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COMMISSION DE RÉGULATION DE L'ÉNERGIE

REPORT

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Report on the performance of system operators in the development of a smart electricity grid

SUMMARY

1. EXECUTIVE SUMMARY

The European Union and France have set the goal of reaching carbon neutrality by 2050, with the 2030 intermediate step of reducing greenhouse gas emissions in Europe by 55% compared to 1990 levels. These targets will require the electrification of numerous end-uses, including in sectors such as transportation, buildings and industrial processes, which will lead to a sharp increase in electricity production and consumption, in addition to the decarbonization of the electricity mix within the European Union.

As part of this major transformation of the power system, electricity grids will undergo significant developments over the coming years to accommodate new generation and new uses, to cope with the growth of consumption and to manage increasingly bidirectional and variable electricity flows, while maintaining the high level of service quality currently observed in the European Union.

New technologies are crucial to achieve these objectives. Smart grids will speed up connections, minimize the need for new investments in grid infrastructure, and help consumers play an active role in this transformation.

CRE attaches the utmost importance to the challenges of smart grids. For several years now, it has been supporting the rollout of smart grids, in particular by monitoring experiments, providing incentive regulation for system operators and regulatory sandboxes, and through a dedicated website[1].

This CRE report studies the performance of French system operators in developing a smart electricity grid. It is in line with the European Directive of June 5, 2019 on common rules for the internal market for electricity , which entrustsnational regulatory authorities with such an assignment. In accordance with the Directive, this report will be updated every two years.

The report is based on a limited set of indicators provided by electricity transmission and distribution system operators serving more than 100,000 customers. These indicators are divided into three key areas: grid connections, flexibilities and grid management tools, and user services.

Overall, French system operators are well positioned at a time when their transformation is set to accelerate. Digital technologies are widely deployed and used extensively at all levels of electricity grids. This is illustrated by Enedis' top ranking among 94 utilities worldwide in the Singapore Power Group's 2022 ranking[2].

The report first looks at the measures put in place in France to manage the crisis during the winter of 2022-2023. It then examines solutions for optimizing connections, before addressing the use of new flexibilities and grid management tools. Finally, the last part is dedicated to data and its role in developing new services for users.

Crisis management measures

The winter of 2022-2023 was marked by the energy crisis caused by the consequences of reduced Russian gas supplies to Europe and the low availability of France's nuclear fleet. The system operators, alongside the public authorities and CRE, were on the front line in managing this situation. This is why CRE has highlighted the actions taken during this period in the first part of this report.

Towards optimized connections to accelerate the integration of renewables and new uses in the context of decarbonization

The boom in renewable energie sources (RES) and the electrification of energy end-uses are generating a strong increase in demand for grid connections, both in terms of number and volume. Proper management of these connections will have a significant impact on France's ability to meet its targets. In recent years, CRE has observed an increase in connection lead times, which can be explained by the need to reinforce grids, sometimes lengthy administrative delays, and also by system operators' internal procedures, which still need to be perfected.

In this context, all levers for anticipating and accelerating connections and optimizing the associated costs and lead times need to be activated. In particular, it is necessary to make widespread use of new connection offers.As an alternative to conventional offers, they will help to optimize the size and cost of connection infrastructures, and to connect more facilities while rationalizing investments in return for occasional limitations on injection or withdrawal. **These solutions are still restricted to certain uses, and need to be generalized for consumers and storage, and facilitated for all other uses.**

Access to reliable, high-quality grid data is a prerequisite for optimizing connections. This data, made available by system operators through open data tools or specific services, should provide private stakeholders with information on the feasibility of their projects upstream of the connection request. In this respect, CRE draws attention to the need to improve the quality of service provided by the "Caparéseau" platform, in particular by ensuring that the data displayed is regularly updated.

[1] https://www.smartgrids-cre.fr/
[2] https://www.spgroup.com.sg/our-services/grid/overview/smart-grid-index

Towards new flexibilities and new tools for transforming grids

The deployment and widespread use of information and communication technologies now make it possible to manage a grid with greater precision and dynamism. This report presents the tools and methods developed by operators to optimize their grid management. These tools make it easier to manage the grid, while enabling new stakeholders to participate in grid service mechanisms. The measures put in place by operators to make use of flexibilities, whether for the overall supply-demand balance or to resolve localized congestion, are analyzed, as well as the observability of grids and the equipment that facilitates their operation and maintenance.

Firstly, CRE notes that the rules put in place by the system operators enable all forms of flexibility to have efficient access to the various markets. CRE will continue to ensure that these rules foster innovation.

CRE also notes that system operators have issued calls for tender for local flexibilities to resolve grid congestion. However, these calls for tender remain *ad hoc* or experimental, whereas the use of flexibilities will play a major role in limiting investment in grid infrastructure, which will rise sharply in any case. For CRE, it is important for system operators to demonstrate technological neutrality when arbitrating between the use of flexibilities and grid reinforcement. **That's why CRE is asking them to systematically study the use of flexibilities and how to industrialize the associated solutions whenever they prove more appropriate than grid reinforcements.**
Grid observability, which involves collecting data on grid structures to ensure that they are working properly, and monitoring certain assets remotely, has multiple use cases: remote fault detection, predictive maintenance and fault identification, and optimizing grid utilization. **CRE has observed a good level of integration of smart grid operation and information feedback, with numerous industrialized projects** and R&D programs focusing on predictive maintenance and grid sizing.

Lastly, CRE has asked RTE (French Transmission System Operator) to provide initial data on the rate of utilization of the transmission system, as part of the tariff for the use of public electricity grids (TURPE 6 HV). This indicator, which currently lacks the historical data required for its use, could provide useful information in the future on the performance of system operators. CRE is therefore continuing to work in coordination with RTE to better define and characterize the evolution of this infrastructure utilization rate.

Data at the heart of new user services

The widespread deployment of advanced electricity meters, the cornerstone of smart grid technologies, is a great success in France and provides a wide variety of new services for users. Access to reliable, high-quality and secure data is a *sine qua non* for the development of new innovative offers and services that benefit both the power system and the consumer.

In general, system operators produce a great amount of data that is of interest to various stakeholders: the State, local authorities, domestic and business consumers, energy producers, suppliers and balance responsible entities, service providers, etc. **Much of this data is available on open data platforms, already widely developed by French electricity system operators and is particularly useful**. CRE draws attention to the need to improve the quality of the data provided to users, and to ensure that it is updated regularly.

More than ever before, the development of smart grids requires excellent cooperation between system operators. Achieving the objectives detailed above will not be possible without increased cooperation. This is the case, for example, when it comes to using tools common to all system operators and making optimal use of flexibility resources located on distribution grids. CRE expects Enedis (Distribution System Operator) and RTE, the two main French stakeholders, to set an example in this area, and to stimulate cooperation with all system operators.

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This report is the first edition of a biannual exercise listed in Article L. 134-15 of the Energy Code since March 3, 2021, in application of Article 59 of Directive (EU) 2019/944. Future editions will be able to incorporate more of the best practices observed among European regulators. It will also involve integrating common indicators to be monitored by all EU regulators, currently being developed by ACER[3] and the CEER[4].

[3] Agency for the Cooperation of Energy Regulators
[4] Council of European Energy Regulators

2. INTRODUCTION

The mission of the Commission de Régulation de l'Energie [Energy Regulatory Commission] (CRE) is to ensure that the electricity and natural gas markets operate smoothly for the benefit of end-users, in line with energy policy objectives, in particular those relating to reducing greenhouse gas (GHGs) emissions, controlling energy demand, developing clean mobility and flexibility, and increasing the share of renewable energy production in final energy consumption. Against this backdrop, CRE is supporting and encouraging the evolution of electricity and natural gas grids towards smart grids.

Making grids smarter means adding a digital layer to the physical layer of historic grids, from which new applications can be developed. This is a major challenge for the energy transition. Smart grids will speed up connections, limit investment and the physical footprint of grids, while maintaining quality of service despite completely reconfigured and much less predictable electricity flows.

CRE already has a range of tools to support the development of smart grids:

- financing and monitoring of R&D system operators;
- publication of feedback from experiments;
- monitoring indicators as part of the incentive regulation for system operators;
- regulatory sandbox, to facilitate experimentation hampered by the current regulatory framework;
- the website www.smartgrids-cre.fr the crossroads of smart grid information.

It also publishes reports and roadmaps to support issues such as the development of electric mobility and storage.

A new assignment has been added to this list of actions. Pursuant to Article L. 134-15 of the French Energy Code, every two years, CRE will publish a new report assessing the performance of system operators in developing a smart electricity grid that promotes energy efficiency and the integration of renewable energies, based on a list of indicators agreed to in advance. This article results from the transposition, on March 3, 2021, of Article 59 of Directive (EU) 2019/944 of the European Parliament and of the Council of June 5, 2019. The purpose of this report is to assess grid intelligence, to measure the progress made by system operators, and to identify the obstacles and actions to be taken to overcome them. This regular monitoring of system operators' performance over the long term will enable us to identify their strengths as well as areas requiring improvement and may lead CRE to reinforce existing incentives or to introduce new ones. This report is the first edition of this new exercise. The report covers the transmission system operator (RTE) and the operators of distribution grids with more than 100,000 connected customers: Enedis, EDF SEI, Gérédis, GreenAlp, réséda, Strasbourg Electricité Réseaux (SER) and SRD.

The deployment of grid technologies is designed to improve efficiency. Smart Grid indicators can measure the tools used by system operators, as well as their purpose and the efficiency gains achieved.

