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CRE COMMISSION DE RÉGULATION DE L'ÉNERGIE

REPORT

December 2025

Development of a smart electricity grid: Significant progress has been made, but challenges remain in terms of connection, integration of flexibilities and data sharing

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 many end-uses, both in terms of volume and number, such as transportation, construction and industrial processes. This should result in a sharp increase in electricity production and consumption, in addition to the decarbonisation of the electricity mix within the European Union.

This major transformation of the power system will lead to a new phase of accelerated development of electricity grids in the coming years, which will be able to accommodate new generation and new uses, cope with the growth of consumption and manage increasingly bidirectional and variable electricity flows. This evolution will have to take place while maintaining the high level of service quality currently observed in the European Union.

New technologies are crucial to achieve these objectives as a tool for optimising the power system. Smart grids make it possible to speed up connections, optimise new investments in grid infrastructure and help consumers play an active role in this transformation. This is, and will increasingly be, enabled by the exploitation of the growing volume of data collected by system operators, who will be able to rely on the development of artificial intelligence. This data may also be shared as open data or with authorised third parties to encourage the surge of new services.

For several years now, the French energy regulator, CRE, has been supporting the rollout of ‘smarter’ grids, especially by monitoring experiments, providing incentive-based regulation for system operators and creating a regulatory sandbox.

This report focuses on the performance of French system operators in the development of a ‘smart’ electricity grid. It is part of the European Directive of 5 June 2019 on common rules for the internal market in electricity, which entrusted national regulatory authorities with a mission in this regard. This is the second edition of this report, which, in accordance with the directive, is released two years after the publication of the first report[1].

This new report is based on a set of indicators collected from 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, data and user services. The report therefore focuses on the rollout of smart grid tools by system operators and the benefits they will bring to users in these three areas.

As they enter a phase of accelerated transformation, CRE notes that French system operators are overall well positioned compared to their European and global counterparts. Digital technologies are widely deployed and used industrially at all levels of electricity grids. This is illustrated by Enedis' top ranking among 94 utilities worldwide for the third consecutive time in the 2024 ranking established by the Singapore Power Group[2]. CRE also emphasises that recognition of the rollout of this digital infrastructure supported by grid fare calls for a high level of requirement regarding the sharing of reliable, high-quality data with the ecosystem.

Based on an assessment of the implementation of the recommendations made in its latest edition, the report reviews optimized connection solutions, before addressing the use of new flexibilities and grid management tools. The last part of the report deals focuses on data and its role in the development of new services for users.

Optimised connections to accelerate consumer new uses and renewable energies integration.

The boom in renewable energy sources and the electrification of energy end-uses are generating a strong increase in demand for grid connections, both in terms of number and volume. The effective management of these connections will have a significant impact on France’s ability to achieve its energy policy targets. In recent years, CRE has noted an increase in connection lead times. This can be

[1] Development of a smart electricity grid: Significant progress has been made, but challenges remain in terms of connection, integration of flexibilities and data sharing, December 2025, CRE

[2] https://www.spgroup.com.sg/our-services/network/overview/smart-grid-index

explained by the need to reinforce grids, sometimes lengthy administrative delays, but also by system operators' internal procedures that could be improved.

In this context, all levers for anticipating and accelerating connections and optimising the associated costs and delays must be activated. This is why CRE keeps supporting the widespread adoption of new 'smart' connection offers which, as an alternative to conventional solutions, make it possible to optimise the size and cost of infrastructures and connect more installations while rationalising investments, generally in return for occasional limitations on injection or withdrawal.

Takeaway no. 1: flexible connections with permanent limitations are still marginal but growing for renewable energies

- The first commissioning of renewable energy farms connected with power modulation connection offers (5 in 2023 and 15 in 2024) confirms the relevance of these offers for connecting renewable energy sources and the significant savings they can generate, reaching €600k/MW in 2024.
- In order not to hinder the development of these offers, CRE renews its request to the public authorities to loosen the framework (especially by removing the 30% cap of installed capacity) designed in the decree of July 12, 2021.
- Distribution system operators who have not yet included these offers in their Reference Technical Documentation [*DTR - Documentation technique de référence*] must do so as soon as possible.

Takeaway no. 2: renewable energy producers are increasingly using early connections with temporary limitations

- CRE has noted a strong interest among renewable energy producers for early connections. For instance, one out of every 20 low-voltage projects above 36 kVA commissioned on the Enedis grid in 2024 benefited from an early connection. As a result, hundreds of installations, representing around 200 MW, can start generating several years ahead of schedule. With the early connection offers, the limitations will only be temporary, pending the planned grid upgrades.

