ecological Transition** considers that "the environmental impact of digital technology is the subject of a strong societal awareness that calls for political responses", adding that "digital and ecological transitions... are inseparable" and must "converge to promote controlled progress serving a modern society that respects the environment."[10]
  Several actions and measures have already been deployed by the public authorities. In addition to the Anti-Waste and Circular Economy Act, which focuses on combating software obsolescence and extending the lifespan of equipment, a governmental "digital and environment" roadmap has formalized some of the proposals put forward by the French Citizens' Climate Convention. This work led to the adoption on November 15, 2021 of the law aimed at reducing the environmental footprint of digital, or "REEN law".

10. https://www.ecologie.gouv.fr/numerique-responsable

Focus area 7: Standardization and interoperability

The final focus area of digital sustainability explored with study participants is that of data standardization and interoperability. Standardization of data and metadata reduces the need for specific processing, making it possible to share part of the work, and encouraging cross-fertilization. It also opens the door to the pooling of multi-source data. Finally, it is the basis for interoperability between the various components of smart grids.

In addition, a standardized database optimizes data storage, access and handling, saving space and energy. Interoperability also helps combat technological obsolescence, maximizing hardware investments and reducing cyber risks.

Focus area 7: Illustrations

- **The Interconnect project** is a Europe-wide experiment in interoperability between Smart Grids and Smart Buildings. In this context, several use cases are being tested, implementing communication standards such as OpenADR 2.0, which provides an open, free, standardized and secure "Demand Response" interface enabling electricity suppliers to communicate signals to consumers using a common language over the Internet, or OCPP V2.0, a V2G communication protocol.

- **The NIST (National Institute of Standards and Technology) regularly updates its framework of interoperability standards for Smart Grids**. The latest version of this Framework includes environmental impact management among the stated objectives of standardization. Among the main Smart Grid challenges highlighted by NIST is the **interoperability of smart sensors**, which is essential to enable communication between sensors and with the rest of the network. On this subject, NIST recently published a methodology for measuring and assessing the level of interoperability of smart sensors. This methodology identifies and evaluates interoperability problems between sensors, and resolves them in order to optimize sensor communication on the network. In addition to facilitating network exchanges, NIST emphasizes that optimizing data flows through **interoperability is essential for limiting cybersecurity risks**[11].

THE THREE PRIORITY AREAS FOR THE COMPANIES SURVEYED:

➡ Uses
➡ Hardware
➡ Standardization

11. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r4.pdf

DEPLOYING SUSTAINABLE DIGITAL IN THE SMART GRIDS SECTOR: CHALLENGES AND ISSUES

OBSTACLES TO BE OVERCOME

Although Smart Grid stakeholders are already taking into account the notion of digital sustainability in their activities, there are still several obstacles to be overcome before sustainable digital is fully integrated by all stakeholders.