The development of these indicators was the result of a long process of reflection and consultation with system operators. A panel of stakeholders wider than system operators has also been invited to a call for proposals workshop in June 2022 to gather their proposals and reactions.

This work has resulted in a list of indicators divided into three key areas for adapting electricity grids to the challenges of the energy transition: i) connections, ii) grid management, iii) and services provided to users.

Each theme is the subject of a qualitative analysis and a quantitative analysis based on indicators. This approach makes it possible to take into account the diversity of the grids concerned and the actions implemented by system operators, while at the same time being able to track changes in their performance on specific subjects that CRE considers essential.

Given the exceptional energy situation this year, CRE also wanted to include in this first report a section dedicated to the tools and levers put in place by system operators, to highlight their role in managing the energy crisis and the passage of winter.

Finally, future editions of the report will be able to draw on and integrate best practices observed among European regulators and shared through working groups. In particular, this will involve integrating the common indicators currently being developed by ACER and the CEER.

3. CRISIS MANAGEMENT MEASURES

The exceptional situation in 2022, marked by an energy crisis accentuated by the consequences of reduced supplies of Russian gas to Europe, and the low availability of France's nuclear power plants, resulted in a weakening of France's electricity supply security during the autumn and winter of 2022-2023. System operators have been on the front line in dealing with this situation, alongside the public authorities and CRE. This is why RTE has presented the Winter Security Emergency Plan (Plan d'Urgence de Sécurisation des Hivers - PUSH) to the public authorities. In addition to their grid management and operation missions, French system operators have encouraged consumers to be frugal with their energy use, and prepared levers to avoid or reduce the extent of potential load shedding, and, if load shedding was unavoidable, to carry it out under the best possible conditions. To achieve this, they set up communication campaigns to raise public awareness of the challenges facing the power grid, as well as technical solutions.

1.1 A communication for the general public to raise awareness of the challenges facing the power grid

The system operators' first priority was to raise awareness among all consumers (residential, business, local authorities, industrial, etc.) of the challenges facing the electricity grid during the winter of 2022-2023, but also, and above all, of the levers available to consumers to reduce the risk of load shedding:

- achieving energy savings through frugality and efficiency;
- shifting consumption to position electricity use at the right time, and thus limit peak consumption;
- adopting exceptional measures in the event of a high risk of load shedding (reducing street lighting, reducing heating temperatures as much as possible, etc.).

The cornerstone of this communication campaign, the EcoWatt signal, dedicated to the issue of power supply security, was developed by RTE with the aim of making it the equivalent of Météo France's Vigilance signal, and ensuring that this signal is actually used by electricity consumers to trigger spot power reduction actions. A major partnership plan was launched at the end of summer 2022, with major companies in all sectors and many local authorities pledging to reduce their electricity consumption during EcoWatt alerts. The eponymous application, developed in autumn 2022, has been downloaded to over 3 million smartphones. EcoWatt also features an application programming interface (API) to enable any IT solution developer to automatically retrieve the signal and, if desired, modify equipment programming according to the alerts. This API has been taken up by numerous partners to communicate alerts, but also to modify the programming of Building Management Systems (BMS) in commercial buildings.

In addition, from September 2022 onwards and throughout the winter, RTE regularly published weather-corrected electricity consumption data to demonstrate the efforts made by French consumers to be more frugal.

Lastly, several system operators (notably Gérédis, SER and SRD) have set up a map displaying areas that have been or are to be subject to load shedding, which would have enabled consumers to easily check whether they were affected and during which time slot.

1.2 Technical solutions to relieve grid congestion

In addition to communication and calls for eco-actions, French system operators set up and prepared a range of technical solutions to relieve the grid at peak times and during periods of high stress.

The first action was to prevent the automatic switching on of uses connected to the dry contact of the meters (mainly water heaters) during off-peak hours for the customers concerned with a peak/off-peak tariff (HP/HC) from 15/10/2022 to 15/04/2023. This solution of regularly shifting consumption from hours of high stress for the grid to less critical hours was implemented by all distribution system operators. This avoided between 1 and 2.5 GW of consumption between 12pm and 2pm, according to RTE, and thus limited the duration of the "morning plateau" of high electricity consumption. For its part, Enedis announced a confirmed saving of 2.4 GW at 12:30 p.m. over its perimeter of 4.3M customers with peak/off-peak (HP/HC) contracts with midday off-peak hours. This solution was made possible by the almost complete deployment of advanced electricity meters throughout France.

If the situation became very tense (orange or red EcoWatt signal), Enedis was prepared to apply a 5% voltage reduction order across its entire grid, with no consequences for customers. This measure would have saved an estimated 3 to 3.5 GW.

Enedis also proposed and implemented an innovative public lighting scheme for over 250 local authorities and electricity distribution authorities. Using the Linky smart meter, and only at the request of these local authorities, it enables targeted, temporary extinction of public lighting points on EcoWatt orange and red days. Successfully tested in 3 French Departments this winter, Enedis will now be able to offer this system throughout France to willing local authorities.

System operators prepared for the last resort of scheduled load shedding.

Finally, a solution for temporarily limiting meter power was successfully tested in 2018 through the SOLENN project. In its reports on smart grid demonstrators dated June 11, 2020 and May 19, 2022, the CRE considered that this functionality could be useful as an alternative to load shedding, by protecting certain uses and guaranteeing a minimum supply to consumers. The government plans to ask Enedis and RTE to carry out a new large-scale experiment (200,000 residential customers), in order to measure the effects of power limiting on electricity consumption and to study the relevance of implementing it in the event of a crisis.

1.3 ZNI cases

The grids in non-interconnected zones (ZNI-zones non interconnectées) managed and operated by EDF SEI were not affected by the "passage of winter" issue. However, due to their insular nature, situations (drought, strikes, technical incidents) where the supply-demand balance is threatened may lead EDF SEI to call for energy frugality and implement solutions similar to those put in place by system operators in mainland France this winter:

- Communication / call for frugality;
- Introduction of an "EcoWatt"-type power system status signal on Reunion Island, under development in other territories.

2. TOWARDS OPTIMIZED CONNECTIONS TO ACCELERATE THE INTEGRATION OF RENEWABLE ENERGIES AND NEW USES IN THE CONTEXT OF DECARBONIZATION

2.1 Grid connection challenges

France's carbon-neutral strategy is based on the electrification of sectors that currently consume fossil fuels (notably mobility and industry) and on decarbonizing our electricity mix. This dual objective will result in a necessary increase in demand for electricity, which cannot be achieved without significant development of renewable energies (RE)[5].

The Pluriannual Energy Program (PPE), adopted by decree on April 21, 2020[6], set significant renewable electricity development targets in relation to installed capacity when it was drawn up, with a total target of between 101 and 113 GW in 2028 compared with 48.6 GW at the end of 2017. As of September 30, 2023, some 23.3 GW of wind power and 17.8 GW of photovoltaic (PV) power was connected in France[7]. Achieving these objectives will require a significant acceleration in the pace of RE deployment.

The growth of renewable energies and the electrification of energy uses are generating significant demand for grid connections, both in terms of number and volume. These connections will have a significant impact on France's ability to meet its targets, and delays in making them available would be detrimental. In 2021 and 2022, the CRE generally observed that this increase in requests was accompanied by an increase in lead times, which can be explained by the need to reinforce grids, sometimes lengthy administrative delays, and also by the system operators' internal procedures, which are still in need of improvement.

In this context, CRE considers that all levers for anticipating and accelerating connections and optimizing the associated costs and lead times should be activated. One of these levers is the development of new connection offers as an alternative to conventional offers (reference connection bids [ORR-offres de raccordement de référence]. In fact, the grid work carried out in the framework of ORRs are sized so that users can inject or withdraw at any time, and particularly during peak periods, at the level of their maximum power requested at the time of connection. However, RE production sites only inject at maximum power for a few hours a year, and flexible assets do not generally need to inject or withdraw at maximum power at all times. Some assets, such as storage facilities, are also capable of counter-cyclicality and can be controlled to ensure that they help relieve grid stresses.

2.2 Development of smart connection solutions which must accelerate

Smart connection offers [ORI-offres de raccordement intelligentes] are emerging as an innovative solution for connection applicants. They are an effective way of optimizing the sizing of our own facilities and reducing connection commissioning times. In this way, the applicant can agree to specific limitations on injection or withdrawal in the event of grid stresses, in order to benefit from less costly connection works and/or a faster connection. These offers encourage the development of renewable energies and flexible assets, while reducing the cost to the community.

The regulatory framework has already evolved to allow and facilitate the deployment of this type of connection offer for producers. The Order of July 12, 2021[8] details the conditions under which these producers can request an alternative connection offer with power modulation [ORA-MP-raccordement alternative à modulation de puissance]. In particular, the Order specifies that the injection limits of the alternative connection offer comply with the following thresholds:

- the minimum non-guaranteed injection power is less than or equal to 30% of the requested connection power;
- the annually curtailed energy does not exceed 5% of the connected plant's annual production.