Takeaway no. 3: customised flexible connection solutions for storage facilities are developing but can still be improved

- Thanks to recent progress in connection framework for storage facilities, a quarter of the queue of storage projects on the transmission grid (i.e. 2.8 GW) has opted for an optimised connection offer incorporating limitations.
- RTE's publication of available capacities with or without limitations on Cartostock is an important step forward. However, these capacities were very quickly requested, highlighting two issues:
    - the need to find new capacities to offer with a template format, i.e. a standardised format for optimised connection offers incorporating limitations;
    - the need for rigorous enforcement of the recently approved queue management rules to ensure that only projects demonstrating progress remain in the queue, and if this is not sufficient, to update them.

Takeaway no. 4: consumers do not have access to innovative connection offers

- Connection offers for consumers need to be improved: offers with permanent limitations must at least be provided for electric vehicle charging infrastructures. CRE asks distribution system operators to include these offers in their reference technical documentation. The case of motorway service areas, where complementary uses (heavy and light vehicles) lead to diverse charging needs (during the week vs. during weekends and holidays), is an excellent illustration of this.
- Such offers for other consumers, particularly industrial sites, can also be relevant. Given the cost and time that these solutions can save, CRE advises interested manufacturers to express their interest in such offers to system operators, especially in saturated areas.

Access to reliable, high-quality grid data is a requirement to optimise connections. This data, made available by system operators through open data tools or specific services, should provide stakeholders with insight into the feasibility of their projects prior to submitting a connection request.

Takeaway no. 5: CRE considers that reliable open data tools are necessary to support connections

- CRE welcomes the provision by system operators of several tools for visualising available capacity and encourages them to ensure the quality of the data presented.
- In particular, pending the essential overhaul of the Caparéseau tool, RTE must offer a temporary alternative since grid users need enough visibility to develop their projects in the meantime.

New flexibilities and new tools for transforming grids

The deployment and widespread use of information and communication technologies enable more precise and dynamic grid management. The report presents the tools and methods developed by operators to optimise their grid management. These tools facilitate their operation 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 localised congestion**, are analysed, as well as the observability of grids and the equipment that facilitates their operation and maintenance.

Takeaway no. 6: new sources of flexibility continue to develop, supported by CRE

- New sources of flexibility continue to develop and accelerate:
  - The volume of certified battery capacity has doubled for primary reserves (or Frequency Containment Reserves “FCR”), which can now be supplied entirely (including exports) by batteries, while they already account for 8% of the activations on secondary reserve (or Automatic Frequency Restoration Reserves “aFRR”);
  - The cumulative power of load shedding certified for NEBCO has almost doubled, from 5.7 GW in 2022 to 10.9 GW in 2024, for a shedding volume of 56 GWh in 2024.
- System operators must continue to adapt the access rules for the various markets in order to facilitate the development and participation of new capacities.

The widespread use of flexibility solutions to resolve localised grid congestions is tackled by several priority actions and incentive regulations set out in the TURPE 7 deliberations, such as monitoring the pace of deployment of the Reflex project by Enedis and the implementation of a new contractual framework for calls for tenders for local flexibilities by RTE (full details available on pages 7 and 8).

Takeaway no. 7: the use of flexibility solutions to resolve local congestion is experiencing contrasting developments

- The acceleration of the pace of deployment of NAZA controllers and the doubling of the number of high-voltage lines equipped with Dynamic Line Rating are positive developments.
- On the other hand, CRE notes that the volumes of flexibility contracted and activated to resolve localised grid congestion are still very low, but they are set to increase with the proliferation of calls for tenders for local flexibilities.

Takeaway no. 8: modulation of renewable energy production remains a pillar of grid management for optimal sizing

- RTE's optimal sizing strategy has already freed up 18 GW of additional grid capacity without any renovation. Enedis' Reflex project is yielding excellent results and is expected to reach 100 transformers in 2028 (vs. 10 in 2024).
- Curtailment should not be the only flexibility tool. Enedis and RTE will need to quickly implement solutions that enable the mobilisation of storage and demand flexibility as an alternative to modulating renewable energy production when it is economically relevant.

Takeaway no. 9: control of low-voltage production is becoming a local necessity

- The reference technical documentation for distribution system operators must include, by default, the possibility of requiring the installation of a technical device enabling the limitation of the power injected into the grid by low-voltage producers. Exemptions for very small facilities or those connected in areas without constraints will need to be considered.

CRE notes, like in 2023, a good level of integration of intelligence in system operation and information reporting, with numerous projects already industrialised or in the process of industrialisation (predictive maintenance, use of artificial intelligence and optimised grid sizing). Grid observability, which consists in collecting data on grid infrastructure to ensure its proper operation and to remotely control some assets, has multiple uses: remote fault detection, predictive maintenance and fault identification, and optimisation of grid usage. CRE especially highlights the improved coordination between RTE and Enedis in the joint management of flexibilities.