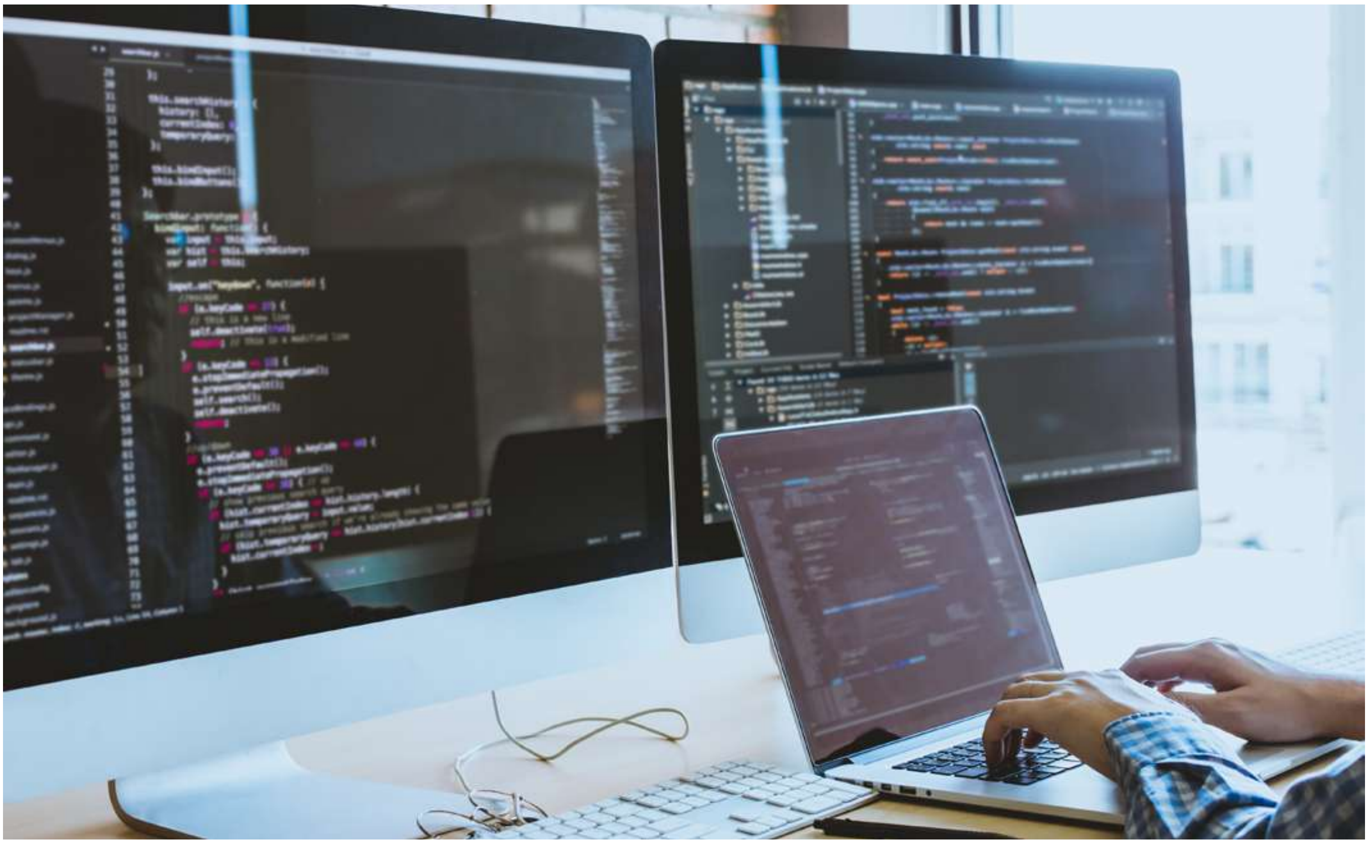
One of the main obstacles is the lack of metrics and global measurements on the volumes of data exchanged, processed and stored by smart grids. Knowledge of these volumes is essential to compare them with the energy gains made possible by the digitization of networks. It would also help raise awareness of the environmental impact of this digitization, which is not obvious today as it has not been quantified.

> "It would be interesting to have some figures on the energy impact to know where to act, but today we don't have them."
>
> **Hyperscaler**

In addition to environmental impact, smart grid stakeholders also need to consider other essential criteria, such as cost and cybersecurity constraints. Some new stakeholders are also more into the logic of massive data collection to learn and perfect their models before introducing the notion of digital frugality, which would limit the volumes of data processed.

> "There's a real need to educate people and change their digital practices. It is essential to raise awareness of the environmental impact of data processing, exchange and storage. Scope 4 (tons of carbon avoided) is a methodology that can be used to consider the benefits of digital technology, compared with the carbon impact of digital infrastructure and terminals."
>
> **ABB France**

Lastly, regulatory constraints are currently not very stringent, even if they are likely to become stricter. There are generally only incentives, or the sharing of best practices and recommendations, but no specific obligations or sanctions to force companies to deploy digital sustainability in their activities.