[5] *Energy Futures 2050*, RTE, February 2022
[6] Decree of April 21, 2020 on multi-year energy planning
[7] National register of electricity generation and storage facilities on 09/30/2023
[8] Order of July 12, 2021 implementing article D. 342-23 of the Energy Code

Several system operators already offer these services to producers and have included them in their Reference Technical Documentation [DTR-Documentation technique de référence]. However, the CRE has noted that the number of applications for the latter is still low. 3In fact, only EDF SEI and Enedis have received any requests in 2022, with 3 and 22 requests respectively (by way of comparison, Enedis has received 688 connection requests for photovoltaic installations to be connected as Medium Voltage (MV) during 2022). Of the 3 requests received by EDF SEI, only one was compatible with the thresholds defined by the above-mentioned order. For its part, Enedis has issued 3 technical and financial proposals [PTF-propositions techniques et financières] which have been accepted, 2 requests are still under consideration and 17 requests have been unsuccessful, either due to a lack of relevance of the offer compared with connection without limitations (8 cases out of 17) or failure to comply with the power threshold of the above-mentioned Order (6 out of 17). For the 3 PTFs issued and accepted in 2022, Enedis estimates the savings on connection costs at €3.3 million. System operator réseda has also experimented with the connection of a wind farm incorporating selective injection limitations to optimize the ratio between investment and injectable yield. This connection offer resulted in a saving of 730 k€ compared with the reference connection, or 42% of the connection costs. Whenever possible, these offers offer significant cost and time savings.

The CRE is delighted that several system operators have included these power-modulated connection offers in their procedures for connecting renewable energy producers. It calls on those who have not yet done so to integrate them.

In addition, the CRE has noted that the number of requests and offers for connection with power modulation is still low. **It recommends the removal of the power ceiling in the Order of July 12, 2021, in line with the opinion it already expressed in 2020[9] considers this ceiling to be irrelevant, and to lead to excessive regulation of these offers, which limits the possibility of using them, as has been observed.**

For its part, RTE has begun to offer smart connection options to consumers also, with the first connection proposals accepted in 2022: the first concerns the connection of a manufacturer wishing to decarbonize its process, and the second concerns the connection of an electrolyser. At the request of customers wishing to limit connection work and the associated costs and lead times, RTE has proposed connection solutions incorporating limitations on withdrawal in the event of stresses. **CRE welcomes RTE's initiative, and calls for these offers to be made widely available to consumers, particularly as industry decarbonizes.**

2.3 Customized connection offers for storage assets

Storage devices are controllable and flexible. With the right control tools and operation in line with system operators' expectations, these installations should not generate any stresses on the electrical system and can even resolve stresses on the grid. However, system operators generally do not take the characteristics of these devices into account when sizing their connections. Thus, connection studies have historically been the same as those carried out for the connection of non-flexible uses. In practice, system operators' studies are based on scenarios in which the stresses generated by these installations are at their maximum. For example, it is assumed that the storage system draws-off or injects at maximum power when the grid node is saturated in withdrawal or injection respectively.

The boom in stationary storage and the saturation of the public transmission grid in places where injection is taking place has led RTE to develop optimized connection offers for storage facilities, enabling them to be connected in saturated zones in exchange for limitations for a few hours a year in the event of stresses. Several optimized connection offers have been accepted in 2023. RTE has also modified the rules governing participation in ancillary services to enable storage facilities that have accepted this type of offer to take part. Indeed, system services, and more specifically primary reserves, are still the main lever for enhancing the value of storage facilities in France and Europe. **Making the rules governing system services and, more generally, the rules governing participation in the various flexibility markets compatible with the specific features of these new connection offers is therefore a major challenge. CRE is delighted with these recent developments, and will continue to ensure that these offers will thrive and be improved.**

[9] The CRE deliberation no.2020-122 of May 28, 2020 giving its opinion on the draft order relating to alternative connection offers taken in application of article D. 342-23 of the Energy Code

These connection offers for storage or Electric Vehicle Charging Infrastructures are still at the experimental stage on public distribution grids. As part of the regulatory sandbox[10], Enedis is testing a new connection study method that takes into account the counter-cyclical nature of a storage facility and its operating curves, enabling it to be connected in a zone saturated with injection for a certain number of hours per year. **CRE considers that the results of this experiment, which is of real interest for the integration of new uses at an optimized cost for the community, should be rapidly generalized.**

2.4 Advance connection offers to reduce lead times

When the connection of an RE production facility requires the creation of extension works and, where applicable, the reinforcement of existing public grids, its commissioning may, under certain conditions, take place before completion of the corresponding works, in accordance with article D. 342-23 of the French Energy Code. This is an early connection. System operators therefore provide mechanisms for temporarily limiting the power injected by the applicant's installation, in order to respect the transit capacity of existing facilities. **This connection solution means that installations can be commissioned more quickly, without waiting for the sometimes lengthy construction work to be completed, thus encouraging the integration of renewable energy production**.

In a context of decarbonization of industry, the use of these early connections can also be relevant for the connection of consumers. Today's decarbonization zones are areas of high demand for connections linked to the electrification of existing industrial facilities and the development of new uses (including hydrogen production), requiring major work on the public transmission grid. **CRE is asking system operators, and RTE in particular, to offer early connections in these areas to consumers who request them, whenever possible.** However, these early connection offers are not a substitute for completing all connection work as quickly as possible.

[10] The French Energy and Climate Act of November 8, 2019 known as the "Energy-Climate Law", introduced a system of regulatory experimentation (also known as "sandboxing") in the energy sector. Under this scheme, the CRE can grant exemptions from the conditions governing access to and use of grids and facilities for the experimental deployment of innovative technologies or services to promote the energy transition and smart grids and infrastructures, for a maximum period of 4 years, renewable once. This new system provides a legal framework adapted to projects enabling the testing of innovations that would ultimately require changes to the applicable regulatory and legislative framework.

ORI Focus - Smart Connection Offer

Unlike a reference connection offer, which guarantees that the plant can inject or withdraw 100% of its capacity at any time, ORIs are characterized by a restriction on the power injected or drawn-off at certain times. For CRE, it is important to differentiate between ORIs depending on the nature of the restriction, which can be of two kinds.

In the first case, the **restriction** can be **dynamic**, in which case the connection power is equal to the installed power, but limitations on injected and/or withdrawn power can be applied during certain periods at the request of the system operator. The above-mentioned ORA-MPs are an example of a dynamically restrained ORIs.

In the second case, the **restriction** is **static**: the connection solution guarantees a certain injection and withdrawal power for the installation but these vary according to a schedule defined at the time of the connection offer. This is the solution chosen by RTE to define the connection offer made to storage operators as part of its first local flexibility Call for Tenders for the Perquie zone, as well as for its "optimized connection offers" [ORO-offres de raccordement optimisées].

Name of the Connection Offer		System operators	Users concerned	Type of limitation	Type of restriction
Reference Connection Offer: **ORR**		All	All users	Unlimited connections	
Smart Connection Offers: **ORI**	Power Modulation Alternative Connection Offer: **ORA-MP**	In theory, all system operators can offer such services. In practice: to date, only Enedis, EDF SEI and SRD offer them	RE producers	Permanent	Dynamic
	Optimized Connection Offer: **ORO**	RTE	Storage systems	Perennial	Static
Early Connection Offers: **ORA** Users are connected before connection work is completed.		All	All users	Temporary (pending grid reinforcement)	Dynamic (or static)

Table 1: Type of existing connection offers

2.5 Digital tools are being developed to support connections

The development of renewable energies, but also of new sources of flexibility (storage in particular) and electric mobility, which requires the deployment of Electric Vehicle Charging Infrastructures, means that system operators have to deal with an ever-increasing number of connection requests. These requests require technical studies to determine the cost and timeframe for connection, two essential criteria for determining the feasibility and economic viability of projects. But these studies require time and resources, both on the part of system operators to carry them out and on the part of developers to supply the necessary elements. In order to rationalize the number of applications submitted and limit the number of unsuccessful applications, system operators offer solutions that enable developers to assess grid capacity before submitting their applications.

This is why RTE and SER offer "Flash" exploratory studies, which provide an estimate of the cost, technical solution and lead time for connection, mainly by examining current transit stresses and the capacity of existing facilities to meet demand. These studies are non-binding for both parties. This solution provides the client with a relatively rapid idea of the project's feasibility (within 6 weeks, as opposed to 3 months for a technical and financial proposal).

Another solution is for system operators to provide " self-care " tools that enable stakeholders wishing to apply for a connection to assess the constraints their project might face. Enedis has recently developed two such tools:

- "Tester mon raccordement [Test my connection][11]", a mapping tool freely accessible via Enedis portals for connections of less than 2 MW, as well as for cases of individual self-consumption at low voltage (LV);
- "Capten[12] is a similar tool for businesses and local authorities, providing a mapping of the injection and withdrawal capacities available on the Medium Voltage (MV) and low-voltage (LV) grids.

Initial feedback on these tools is generally positive, and highlights their value, partly because they provide access to detailed mapping of the LV and MV grid. However, these tools are sometimes limited by the fact that they do not take into account any congestion on the transmission grid or projects in the queue, two factors that can have a significant impact on the work required to connect a facility. **CRE is therefore asking Enedis to continue its development efforts to further improve the performance of these tools.**

For its part, RTE offers the "Caparéseau[13]" tool, also supplied by distribution system operators, which gives access to injection capacities available on the High-Voltage (HV) and Medium Voltage (MV) grids. This mapping covers 100% of source substations in mainland France. The value of this tool depends heavily on how often the data it contains is updated. This frequency is nowadays deemed insufficient by the stakeholders involved. **To guarantee the relevance and usefulness of this tool, CRE asks RTE to ensure that the data published is reliable and regularly updated.**

Lastly, EDF SEI has provided a mapping of favorable and unfavorable areas (source substations with low residual transformer capacity or areas requiring High Voltage reinforcements) for connections, as part of its calls for tenders for the construction and operation of storage facilities in ZNIs. This mapping covers the territories of La Réunion, Martinique, Corsica, Guadeloupe and French Guiana, and covers 100% of source substations. **CRE welcomes the publication of such mappings to help applicants identify the best locations for their projects, and calls on system operators who do not have them to undertake the necessary work to implement them.**

[11] Welcome to the Enedis login area
[12] Access limited to local authorities and companies via the dedicated portal sent by Enedis to the connection applicant
[13] Grid production capacity (capareseau.fr)

3. TOWARDS NEW FLEXIBILITIES AND NEW TOOLS FOR TRANSFORMING GRIDS

3.1 Mobilizing new sources of flexibility to meet an ever-increasing number and variety of needs

One of the levers for optimizing grid management costs is technological evolution and the development of grid flexibility. The challenge for system operators is to mobilize new sources of flexibility (storage, load shedding, aggregation of decentralized flexibilities, electric mobility, etc.) to maintain the quality of supply, while optimizing grid reinforcements. These flexibilities can and must be taken into account in local grid management, just as they have been in national supply-demand balancing for decades.