Takeaway no. 10: grid observability remains a requirement for dynamic management

- Work on coordination between RTE and Enedis must continue and accelerate in order to ensure joint, relevant and effective management of flexibilities.

Data at the heart of new user services

The widespread deployment of smart meters, a cornerstone of smart grid technology, enables a wide variety of new user services. These meters enable remote operations that previously required to dispatch an agent on location, resulting in significant savings. They also provide access to reliable, high-quality and secure data, which is essential for the development of new smart offers and services that benefit both the electricity system and consumers.

Takeaway no. 11: advanced meters remain a cornerstone of smart grids

- The widespread deployment of advanced meters has made it possible to:
    - First, generate significant savings (€1.7 billion over the period 2017-2024), especially thanks to the implementation of remote operations that previously required to dispatch an agent on location;
    - Access to new services such as load curves, now available for more than 11 million delivery points;
    - The development of personalised supplier schedules with up to 10 time indices, enabling the proposition of innovative supply offers;
    - The possibility for consumers to choose their contracted power in 1 kVA increments, compared to 3 kVA previously, allowing them to tailor their offer to their needs and make savings.

Takeaway no. 12: the availability of open data is becoming increasingly attractive

- **CRE welcomes the availability and diversity of data made accessible by system operators, especially through the ORE Agency and ODRE, with several hundred data sets covering a wide range of topics such as grid mapping, grid capacity, production and storage, and consumption.** In general, electricity system operators publish a large amount of data that provides an excellent level of information on the operating of the electricity system and is of interest to a wide range of stakeholders: the State, local authorities, domestic and professional consumers, energy producers, suppliers and balance managers, service providers, etc.
- The increase in average monthly traffic to open data platforms from 10,000 visitors per month in 2021 to 38,500 in 2024 demonstrates the importance and success of these platforms developed by French 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 may incorporate more of the best practices observed among European regulators, as well as common indicators to be monitored by all EU regulators, which are currently being developed by ACER[3] and CEER[4].

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Reminder of the incentives (incentive regulation or priority action) set in the TURPE 7 deliberations in relation to grid connections, grid flexibility and management tools, and data and user services:

Enedis	
Incentive regulation	**Deadline**
Connection	
Implementation of flexible connection offers (ORA-MP) for MV storage operators	01/08/2026
Implementation of flexible connection offers for all MV users upon request	01/08/2027
System management	
Generalisation of Reflex with monitoring of the number of transformers for which Reflex has been implemented	01/01/2027: 60 transformers 01/01/2028: 100 transformers
Compatibility of NAZA controllers and the Reflex project	01/01/2026
Bonus equal to 20% of flexibility gains	immediately
Monitoring of CritFlex5 application [5]	immediately
Coordination of contracting and activation of available flexibility Enedis/RTE	01/09/2026
User services	
Provision of information on customer time slots to authorised third parties	01/08/2027
Monitoring of load curve completeness rates for the mass market	01/01/2025

RTE	
Incentive regulation	**Deadline**
Connection	
Publication of a map of S3REnR work areas	01/04/2025

[3] Agency for the Cooperation of Energy Regulators

[4] Council of European Energy Regulators

[5] Method already implemented by Enedis, consisting of calculating the “willingness to pay” for flexibility, i.e., the savings made possible by using flexibility compared to an investment scenario (in terms of investment cost, additional losses, and residual non-quality).

Map for connecting batteries 'Cartostock' and implementation of seasonal operating templates for connecting batteries	01/11/2025
Redesign of Caparéseau	01/01/2027
Grid management	
Deployment target for NAZA controllers (in units per year)	2025: 10; 2026: 10; 2027: 15; 2028: 15
Implementation of a new contractual framework for calls for tenders for local flexibilities and publication of new calls for tenders for local flexibilities	01/08/2027: at least 2 calls for tenders 01/08/2029: at least 4 calls for tenders
Making NAZA controllers and the Reflex project compatible in order to optimise the activation of renewable energy curtailments	01/01/2026
Bonus equal to 20% of flexibility earnings	immediately
Coordination of contracting and activation of available flexibility Enedis/RTE	01/09/2026

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 and optimised grids.

Making grids smarter involves adding a digital layer to the physical layer of historic grids, which facilitates the evolution of grid usage by enabling the development of new applications that optimise the system and fully exploit the potential of the existing grid. Smart electricity grids will make it possible to speed up connections, limit investment and the physical footprint of grids, and maintain a high level of service quality despite completely reconfigured and much less predictable electricity flows. This is therefore a major challenge for the energy transition. This will especially be possible by exploiting the growing amount of data collected by system operators, who will need to adapt their information systems accordingly and will be able to use artificial intelligence.