BUSINESS CHALLENGES

> "Today sustainability is a Nice-to-have for our customers, but it's becoming increasingly important."
>
> **Quantmetry**

The energy performance criteria of the solutions and software offered as part of smart grids are becoming increasingly important in the eyes of customers. As a result, the commitment to digital sustainability is becoming a real marketing lever for smart grid stakeholders, whether they are equipment manufacturers, software developers or digital solutions providers. Energy performance criteria are also required to respond to calls for tender in certain markets, and this is becoming increasingly widespread.

> "There is no longer any call for tenders in the digital sector that doesn't include criteria on the environmental impact of solutions and services, as well as on companies' strategies for reducing their environmental footprint. This also applies to the IT, Cloud and data management dimensions, which require a sustainable approach to support business performance."
>
> **ORANGE**

IN CONCLUSION

In retrospect, the variety of participants and perspectives involved in the preparation of this white paper has enabled us to observe a general awareness, but also very specific commitments to meeting the challenges of digital sustainability in smart power grids.

Even if consolidated measurements of the carbon footprint of smart grid use cases do not yet exist, the participants in the study are unanimous: given the role of smart grids in the energy transition, sustainable digital should not be an argument against the digitization of networks.

First of all, the benefits in terms of network control, operation and planning are a factor in the resilience and performance of local and global power supplies. Secondly, energy data is the very basis for estimating the benefits of many green transition use cases. It is impossible to develop relevant strategies on these issues without being able to rely on sufficient, verifiable data.

The actors interviewed also all agreed that sustainable digital is set to become a key issue for all stakeholders in the sector in the near future, for three reasons: (1) the need to drastically reduce our energy consumption, whether due to the rising cost of energy or to achieve our climate objectives, (2) the increasing scarcity of the materials needed to manufacture digital equipment and infrastructures, and (3) the exponential multiplication of data and metadata.

What emerges is a positive, non-restrictive notion of digital "common sense". This approach, which is not specific to smart grids, consists in seeking to minimize the environmental impact of digital technology as far as possible, without forgoing the benefits sought by data use cases. Such an approach nevertheless presupposes major changes in business practices and organization, in order to "do more with less", without curbing the capacity for innovation. However, several of the smart grid stakeholders interviewed have already fully integrated Green computing principles into the business model of their projects.

While this white paper cannot provide a comprehensive systemic vision of sustainable digital as applied to smart grids, it does demonstrate the importance of collective, coordinated action across the sector, locally as well as on national and European levels, to:

- Implement a common framework for measuring the digital impact (including hardware) of Smart Grids on a global scale;
- Integrate digital impact into individual assessments of the relevance of Smart Grids use cases.

This approach would also be in line with the initiatives taken by the European Commission as part of the "Digitizing the energy system" action plan, which includes the launch of a project to control the environmental footprint of ICT.

The sector's commitment to promoting sustainable digital is fundamental, given that smart grids are one of the essential building blocks in the energy transition and in achieving the "green" energy objectives.