As part of this report, CRE is monitoring the participation of new assets (Electric Vehicle Charging Infrastructure, storage (excluding STEP) and load shedding) in the various flexibility markets. The table below details the cumulative power certified on these different markets by type of asset:

Cumulative capacity in MW	RTE	
	2021	2022
Cumulative power of Electric Vehicle Charging Infrastructures certified for participation in system services (by market)	0.1	0.1
Cumulative capacity of storage facilities certified for participation in system services (by market)	108	332
Cumulative power of load shedding certified for participation in system services (by market) with diffuse reserve entity	6	14
Cumulative power of certified load shedding for participation in system services (by market) with Public Electrical Transmission Grid [RPT- Réseau Public de Transport] sites	126	126
Cumulative power of consumption load sheddings certified for participation in the balancing mechanism	5900	6200
Cumulative power of consumption load sheddings certified for participation in the Notification of Exchange of load shedding blocks system [NEBEF - Notification d'Echange de Blocs d'Effacement].	3700	5700
Cumulative power of Electric Vehicle Charging Infrastructures, storage facilities and certified load shedding systems participating in "Local Flexibility" Call for Tenders **RTE's experimental local flexibility Call for Tenders launched in 2022 is still being awarded.*	0*	0*

Table 2: Certified cumulative power on the markets by asset type

This indicator highlights the following key elements:

- load shedding, which is already well developed, continues to grow, notably via the balancing mechanism and the Notification of Exchange of load shedding blocks system [NEBEF].
- storage is undergoing increasing development, driven by the primary reserve (FCR-Frequency Containment Reserve), now mainly supplied by batteries. Volumes of certified capacity are set to increase further, given the many projects under development, and their deployment is set to accelerate with the forthcoming opening of the secondary reserve market (aFRR-automatic Frequency Restoration Reserve) and the development of local flexibility Calls for Tenders. This development in response to favorable market signals shows that there are no obstacles to their participation in these markets;
- the participation of Electric Vehicle Charging Infrastructures in these markets is still marginal, but is set to grow with the electrification of the vehicle fleet that has begun. The participation of Electric Vehicle Charging Infrastructures in explicit flexibility markets will also depend on the average level of piloting of the Electric Vehicle fleet[14].

[14] Electric vehicle charging control, December 2020, Enedis

The rules governing access to the various markets must continue to facilitate the development and participation of new capacities and encourage innovation. The CRE also encourages experimentation with new rules in the regulatory sandbox[15].

3.2 Flexibilities for resolving local congestion

Flexibilities can also be used to resolve local congestion on the grid. Such congestion may arise due to an excessive mismatch between generation and consumption in a given area (e.g. rural areas with low consumption and numerous photovoltaic and wind power sites during periods of strong sunshine and/or wind), or to meet an immediate and temporary operating requirement (e.g. to avoid local outages if the current grid situation does not allow all customers in a given area to be supplied, due to the accidental or planned unavailability of a facility) or for work placement (to avoid the mobilization of generators). In this case, flexibility complements or replaces grid investment.

Enedis was the first system operator to launch a project on the subject, which began in November 2018 with a call for contributions, followed by the following stages:

- November 2019: publication of a census of interest for 6 zones with flexibility needs;
- March 2020: launch of a first call for tenders for 5 zones. Winners were selected in 2 zones for contracts without capacity reservation with local stakeholders;
- 2021: new call for tenders for the 3 zones for which there were no candidates. No bids were received;
- March 2022, Enedis has relaunched a call for tenders for 3 zones (2 zones already published in 2021 and 1 new zone). In the end, the candidate selected for the Paris-Breteuil zone was unable to put together its portfolio (all the capacities involved in providing the service) in time, and the Call for Tenders was therefore declared unsuccessful.

Contracted and mobilized capacity in MW	2021	2022
Cumulative power of contracted flexibilities at the end of each Call for Tenders by orientation (up/down) (in MW)	6.1	6.1
The sum of energy activated during the year for local flexibilities by orientation (up/down) (in MWh)	1.9	0

Table 3: Local flexibilities contracted and mobilized through Calls for Tenders

In March 2023, Enedis launched a call for tenders for 11 zones. To take account of feedback from stakeholders concerning previous calls for tenders, Enedis has extended the deadline for setting up scopes to 12 months, and introduced the possibility of having several winners per geographical area. To date, 6 winners have been selected for 5 needs, including a storage system (NW) and an aggregator of diffuse flexibilities (Voltalis), while the contracts for the other 6 needs have been declared unsuccessful.

Enedis also publishes flexibility opportunities on a dedicated website[16]. All opportunities of all types (investment deferrals, operational flexibility, etc.), and at all stages of development (completed, in progress and planned), are freely available on this site. For each opportunity zone, Enedis provides geographical and technical data and tools to help market stakeholders participate in Enedis calls for tenders. The data in the tool is updated once a year to take account of new connections in the zone, any restructuring of the grid, and any new opportunities that have arisen over the period. This mapping covers 100% of MV source substations and feeders.

CRE is delighted with the efforts made by Enedis to launch the 2023 call for tenders, taking into account feedback from stakeholders and the tools made available to them. The CRE is calling on Enedis to extend these calls for tenders to develop all opportunities for flexibility on its grid.

At the CRE's request, RTE has also launched a process to develop experimental local flexibility tenders. A call for tenders was launched from June 2022 to June 2023 for the Perquié zone and the contract is currently being awarded. The CRE believes that these experimental tenders are a positive first step. **That's why CRE is asking system operators to systematically study the use of flexibilities and how to industrialize the associated solutions whenever they prove more appropriate than grid reinforcements.**

In its deliberations of January 21, 2021[17] concerning its decision on TURPE 6 HTB, CRE also asked RTE to publish a map of stresses on the entire public transmission system. The aim of such a map was to encourage the development of flexibilities. Indeed, for storage project developers and flexibility operators, a congested area can represent

[15] Regulatory experimentation system - CRE
[16] https://flexibilites-enedis.fr/
[17] The CRE deliberation no.2021-12 of January 21, 2021 concerning the tariff for the use of public electricity transmission grids (TURPE 6 HTB)

a revenue opportunity by helping to resolve it. This map[18] was finalized by RTE at the end of 2022 and to date, incorporates the residual stresses over a 3-to-5-year horizon on the connection structures of renewable energy producers carried out as part of the regional schemes for connecting renewable energies to the grid (S3REnR). At this stage of its development, this map does not fulfill its initial mission, which is to facilitate the development of flexibilities by indicating zones where RTE may need flexibility.

CRE considers that RTE's mapping needs to be enriched to serve as a basis for identifying future zones for the launching of new local flexibility calls for tenders and, more broadly, the development of market mechanisms dedicated to resolving such congestion as a complement to the grid. These maps also need to be updated more regularly to provide a reliable service to stakeholders.

3.3 Modulating renewable energy production to optimize grid sizing

The main renewable energy sources with high development potential (wind and solar power) have variable output, which depends on weather conditions (wind or sunshine) and rarely reaches the installed capacity of production units. This means that a grid sized to handle the entire output of renewable energy installations would rarely be used to its maximum capacity. So, from an economic point of view, it makes sense to size grids so as not to be able to inject all installed capacity at all times. **CRE therefore considers that the use of this flexibility solution should be systematically examined in all grid sizing studies, and should replace structural grid developments and reinforcements whenever this is economically and technically relevant.**

RTE was the first system operator to incorporate this principle into its grid sizing methods. RTE's approach is to accept occasional modulation of production at certain sites, in order to avoid building or reinforcing new grid structures that would be little used other than for very occasional peaks. This methodology is based on the search for the economic optimum between (i) the curtailments of production assets, with particular emphasis on their economic and environmental impact, and (ii) the development or reinforcement of grid infrastructures.

To implement this lever, RTE has developed the New Adaptive Zone PLC [NAZA - Nouvel Automate de Zone Adaptatif] digital solution. In the event of a production surplus that cannot be transported by the grid - for example, when production peaks at the time of a windy episode - NAZA automatically controls the production of renewable energies from wind and photovoltaic sites to reduce it on a spot basis.