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

- financing and monitoring R&D of system operators;
- publishing feedback from experiments;
- monitoring indicators as part of the incentive-based regulation for system operators;
- the regulatory sandbox, which facilitates experimentation hampered by the current regulatory framework.

Since 2021, this list has been expanded with a new mission. Pursuant to Article L. 134-15 of the French Energy Code, CRE will publish every two years a 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[6] 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. The report covers the transmission system operator (RTE) and the distribution system operators with more than 100,000 connected customers: Enedis, EDF SEI, Gérédis, GreenAlp, réséda, Strasbourg Electricité Réseaux (SER) and SRD. CRE published its first report on this topic in 2023, covering indicators for the years 2021 and 2022[7].

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 report first reviews the recommendations made in its last edition. The aim is indeed to ensure continuity in the analysis by taking into account the actions that have been implemented and the progress that remains to be made in order to put the results of this edition into perspective.

As in the previous report, the indicators are 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 and quantitative analysis based on indicators. This approach makes it possible to take into account the diversity of the grids involved and the actions implemented by system operators, while being able to monitor changes in their performance on specific topics that CRE considers essential.

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

3. Review of the 2023 recommendations

In its first report on this topic, CRE issued several recommendations and takeaways. This report reviews the actions taken following the 2023 report.

2023 Recommendations	2025 Review
Main recommendations on optimising connections to accelerate the integration of renewable energies and new end-uses in the context of decarbonisation	
CRE will continue to ensure the widespread availability and improvement of innovative and optimised connection offers for storage operators.	Growing interest among storage operators in optimised connection offers, with 2.8 GW of additional projects in the queue since then (compared to 600 MW in 2022). New projects are expected to enter the queue with the publication of areas where standardised optimised connection offers (i.e. providing greater visibility on the periods when limitations will occur), known as template offers, are planned in TURPE 7 HV[8].

[6] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) (Text with EEA relevance.)

[7] Report on the performance of system operators in the development of a smart electricity grid, December 2023, CRE

[8] CRE Decision No. 2025-77 of March 13, 2025, on the tariff for the use of public electricity transmission grid (TURPE 7 HV)

CRE is asking system operators to rapidly roll out connection offers that consider the countercyclical nature of storage.	No generalisation at this stage, but TURPE 7 MV-LV[9] provides for priority action by Enedis to ensure that these offers are made available to all MV storage sites that request them by the 1st of August 2026. Enedis launched a consultation with stakeholders at the end of 2025 with the aim of updating its DTR.
CRE calls on system operators who have not yet incorporated power modulation connection offers (ORA MP) into their connection procedures to do so.	Some distribution system operators (SER, réséda, GreenAlp) have still not incorporated ORA MP into their Reference Technical Documentation (DTR).
CRE recommends removing the power cap (the cap on the amount of power that can be curtailed by the system operator), which excessively restricts these offers and therefore limits their appeal.	The cap is still effective. An experiment led by TotalEnergies, as part of the regulatory sandbox, is being considered on this topic but has not yet started[10].
In the context of the electrification and decarbonisation of industry, CRE is calling for the widespread adoption of innovative connection offers for consumers.	All consumers were connected with conventional connection offers in 2023 and 2024.
CRE considers it important for system operators to improve the reliability of the 'Caparéseau' platform and to regularly update the data it contains.	TURPE 7 HV provides for priority action on the overhaul of the platform by the 1st of January 2027, as well as incentive-based regulation on the handling of complaints. Stakeholders are currently reporting difficulties in the meantime.
Main recommendations on the use of new flexibilities and new tools for grid management	
The rules for accessing the various markets must continue to facilitate the development and participation of new capacities.	Several regulatory changes have taken place since 2023, such as the reopening of the aFRR[11] call for tenders and the publication of the new NEBCO[12] (Notification of Exchange of Consumption Block) rules authorising the valuation of load shifting. The TURPE 7 HV and MV-LV deliberations provide for priority action on the publication of rules for managing simultaneous activation requests on the various market mechanisms for supply-demand balance or grid flexibility, as of the 1st of September 2026.
CRE is asking Enedis to generalise calls for tenders for local flexibilities and develop all	Continuation and growth of Enedis' calls for tenders for local flexibilities with the integration of Reflex[13] lots into the latest call for tenders.