APPENDICES

GLOSSARY OF KEY CONCEPTS

Technical architecture	In IT, architecture describes the organization, interaction and interdependence of the various elements of a system to ensure that all system requirements are met.
Sustainability	The ability of a product to remain functional without requiring excessive maintenance or repair.
Eco-design	Considering and reducing environmental impacts right from the design stage of products and services.
Edge Computing	This method of optimizing data processing involves processing information as close as possible to its source, without using the cloud (remote computer servers hosted on the Internet). The result is virtually no latency between data transmission and processing, less private data being transmitted, the use of previously under-utilized network resources, and the development of new services thanks to the pseudo-real-time nature of data processing.
Data interoperability	The ability of an IT system to work with other existing or future IT products or systems, without restrictions on access or implementation, thanks to consistency rules.
IoT (or "Internet of Things")	Network of physical terminals that integrate sensors, software and other technologies to connect them to other terminals and systems on the Internet and exchange data with them.
Responsible digital	A continuous improvement approach to the environmental and social dimensions of digital technology.
Open Data	Digital data accessible to all, free of charge and free of rights. This approach aims to make public data accessible and usable by all to enrich knowledge and innovation.
Security of supply	Ability of the electricity and gas systems to continuously meet market demand. In particular, it involves reinforcing energy system safety criteria and diversifying means of production or sources of energy supply, to guard against systemic risks.
Smart Grid	An energy network that integrates digital technologies to improve its operation and management, enabling the development of new modes of production and consumption (intermittent renewable energies, self-consumption, electric vehicles, storage, etc.).
Sustainable digital	An approach that involves designing digital services that offer savings in terms of resources, and moderating their use in order to minimize their environmental impact. It encompasses, for example, energy efficiency, eco-design, pooling and optimizing the use of existing resources, reusing and recycling equipment, etc. Sustainable digital can be distinguished from a frugal approach, which consists in developing only what is necessary, by re-examining the usefulness of a product or service to retain the bare essentials, regardless of the technical efficiency of the tools.

PRESENTATION OF THE COMPANIES INTERVIEWED

ABB	**ABB** offers solutions in the fields of electrification and automation, drawing on its know-how in software and engineering.
COMMISSION DE RÉGULATION DE L'ÉNERGIE	The **Commission de Régulation de l'Energie (CRE)** is the independent administrative authority responsible for regulating France's energy grids and markets. In particular, it is responsible for monitoring the proper management of energy networks as natural monopolies.
ENEDIS	**Enedis** is the main operator of the public electricity distribution network in France. The company develops, operates and maintains the low and medium-voltage network over 95% of the country.
Entech smart energies	**Entech** develops and commissions energy storage and conversion systems, as well as photovoltaic power plants.
Energy Pool Smart energy management	**Energy Pool** designs and supplies solutions for flexible, sustainable energy. Founded in 2009, making it France's leading flexibility aggregator, it operates mainly in Europe, Asia, the Middle East and Africa.
INR	**L'Institut du Numérique Responsable** is an association dedicated to reducing the environmental impact of digital technology and promoting digital inclusion.
Itron	**Itron** is an equipment manufacturer specializing in measurement and metering solutions.
orange™	**Orange** is a French telecommunications group present in 26 countries worldwide. Its mission is to give everyone the keys to a responsible digital world.
Quantmetry Part of Capgemini Invent	**Quantmetry** is a pure-play consulting firm specializing in AI. The company works in particular on the issue of trust that can be placed in AI.
Rte	**RTE** is France's electricity transmission system operator, ensuring the balance of the power system. The company develops, maintains and operates this network.

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THE THINK SMARTGRIDS ASSOCIATION

Chaired by Xavier Piechaczyk, President of RTE, the association federates and develops the French smart grids sector. It brings together around a hundred French stakeholders, from startups to major groups, as well as research laboratories, universities, competitiveness clusters and associations. Its members' activities cover the entire smart grids value chain: grid operation, electronic engineering, automation, equipment and information systems, digital services, training, studies and consultancy, research and regulation. The French Energy Regulatory Commission and the French government, through the Direction Générale des Entreprises (Directorate General for Enterprise) and the DGEC (Energy and Climate General Directorate), are observer members of the association.

Think Smartgrids' mission is to represent and develop the French smart grid industry, for the benefit of consumers, the economic development of regions and the energy transition. The association promotes smart grid solutions that contribute to the energy efficiency, security of supply and competitiveness of the electricity system. Think Smartgrids also sheds light on solutions to be tested in the future.

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Think Smartgrids – Phone: +33 1 42 06 52 50 – contact@thinksmartgrids.
www.thinksmartgrids.fr - @ThinkSmartgrids

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