Sites, that can be controlled and their production curtailed, are equipped with a Operating Information Exchange System [DEIE - Dispositif d'Echange d'Information d'Exploitation] which automates the transmission of information concerning the plant's operating status. While this solution is used on the majority of sites with MV and HV connections, no solution is currently available to control low-voltage production, despite the significant potential (almost 49% of photovoltaic capacity installed in mainland France is less than 1 MW). **Given the importance of low-voltage generation, CRE is calling on distribution system operators to jointly develop a solution for managing these producers, which would also enable them to be offered smart connections or early connection while waiting for reinforcements to be built.**

[18] https://www.contraintes-reseau-s3renr-rte.com/

The graph below shows the sum of the maximum power that can be curtailed of RE sites for each operator:

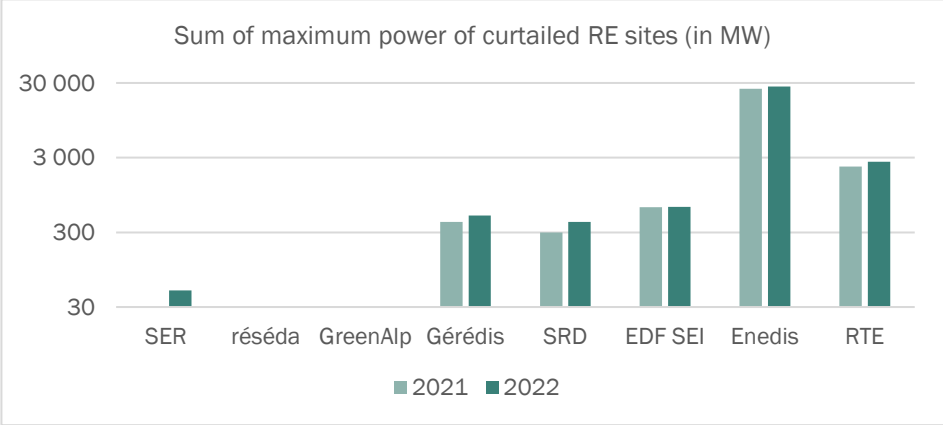


Figure 2: Ability to cap RE in the framework of optimal grid sizing

Some system operators have carried out prospective studies demonstrating that there will be no congestion in the medium term due to the injection of renewable energies on their territory, hence the low volume of curtailed renewable energies on their grids.

The use of optimal sizing at RTE should bring significant savings for the power system: RTE estimates this saving at nearly 7 billion euros for the community over fifteen years. **Given the importance of optimal sizing, the CRE is asking RTE to regularly monitor the benefits of its deployment and share them with all market stakeholders.**

The integration of this flexibility is currently at the experimental stage on the Enedis grid. Indeed, with its Réflex project, Enedis is testing the use of flexibilities (overlapping between consumption and production and between sectors, balancing, local flexibility) to optimize the sizing of its grid in order to accommodate more renewable generation at a constant investment volume. **CRE welcomes the progress of the Reflex project and calls on Enedis to generalize and industrialize the corresponding solutions.**

ZNI focus

The curtailment of renewable energies can also serve as a solution for guaranteeing grid stability and security, particularly when these energies account for a very large proportion of the energy injected into the grid at any given time. While this situation is not yet common in mainland France, but island grids are already faced with it, due to their geographical location, which is often conducive to the development of renewable energies, and the technical characteristics specific to small-scale grids. To meet these challenges and facilitate the integration of photovoltaic and wind renewable energies into ZNI grids, EDF SEI has developed and commissioned innovative solutions in close collaboration with R&D:

- various PLCs to ensure grid stability;
- real-time forecasting and analysis tools to monitor stresses and limits in terms of inertia, fast and slow reserves, and to activate the levers needed to comply with EDF SEI's risk policy;
- storage facilities to meet needs for rapid reserve (primary frequency control), arbitration (load shifting) and eventually slow reserve (intermittency control and flexibility needs);
- synchronous compensation to meet inertia requirements (project underway in Guadeloupe);
- a control tool to ensure the observability of renewable energies, calculate the penetration rate of non-synchronous renewable energies in real time, and propose and implement the necessary limitations to control system safety risks.

Faced with the challenges of integrating unusable renewable energies, the 2021 and 2022 Annual Energy Plans (PPEs) for the ZNIs provided for the possibility of EDF SEI to top up renewable energies above a threshold of 35% penetration. However, as the table below shows, because of the solutions developed and implemented, EDF SEI did not systematically resort to curtailments when the criterion defined by the Annual Energy Plan was met.

Number of hours	2021			2022		
	Annual Energy Plan criterion met	With curtail-ments	Amount of RE curtailed	Annual Energy Plan criterion met	With curtail-ments	Amount of RE curtailed
Corsica	350h	261h	1.46 %	500h	300h	1.77 %
Réunion	4h	-	0 %	5h	-	0 %

Table 4: Curtailements linked to the instantaneous penetration rate of renewable energy sources in the ZNIs

These results testify to the potential of innovative smartgrid solutions for the massive integration of renewables into grids, enabling EDF SEI to operate its grid safely even with a very high proportion of renewables on its grid at any given time (see figure below).

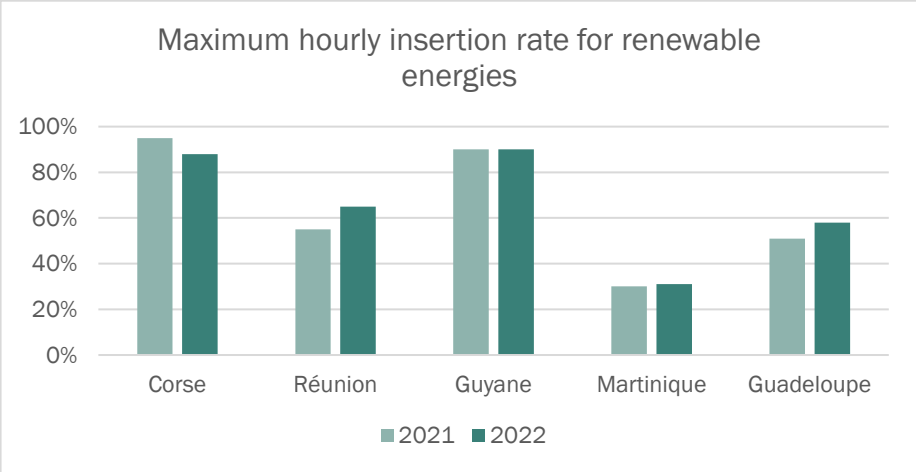


Figure 3: Maximum hourly insertion rate for renewable energies in ZNIs

3.4 Grid observability, a necessity for dynamic control

Energy transmission and distribution system operators collect data on the structures that make up these grids: dispatching and delivery substations, source substations, public distribution substations, transformers, pipelines, cables, compressor stations, pressure-reducing stations, metering devices and other measuring equipment, sensors, etc. The modernization of this equipment means that it can now be controlled as accurately and automatically as possible. The modernization of our equipment now makes it possible to control them as precisely and automatically as possible.

System operators use geographic information systems (GIS) to carry out their tasks of operating and developing electricity grids. Fed by numerous sensors measuring energy flows on grid structures and infrastructures, these tools enable operators to build up a detailed description of the grids they operate, potentially down to the level of each individual piece of equipment. This data represents a major issue for system operators, since it enables them to improve the observability of the electrical system, and thus improve its operation, maintenance and development.

Thus, for certain asset categories, data essential to the proper operation of the grid can be transmitted in near-real time (i.e. in less than 30 minutes):

	reseda	SRD	EDF SEI	Enedis	RTE
Metering data from consumption sites	MV: 100% LV>36 kVA: 100% LV<=36 kVA: 40%	MV: 100% LV>36 kVA: 100% LVT<=36 kVA: 58%	MV: 98.4% LV>36 kVA: 99.1% LV<=36 kVA: 71.2%	MV: 95% LV>36 kVA: 95% LVT<=36 kVA: 93%	97%
Metering data from production or storage sites	100%	MV: 100% LV>36 kVA: 100% LVT<=36 kVA: 58%	MV: 100% LV>36 kVA: 100%	MV: 95% LV>36 kVA: 95% LVT<=36 kVA: 99%	93%
Source station transit data	100%	100%	100%	100%	
MV/LV substation transit data	0%	0%	0%	0.25%	
MV or HV line transit data	100%	100%	100%	100%	97%
LV line transit data	0%	0%	0%	0.1%	

Table 5: Type and % of data available in near-real time in 2022

In addition to collecting and transmitting data, system operators need to be able to monitor assets remotely to facilitate grid management. In the case of MV-LV substations, system operators have the option of installing a remote-controlled switching system [OMT - organe de manœuvre télécommandé] to make them remotely operable. The decision to install such a system is based on a local technical and economic assessment, taking into account the probability of incidents, the number of customers concerned, and the investment and maintenance costs of the system. The figure below shows the proportion of MV/LV substations that can be remotely operated on the various distribution grids:

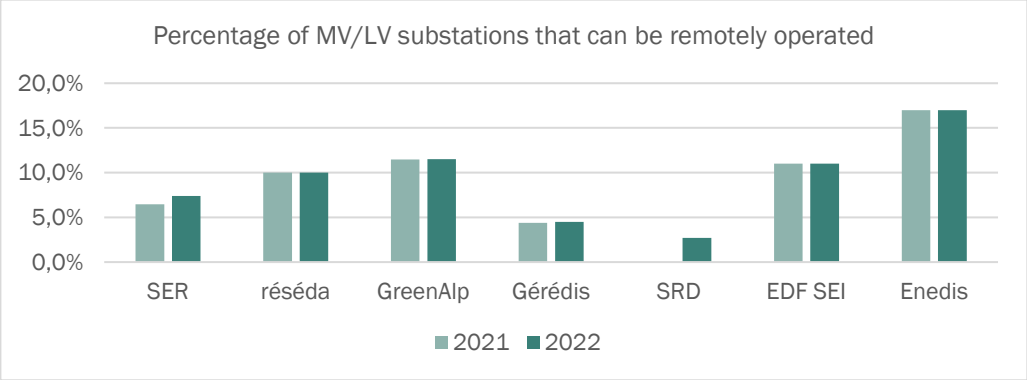


Figure 4: Percentage of MV/LV substations on public distribution grids that can be remotely operated

Dynamic Line Rating Focus

When a line carries a lot of electricity, the cables heat up, lengthen and come closer to the ground. The temperature of a cable depends on weather conditions and the amount of electrical current flowing through it. Until now, RTE has defined the maximum current or transit capacity for each overhead line on the basis of a meteorological history for each season, in order to guarantee compliance with regulatory distances and to protect the safety of people and property.