[9] CRE Decision No. 2025-78 of March 13, 2025, on the tariff for the use of public electricity distribution grids (TURPE 7 MV-LV)

[10] CRE Report No. 2025-03 on the progress of projects benefiting from exemptions granted under the regulatory experimentation sandbox, May 2025, CRE

[11] *automatic Frequency Restoration Reserve* – Secondary Reserve

[12] CRE Deliberation No. 2025-199 of 23 July 2025 approving harmonised market rules relating to the explicit valuation of load shedding and their general provisions

[13] Project initiated in 2020 by Enedis with the aim of optimising grid sizing and investments required for the integration of renewable energy sources, in particular by using flexibilities.

opportunities for flexibility on its grid following the positive results of the 2023 call for tenders.	TURPE 7 MV-LV incorporates changes to the regulatory framework, especially the sharing of gains made possible by the use of external flexibility between Enedis and the local authority (20% of gains for the system operator) as well as several incentive regulations (IR): monitoring the application of CritFlex[14], the establishment of a continuous flexibility market, the demand for a call for tenders to enable the contracting of flexibilities with capacity reservation, whenever this makes it possible to postpone or replace investments, and the widespread implementation of Reflex (the first wave is currently underway).
CRE is asking RTE to systematically study the use of flexibility and the industrialisation of associated solutions whenever they prove to be more relevant than grid upgrades.	TURPE 7 HV includes a change to the regulatory framework, especially with the sharing of gains made possible by the use of external flexibility between RTE and the local authority (20% of gains for the system operator). TURPE 7 HV also provides for priority action on the implementation of a new contractual framework for calls for tenders for local flexibilities and the publication of at least four calls for tenders for local flexibilities before the 31st of July 2029, including at least two before the 1st of August 2027.
The use of renewable energy production modulation must be systematically studied in grid sizing studies and must replace structural grid developments and reinforcements whenever this is economically and technically relevant.	The use of renewable energy production modulation has been taken into account by RTE since 2019 as part of optimal sizing and has been in the process of being rolled out by Enedis since 2025 with the Reflex project.
CRE is calling on distribution system operators to jointly develop a solution for managing low-voltage producers, which would also enable them to offer smart connection options or even early connection options while waiting for grid upgrades to be completed.	In its TURPE 7 MV-LV deliberation, CRE asked Enedis to carry out a cost-benefit analysis on the capping of low-voltage producers as part of early connection offers by the 1st of August 2027. RTE and Enedis are experimenting with the use of mini-DEIEs (Operational Information Exchange Devices) to cap LV production for optimal sizing purposes.
CRE has asked RTE to regularly monitor the benefits of optimal grid sizing (DO) approach and to share this information with all market players.	As part of its SDDR project, RTE has provided a new estimate of the gains from DO (the previous one dated from 2019): without requiring any additional investment, it has already made it possible to offer 18 GW of grid capacity between 2021 and 2024, representing approximately €1.8 billion in investment savings over this period (for a cost of renewable energy curtailment of approximately €15 million/year).
CRE is asking Enedis to expand and industrialise the Reflex project.	Enedis has begun expanding Reflex with a first wave of implementation between 2025 and 2028 (the pace of deployment is financially incentivised

[14] Method already implemented by Enedis, consisting of calculating the 'willingness to pay' for flexibility, i.e. the savings made possible by using flexibility compared to an investment scenario (in terms of investment cost, additional losses and residual non-quality).

	in TURPE 7 MV-LV). At the same time, Enedis has published the first Reflex lots included in calls for tenders for local flexibilities in 2024.
Recommendations on the digitisation of services and the provision of data to users	
CRE is asking system operators who have not yet done so to monitor the availability rate of the load curve from smart meters.	This system is in place for all of the distribution system operators assessed, except for Réséda and GreenAlp, where access to this data is not yet available to customers at the bottom of their portfolios.
The open data platforms developed by French system operators are important for both the general public and energy professionals. CRE encourages system operators to consult regularly with stakeholders to ensure that the data offered continues to meet their expectations.	In 2024, the ORE Agency led the process of pooling open data from distribution system operators. Enedis conducted two satisfaction surveys in 2023 and 2024 among users of its open data site, the '*Observatoire Français de la Transition Écologique*' (French Observatory for Ecological Transition). Enedis conducted around twenty qualitative interviews to obtain feedback on the navigation and use of the open access graphs and data for the purpose of continuous improvement. These interviews highlighted that the platform meets a real need, particularly for local authorities, with a wish for a simplified navigation.

4. Optimised connections to accelerate consumer new uses and renewable energies integration

The development of renewable energies and the electrification of end-uses have led to a sharp increase in requests for connections to the electricity grids in France, inducing **longer waiting times in recent years**. To speed up connections and optimise costs and lead times, CRE believes that all available levers must be used, in particular by developing new connection offers as alternatives to traditional reference offers, better suited to the real needs of renewable energies, which rarely use their maximum power, or to flexible assets such as storage facilities.