RTE now installs and uses Dynamic Line Rating (DLR) sensors on some of its Medium Voltage lines. These sensors can detect when the wind is blowing and cooling the lines, thus increasing the authorized transit capacity and enabling more electricity to be transmitted. Under these conditions, the DLR enables us to optimize wind generation capacity while limiting the need to adapt the grid. The capacities calculated at any given moment using data collected by the DLR are transmitted directly to the regional control center for the extra-high-voltage power grid.

However, this solution is not appropriate for all Medium Voltage lines on the grid, and is not systematically effective. The choice of lines to be equipped is based on a cost-benefit analysis and a complete and precise topographical survey of the lines to control their geometry in different operating situations. By 2022, 10 lines, representing 266 km, will be equipped, compared with 8 lines for 211 km in 2021.

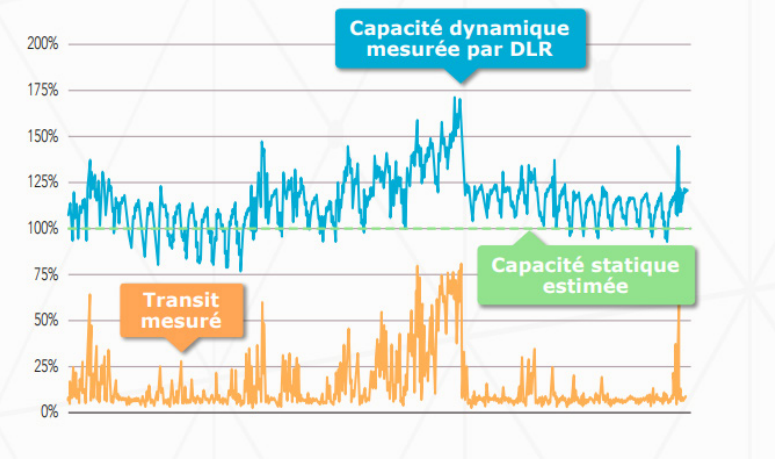


Figure 5: Transit capacity of a 63 kV line over two months (source *SDDR 2019*, RTE)

The integration of this new data is useful in many different ways for system operators. Some of these are already mature and deployed throughout the electricity grid, while others are still at the R&D and pilot project stages.

3.4.1 Communicating work schedules and impacts to users

A first application is the development of mapping tools to keep users informed and to be updated about the planning of work on the grid and the potential impact on their power supply. Updating is automated, but the frequency varies from one system operator to another: daily at réséda and SER, weekly at Gérédis and monthly at GreenAlp.

3.4.2 Remote fault detection and quality control

The deployment of a large number of sensors on MV and HV grids enables incidents to be detected and geolocated more quickly. Several system operators (RTE, Enedis, SRD, réséda, SER) have already deployed solutions for real-time reporting of such incidents.

The use of data from smart, communicating meters makes it possible to improve the calculation of outage rates and durations. What's more, each advanced meter has its own quality control dashboard that records and time-stamps any upstream power cuts it experiences.

3.4.3 Predictive maintenance and fault identification

The exponential increase in the amount of data to which system operators have access to gives them the opportunity to apply artificial intelligence and Big Data tools and methods. These are particularly useful for maintenance actions and predictive fault identification on grid equipment. These tools include:

- Enedis's CARTOLINE LV tool, which uses the data collected by Linky meters and artificial intelligence software to detect potential faults, to process them and to secure customers' power supplies as a preventive measure. This decision-making tool, which has received positive feedback in the field, will soon be extended to the MV grid.
- Other Linky big data processing tools can be used to characterize meters with a high probability of failure, so as to target meter change interventions, avoiding the need to intervene when poor communication with a meter is not linked to its failure.
- The Overhead Grid Structures Diagnostic tool [DORA - Diagnostic d'ouvrage des réseaux aériens] deployed on the Enedis and EDF SEI grids, which uses artificial intelligence to diagnose anomalies on the MV overhead grid based on photos.
- The AGATH tool, which enables Enedis to be informed in real time via fiber optics of the condition of transformers and secondary equipment at its HV/MV source substations, to define maintenance requirements.

In addition, a number of research and development projects are currently underway:

- Gérédis has launched the APOLLO program to develop predictive models for fault management and maintenance;
- through the KAPLA and MONA *(*Management and optimisation of Network Asset) projects, part of a collaborative R&D program launched at the end of 2022, RTE and Gérédis are using artificial intelligence for asset management (optimization of maintenance programs and investment/renewal cycles). Although still at the R&D stage, the MONA tool, developed in partnership with the startup Cosmo Tech, is already finding concrete applications, and in particular has helped to reinforce the orientations of RTE's "Corrosion Plan";
- In 2022, SER launched a project called GAIA, the aim of which is to use grid data to optimize grid maintenance and renewal.

3.4.4 Grid sizing

Metering and telemetering data are used to calibrate load models based on reference consumption profiles. In particular, these models can be used to study grids based on fixed reference situations (high consumption in the middle of winter, high production and low consumption, etc.). These analyses are therefore based on panel customers and not on a detailed analysis of the actual consumption of each customer by territory.

Nevertheless, in view of the significant development of Electric Vehicle Charging Infrastructures, heat pumps (PAC-pompes à chaleur) and low-voltage photovoltaic production, as well as the end of advanced meter deployment, system operators are working on integrating recoverable low-voltage data into their grid sizing models. Several projects at various stages of maturity are underway, including:

- Pinky, a voltage and current measurement tool, which uses Linky's telecoms infrastructure to transmit these measurements, enabling Enedis to gain a better understanding of electricity flows on its public electricity distribution grid. It is occasionally deployed on certain MV/LV transformers to better understand grid usage, refine forecasts and optimize certain investments;
- Gérédis is developing a software tool, PICTRACK, designed to optimize the evaluation of sizing power for source substations by combining data from telemetry and metering with forecasting models for various key parameters (changes in consumer characteristics, changes in producer characteristics, etc.);
- GreenAlp is running an initial pilot project in 2022 on the use of meters and telemetry to size its grid, and the project will be extended in 2023;
- SRD's @LIENOR project includes a focus on improving descriptive and predictive models (i.e. consumer profiles) based on meter and telemetry data.

CRE considers that the deployment of numerous sensors, particularly on medium- and high-voltage grids, as well as advanced meters by French system operators, in comparison with their European counterparts, enables them to collect a large and growing amount of data needed to develop numerous tools aimed at optimizing grid planning, operation and maintenance.

System operators face similar problems and challenges and CRE encourages them to collaborate and pool some of their work in order to reduce costs for the community.

Lastly, in the TURPE 6 Medium Voltage report[19], CRE asked RTE to provide initial data to characterize the rate of use of the transmission grid. This indicator, which currently lacks the historical data required for its use, could bring useful information in the future on the performance of system operators. CRE is therefore continuing to work in coordination with RTE to better define and characterize the evolution of this infrastructure utilization rate.

[19] https://www.cre.fr/documents/Deliberations/Decision/tarif-d-utilisation-des-reseaux-publics-de-transport-d-electricite-turpe-6-htb.

4. DATA AT THE HEART OF NEW USER SERVICES

4.1 Smart metering systems: the cornerstone of smart grids

Smart metering is an essential component of smart grids, offering numerous opportunities for the energy transition and contributing to a wide range of services for consumers and power system management. To seize these opportunities, it is necessary to make widespread use of smart meters and to set up systems for transmitting the resulting data between consumers, system operators and suppliers.

In 2007, Enedis launched the Linky meter rollout project, at the initiative of CRE. The aim of this project was to replace 35 million electricity meters with advanced metering systems by 2021. At CRE's request, a conclusive trial phase preceded the general roll-out of Linky meters.

The French initiative to roll out advanced metering was subsequently reinforced by Directive 2009/72/EC of July 13, 2009, which has since been replaced by Directive (EU) 2019/944 of June 5, 2019, providing a framework for the implementation of smart metering systems in Europe.

The widespread deployment of advanced meters, which began at the end of 2015, is now almost complete within the Enedis perimeter. Deployment by local distribution companies began later and is still ongoing. CRE has made a positive assessment of this massive rollout phase and considers the Linky project to be an industrial success for our country[20]. The graphs below show the deployment rates of advanced smart meters by distribution system operator in 2021 and 2022.

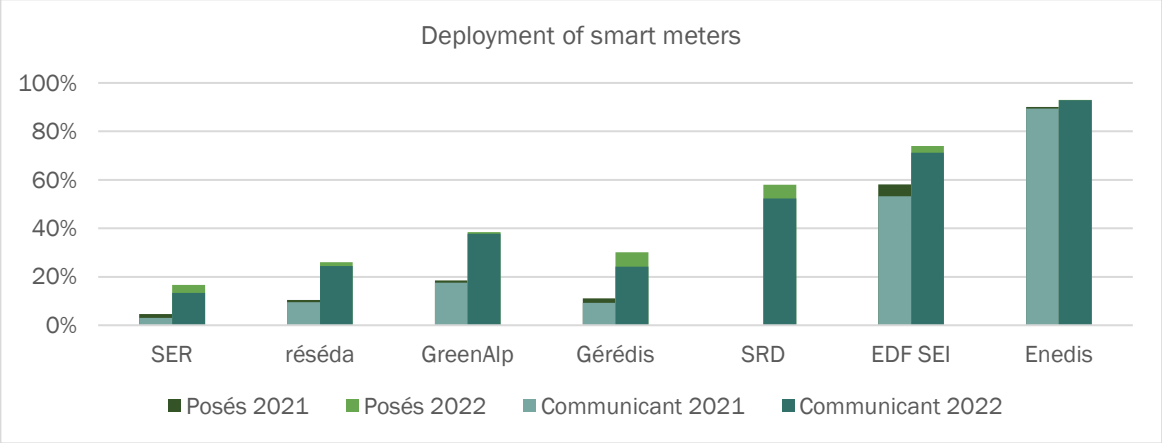


Figure 6: Deployment rate of advanced smart meters

One of the aims of deploying advanced metering systems is to enable metering data to be collected and made available, within short timescales and in an automated way, to the stakeholders concerned (transporters, suppliers, consumers, etc.), as well as to enable distribution system operators to carry out remote operations (these operations are made possible by the bi-directionality of meters). Performing these operations remotely, which in the past would have required an agent to travel to the site, has generated significant savings (€1.7 billion over the 2017-2024 period), contributing to the financial equilibrium of the advanced meter rollout.

Providing customers with better information about their actual consumption patterns is an essential prerequisite for building their confidence in the functioning of the market, and in particular in the quality of their relationship with suppliers.

[20] The CRE deliberation no.2022-82 of March 17, 2022 deciding on the incentive regulation framework for Enedis' advanced metering system in the LV ≤ 36 kVA voltage range (Linky) for the period 2022-2024.

In addition, many market processes (commissioning, decommissioning, supplier changes, special meter readings, etc.) rely on metering data (start index, end index). The low frequency of meter reading on the retail market and, in some cases, the impossibility of access to metering devices or the provision of self-metering reduce the fluidity, speed and efficiency of these processes. The development of competition in electricity supply is thus encouraged by the simplicity and speed of switching suppliers, as well as by the emergence of new services using load curves and supply offers based on personalized schedules. Suppliers can thus offer consumers a wider range of tariffs, based on days or hours of use, for example.

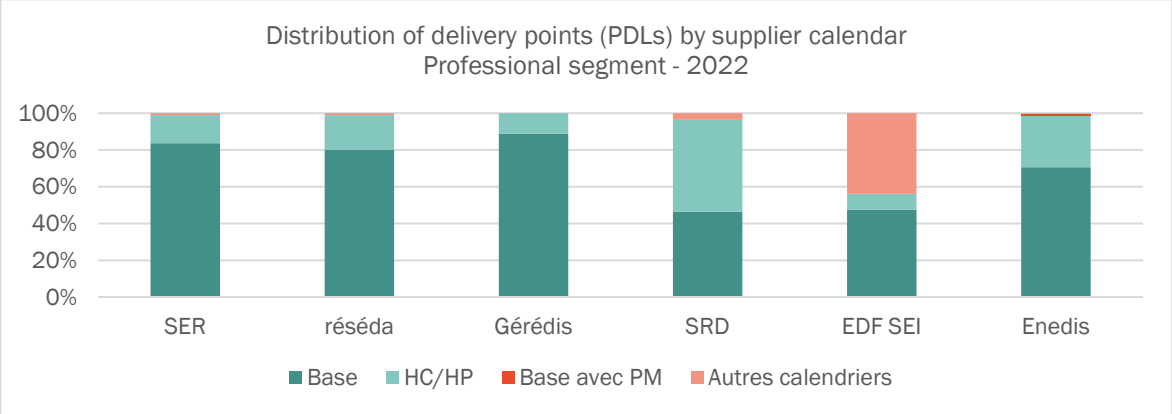
Some suppliers offer special deals for Electric Vehicle owners, with super-off-peak hours during which the consumer can recharge at a preferential rate. Other suppliers propose offers that encourage consumers to switch off during electrical system stress ranges: these are known as moving-peak offers. Consumers are warned in advance of periods of high congestion, and are given financial incentives to shift their consumption away from these periods. These offers are based on the "mobile peak" functionality of Linky's[21] supplier calendar.

Advanced meters allow consumers and authorized third parties to access their load curves free of charge, and in recent years we have seen a growing number of users requesting this service, with the trend accelerating. Among local distribution companies, less than 5% of low-voltage delivery points (PDL-points de livraisons) have activated load curve feedback, but this should be seen in the light of the incomplete deployment of advanced meters. As of June 30, 2023, Enedis has more than 7 million low-voltage delivery points for which load curves have been activated, i.e. 21.22% of all delivery points. This number has doubled in 2 years.

The rate of availability of load curves on D+1 at 9 a.m. for points having subscribed to this service is currently monitored by SER, with results of 95.5% in 2021 and 93.6% in 2022, SRD with 97.8% in 2021 and 98.1% in 2022 and Enedis with 97.7% in 2021 and 97.7% in 2022. Although this rate is high, the essential nature of this data for the development of new services and tariff offers calls for the highest standards. **CRE asks system operators who have not yet done so to set up a monitoring system for this indicator**. In addition to the availability of these data, their quality is also a factor to be monitored. In fact, load curves play an essential role in the proposal of certain tariff offers and flexibility services, since they serve as the basis for reconstituting flows and even invoicing. **This is why CRE and Enedis are working on an indicator for the completeness rate of load curves made available to third parties, which could be subject to incentive regulation.**

Advanced meters also make it possible to provide remote services, such as setting up supplier-specific schedules, an essential element in the development of alternative tariff offers. As an indicator, CRE wanted to track the proportion of these timetables implemented by system operators within the deadline. Enedis implemented all 16 schedules requested in 2022 (including 8 copies of generic schedules and 8 customized schedules) and all 10 schedules requested in 2021 (including 8 copies of generic schedules and 2 customized schedules) by suppliers within the two-month deadline. The other system operators have not received any requests from suppliers in 2021 and 2022.

This low number of requests coincides with a high proportion of customers still on Base tariffs or simply Peak / Off-Peak tariffs. The proportion of customers subscribing to other tariff offers remains low, despite the arrival of advanced meters and the opening up of the market to competition.



[21] A supplier calendar is the schedule of time slots for an energy supply offer. It associates an index, and therefore a tariff, with each time range. It can also be used to program the activation of dry and virtual contacts, useful for controlling usage.

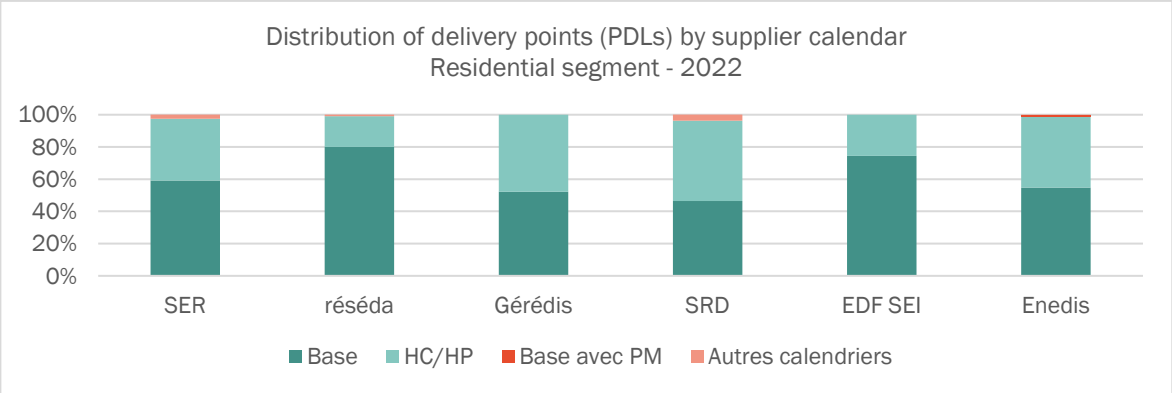


Figure 7: Distribution of PDLs by supplier calendar

CRE stresses that the widespread deployment of advanced meters by distribution system operators is a very favorable factor for the development of innovative supply offers, which will be increasingly useful as the energy transition gathers pace.

4.2 Platforms developed by system operators to serve users

The digitization of electricity grids has been accompanied by the arrival of platforms and services accessible online to stakeholders (consumers, suppliers, balance managers, etc.). The various French system operators have been digitizing their services for several years now.

In connection with the rollout of advanced meters, system operators have developed and made available to customers at the bottom of their portfolios, customer spaces that enable them to:

- consult their daily, monthly or annual consumption data, such as maximum power consumption;
- record and collect the load curve, after giving consent;
- transmit consumption data to a third party.

These customer spaces must comply with the requirements of data regulations, particularly in terms of data protection (GDPR), as well as Decree no. 2017-948 of May 10, 2017 on the terms and conditions for making electricity and gas consumption data available to consumers. Similar platforms have also been developed for businesses and local authorities. On its platforms, Enedis currently has 1.9 million individual customer accounts, 23,000 business customer accounts, and nearly 20,000 local authority customer accounts.