Smart connection offers [ORI – *Offres de Raccordement Intelligentes*] are emerging as an innovative solution for connection applicants. They are effective in optimising the sizing of structures and reducing connection commissioning times. Applicants can agree to **occasional injection or withdrawal limitations in the event of grid constraints in order to benefit from less expensive connection facilities and/or faster connection**. These offers therefore promote the development of renewable energies and flexible assets while reducing costs for applicants and the community.

Depending on grid constraints and the needs of the assets to be connected, system operators may offer ORIs that differ according to the nature of the limitations, whether **temporary** or **permanent**, and the type of restriction used to apply these limitations, whether **static** or **dynamic**.

At the European level, Article 6 bis of Directive (EU) 2024/1711[15] states that the national regulatory authorities of Member States must develop a framework for transmission system operators and distribution system operators to offer the possibility of establishing flexible connection agreements in areas where grid capacity is limited or non-existent. Under this framework, ORIs can be used as a permanent solution in areas where grid development is not the most efficient solution.

CRE has repeatedly asked French system operators to implement these offers, as stated in its 2019 deliberation on connection procedures[16] and in its TURPE 7 deliberations. System operators have begun to implement this type of offer, as shown in the table below:

Table 1 Overview of existing ORIs in 2025

Connection Offer	System Operator	Users involved	Type of limitation	Type of restriction
Reference Connection Offer (ORR)	All	All users	No limitation	
Alternative Connection Offer with Power Modulation (ORA-MP)	All system operators can offer this[17]	Renewable energy producers[18]	Permanent	Dynamic
Optimised Connection Offer (ORO)[19]	RTE	Storage facilities	Permanent	Dynamic but incorporates a static dimension with the development of templates
Early Connection Offer (ORA)	All	Public Electrical Transmission Grid [RPT - *Réseau*	Temporary (pending	Dynamic

[15] Directive (EU) 2024/1711 of the European Parliament and of the council of June 13, 2024, amending Directives (EU) 2018/2001 and (EU) 2019/944 as regards improving the Union's electricity market design (Text with EEA relevance)

[16] CRE Deliberation No. 2019-275 of 12 December 2019 on the rules for developing procedures for processing applications for connection to public electricity distribution grids and monitoring their implementation

[17] In practice, RTE does not offer it in HV, and SER, Réséda and GreenAlp have not included it in their DTR.

[18] In practice, only medium-voltage renewable energy producers. TURPE 7 MV-LV sets out two priority actions for Enedis to offer ORA-MPs to all storage facilities and then all medium-voltage users by August 1, 2026, and August 1, 2027, respectively.

[19] Enedis works with RTE to adapt RTE's OROs and templates (for RPT constraints) for storage facilities connected to medium-voltage systems.

Users are connected before the connection work is completed.	*Public de Transport*] users, consumers and renewable energy producer on the Public Electrical Dsitribution Grid [RPD - *Réseau Public de Distribution*]	completion of grid upgrades)

4.1. Still few flexible connections but a growing offer for renewable energies

For several years, the regulatory framework has included ORI for renewable energy producers with **alternative connection offers with power modulation (ORA-MP)** introduced by Article D. 342-23 of the Energy Code. The decree of the 12th of July 2021[20] details the conditions allowing producers to request such an offer. In particular, the decree specifies that the injection cap for the alternative connection offer must comply with the following thresholds:

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

To date, most system operators have incorporated these offers into their DTRs, with only SER, Réséda and GreenAlp yet to do so.

The first renewable energy farms connected with ORA-MP were commissioned in 2023 and 2024 with 5 (3 PV and 2 wind turbines) and 15 installations (9 PV and 6 wind turbines) respectively. These smart connections have saved €650k and €8.4m respectively in connection costs compared to standard connection offers. This corresponds to **savings of €600k/MW in 2024**.

CRE Takeaway no. 1

The first commissioning of renewable energy farms connected with power modulation connection offers (5 in 2023 and 15 in 2024) confirms the value of these offers for connecting renewable energy sources and the significant savings they can generate, reaching €600k/MW in 2024.

In order not to hinder the development of these offers, CRE reiterates its request to the public authorities to loosen the framework (in particular by removing the 30% cap of installed capacity) provided for in the decree of the 12th of July 2021.

Distribution system operators who have not yet incorporated these offers into their reference technical documentation should do so as soon as possible.

4.2. Increase in early connections for renewable energies

When the connection of a renewable energy production facility requires the **creation of extension structures and, if needed, the reinforcement of existing public grids**, its commissioning may, under certain conditions, take place before the completion of the corresponding works in accordance with Article D. 342-23 of the Energy Code. This is known as an early connection. System operators thus put in place mechanisms to temporarily limit the power fed into the grid by the applicant's facility, especially in order to comply with the transmission capacity of existing infrastructures. **This connection solution**

[20] Decree of the 12th of July 2021 implementing Article D. 342-23 of the Energy Code

allows facilities to be commissioned more quickly, without having to wait for the completion of sometimes lengthy works, thereby promoting the integration of renewable energy production.

CRE notes a sharp increase in the number of PV farms that have benefited from early connection, with 94 installations (22 MW) and 630 installations (191 MW) connected by Enedis in 2023 and 2024 respectively. **The share of early connections for PV projects to low voltage with a capacity greater than 36 kVA (LV > 36 kVA) has thus increased from 1.3% to 5.4%.** For its part, SRD has issued around 200 early connection offers (42.5 MW), of which 142 (26.5 MW) have already been accepted for the 2024/2025 period.

These installations were connected within deadlines that were shorter than or equivalent to the standard deadlines for connecting this category (**less than 1 year**). Excluding early connections, the **average connection time for the producers involved would have been 5 years**.

CRE Takeaway no. 2

CRE has observed strong demand among renewable energy producers for early connections. One in 20 low-voltage projects > 36 kVA commissioned on Enedis' grid in 2024 benefited from an early connection, enabling hundreds of installations, representing around 200 MW, to start producing several years ahead of schedule. Under the early connection offers, the limitations will only be temporary pending the planned system upgrades.

4.3. Customised connection solutions for storage assets

Electricity storage facilities are inherently controllable and flexible, and therefore very well suited to connection offers that include limitations.

RTE has developed **optimised connection offers** (OROs) for storage facilities, enabling them to be connected in saturated areas in exchange for limitations for a few hours per year in the event of constraints. **These offers are available across the entire grid and have sparked growing interest in recent years**, particularly since the evolutions in 2023 allowing participation in frequency system services with these offers.

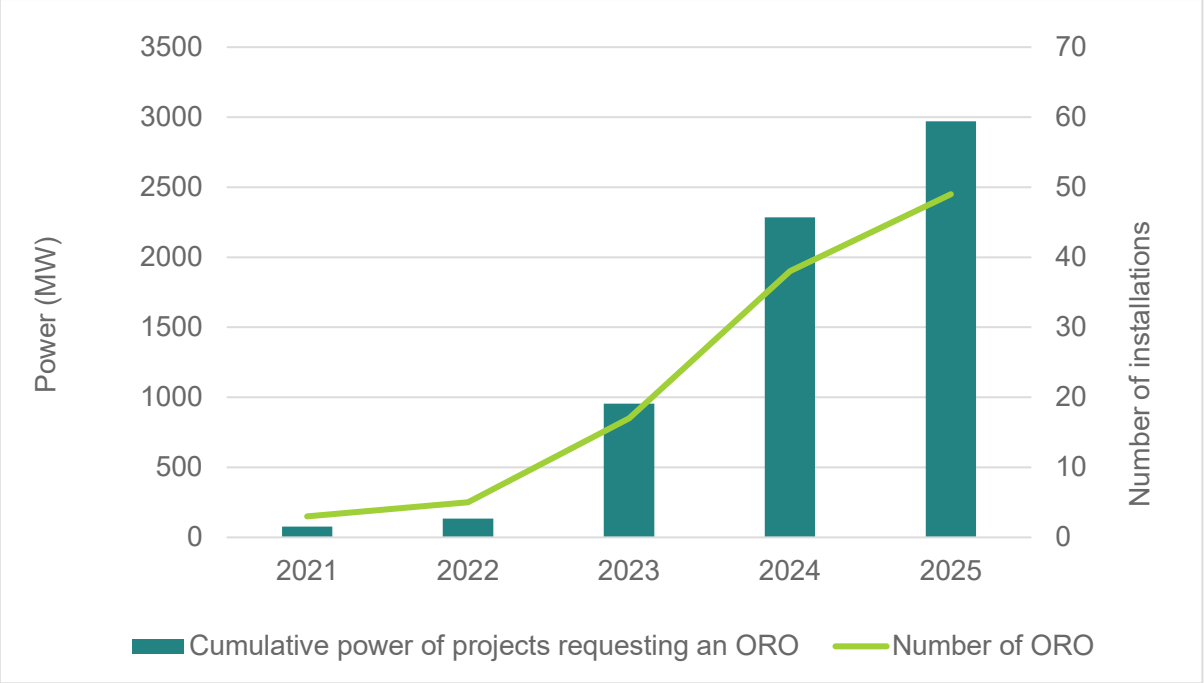

Figure 1 Evolution of the ORO queue

In order to free up additional capacity on the grid for storage operators, **CRE has included in TURPE 7 HV a priority action on the implementation of hourly seasonal operating templates** in areas with high PV injection and consumption, this is a standardised format for OROs. In addition to the capacity

freed up, these templates give developers greater visibility on the occurrence of limitations and therefore the impact on the economic viability of projects. RTE has also announced that constraints will be shared, when possible, with two days' notice, thus enabling participation in frequency system services.