When consumers (individuals or professionals) give their consent, their data may be shared with third parties who can use it to provide them with services or advice on energy efficiency, consumption control or price offers tailored to their consumption profile. To facilitate access to this data, Enedis has developed the Exchange Management Service [SGE-Service de Gestion des Echanges] portal, which handles exchanges between the Information System of electricity and service suppliers and that of Enedis. It is used to order services (53 million requests by 2022), and to send contractual, billing and measurement data to suppliers. This service is already widely used by stakeholders.

4.3 Open data: a lever for democratizing energy data

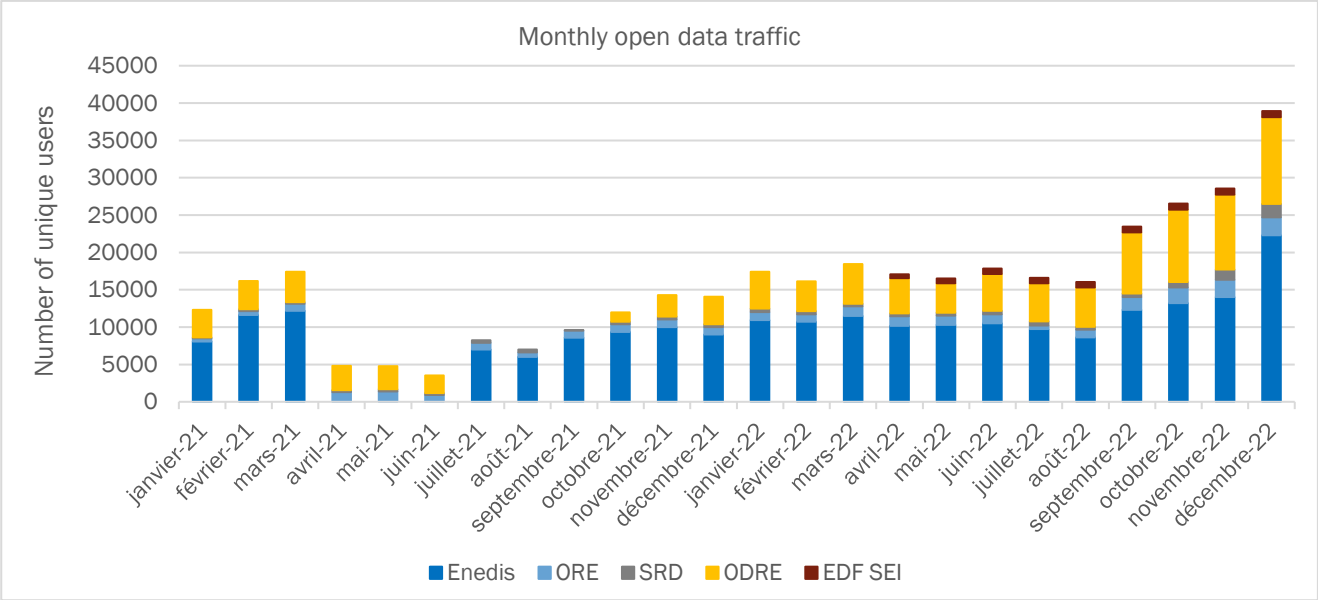
System operators produce a great deal of energy data, which is of interest to a wide range of stakeholders: local and regional authorities, the Government, domestic and professional consumers, energy producers, suppliers and balance responsible parties, service providers, and so on. Of all the sectors in the energy sector, energy data recovery is one of the most dynamic, and has seen strong growth in recent years. It is based in particular on the efforts made by utilities and system operators to make anonymized or aggregated data available in open data format.

Several open data platforms dedicated to energy exist nowadays in France. Some are specific to one system operator, while others are the result of a joint approach by several partners. This is notably the case for the Energy Grid Agency [ORE-Opérateurs de Réseaux d'Énergie], which groups together some 120 energy distributor members and which, via its open data, makes available multi-stakeholder data sets in harmonized formats covering both gas and electricity. Similarly, the Energy Grids Open Data platform [ODRÉ-Open Data Réseaux Énergies] offers multi-energy, multi-operator and multi-grid data. This is the fruit of collaboration between GRTgaz, RTE and Teréga, who were behind its creation. They have since been joined by AFGNV, Weathernews France, Elengy, Storengy and Dunkerque LNG. All French system operators therefore contribute to these two open data feeds. At the same time, some system operators have their own platforms, such as Enedis, EDF SEI and SRD. Those who don't have a platform nevertheless share certain data on their websites, such as the mapping of their grid.

These platforms offer access to various datasets covering a wide range of topics: infrastructure, production, consumption, electrical mobility, the electricity market, etc. These datasets are generally accompanied by a methodological note detailing their content, they update frequency and last update date. These datasets are generally accompanied by a methodological note detailing their content, update frequency and date of last update. All of the above platforms allow you to directly browse, analyze and visualize data, and download it in a variety of formats.

While the provision of raw data is the vocation of open data, the latter are increasingly offering data visualizations. These are either the fruit of the platform's manager or produced by a stakeholder using data available on the platform, which relays this use of its data. While raw data are mainly of interest to stakeholders who are familiar with energy issues (service or electricity providers, balance managers, academics, etc.), data visualizations enable a wider audience to take ownership of energy data.

CRE notes that the use of open data has been on the rise in recent years, and particularly at the end of 2022, due to a growing range of accessible data and services, but above all to the growing interest of a wider public than the sector's traditional stakeholders. Between January and December 2022, monthly visits to these open data sites jumped from 17,419 to 38,944 users, an increase of 128%. The graph below clearly illustrates this:



**Data unavailable for Enedis in April, May and June 2021, for ODRE in July, August and September 2021.*

Figure 8: Using open-data

The open data platforms developed by French system operators play an important role both for the general public and for energy professionals. CRE encourages system operators to consult stakeholders on a regular basis to ensure that the data offering continues to meet their expectations.

4. CONCLUSION AND LIST OF RECOMMENDATIONS

Transforming the electricity grid into a "smart" grid is a major challenge if we are to keep pace with the changes in the energy landscape that began a few years ago and will accelerate over the next decade. Facilitating the integration of renewable energies, promoting the development of electrical mobility, improving grid operation and developing energy management and efficiency initiatives are all challenges included in this transformation of power grids. System operators must support these developments, and CRE's mission is to monitor and assess their performance in developing such a grid, which is the purpose of this report.

Recommendations for optimizing connections to accelerate the integration of renewable energies and new uses in the context of decarbonization

- CRE welcomes the integration by several system operators.of power modulation connection offers in their connection procedure for renewable energy producers. CRE calls on remaining system operators to integrate such offers as well. Nevertheless, CRE notes that the number of applications and accepted offers is still low. It therefore recommends removing the power cap (the limit on the power that can be curtailed by the system operator), which excessively restricts these offers and thus limits their appeal.
- CRE welcomes RTE's proposal for smart connection offers to consumers, and calls for their widespread use, particularly in a context of decarbonization of industry.
- CRE is also delighted with the recent changes authorizing participation in primary reserve markets for storage facilities benefiting from an optimized connection offer (integrating punctual limitations) and will continue to ensure that these offers become widespread and improved.
- CRE calls on system operators to rapidly generalize connection offers that take into account the countercyclical nature of storage facilities.
- CRE believes it is important for system operators to improve the reliability of the "Caparéseau" platform and regularly update the data it contains.

Recommendations on the use of new flexibilities and new grid management tools

This concerns the recourse to flexibilities

- Market access rules must continue to facilitate the development and participation of new capacities.
- CRE highlights the efforts made by Enedis and RTE to conduct experimental calls for tenders for local flexibilities.
    - CRE is asking Enedis to extend these calls for tender and develop all opportunities for flexibility on its grid, following the positive results of the 2023 Call for Tenders.
    - RTE's first experimental call for tenders is a positive signal to stakeholders. That's why CRE is asking RTE to systematically study the use of flexibilities and how to industrialize the associated solutions whenever they prove more appropriate than grid reinforcements.
    - The mapping of congestions published by RTE needs to be enriched to enable the identification of future zones for the launching of new local flexibility tenders and, more broadly, the development of market mechanisms dedicated to resolving these congestions as a complement to the grid. RTE and Enedis mappings need to be updated more regularly to provide a reliable service to stakeholders.
- Curtailments of renewable energy production must be systematically examined in grid sizing studies and must replace structural grid developments and reinforcements whenever this is economically and technically relevant.
- Given the importance of low-voltage generation, CRE calls on the distribution system operators to jointly develop a solution for managing these producers, which would also enable them to be offered smart connections or early connections while waiting for grid reinforcements.
- CRE asks RTE to regularly monitor the benefits of the optimal grid sizing approach and to share them with all market stakeholders.
- CRE welcomes the progress of the Reflex project and calls on Enedis to generalize and industrialize the corresponding solutions.

Grid observability tools

- CRE welcomes the deployment by French system operators of a large number of sensors, particularly on High Voltage and Medium Voltage grids, as well as advanced low-voltage meters. This provides them with the data they need to optimize grid planning, operation and maintenance.
- CRE asks system operators to collaborate and pool their work on smart grid management, in order to reduce costs for the community.

Recommendations for digitizing services and making data available to users

- CRE asks system operators who have not yet done so to monitor the availability of load curves from advanced meters.
- CRE stresses that the widespread deployment of advanced meters by distribution system operators is a very favorable factor for the development of innovative supply offers, which will be increasingly useful as the energy transition gathers pace.
- The open data platforms developed by French system operators play an important role both for the general public and for energy professionals. CRE encourages system operators to consult stakeholders on a regular basis to ensure that the data offering continues to meet their expectations.