These developments have been very well received by storage operators. **Nevertheless, the initial work and results published by RTE on Cartostock[21] have only offered around 1 GW of capacity under the solar template**, spread over 10 areas, 14 substations and 4 regions. Connection requests in these zones have far exceeded this capacity.

CRE therefore considers that the number of areas identified by RTE is low compared to the overall grid capacity. Furthermore, the proper application of queue management procedures should free up available capacity in some areas. In this context, **CRE is asking RTE to find new capacity to offer under the solar template and to update the corresponding map**.

Regarding the public distribution grid, TURPE 7 MV-LV provides for priority action to ensure that Enedis offers connection packages that include limitations on all MV storage facilities by the 1st of August 2026. Enedis will then be able to offer ORA-MPs to storage operators for RPD constraints. In addition, Enedis is also working with RTE to adapt RTE's OROs and templates (for constraints on the transmission grid) for MV-connected storage facilities.

CRE Takeaway no. 3

Thanks to recent evolutions in connecting storage facilities, a quarter of the queue of storage projects on the transmission grid (i.e. 2.8 GW) has chosen an optimised connection offer incorporating limitations.

RTE's publication of available capacities with or without limitations on Cartostock is an important step forward. However, these capacities were very quickly requested, highlighting two issues:

- **the need to find new capacities to offer below the template, i.e. a standardised format for optimised connection offers incorporating limitations;**
- **the need for rigorous application of the recently adopted queue management rules to ensure that only projects demonstrating progress remain in the queue, and if this is not sufficient, to move them forward.**

4.4. A lack of innovative connection options for consumers

The electrification of transportation and of the industry is generating an increase in demand for grid connections for these new consumers. This increase in demand is accompanied by longer waiting times, particularly for electric vehicle charging infrastructures, which could slow down the decarbonisation of these sectors.

Currently, no distribution system operator offers connection solutions with long-term limitations for consumers, including electric vehicle charging infrastructures, even though work carried out by system operators has confirmed the technical feasibility of these connections and their economic relevance[22]. However, Enedis does offer early connection options for consumers, with two data centres having received and accepted offers in 2024 and whose connections are currently in progress.

In this context, **TURPE 7 MV-LV provides for priority action to ensure that Enedis offers deals incorporating permanent limitations to all MV users by the 1st of August 2027**.

For its part, **RTE has offered early connection deals**, with non-permanent limitations, to several consumers. In addition, **RTE has initiated a review of connection solutions with permanent limitations for consumers** by offering this type of solution in the industrial port area of Fos-sur-Mer, although no consumer has requested it so far.

[21] https://analysesetdonnees.rte-france.com/reseaux/cartostock

[22] aVEnir demonstrator, Feedback from smart grid demonstrators in 2024, CRE, November 2024

CRE Takeaway no. 4

Connection offers for consumers need to be improved: offers with permanent limitations must be provided at least for electric vehicle charging infrastructures. CRE is asking distribution system operators to include these offers in their reference technical documentation. The case of motorway service areas, where complementary uses (heavy and light vehicles) lead to diverse charging needs (during the week vs. during weekends and holidays), is an excellent illustration of this.

Such offers for other consumers, especially industrial users, also seem interesting. Given the cost and time savings that these offers can bring, CRE recommends that industrial users who are interested in such offers express their interest to system operators, particularly in congested areas.

4.5. *Open data* tools for connection

Securing access to the grid is crucial for the development of renewable energies, new sources of flexibility (particularly storage), electric mobility, decarbonisation and electrification projects, and data centres. **Access to up-to-date and reliable data on available grid capacity is therefore essential for stakeholders and system operators alike**, as it enables them to streamline applications and limit those that are ultimately unlikely to be successful. Several tools and platforms already exist:

- **Capten** and "***Tester mon raccordement***" (Test my connection) offered by Enedis for the RPD: stakeholders have made good use of these tools, as evidenced by the increase in visits and simulations carried out (+80% between S1 2025 and S1 2024 for Capten). However, neither platform has been the subject of large-scale user satisfaction surveys.
- **Caparéseau**, offered by RTE in coordination with distribution system operators, for available injection capacity for MV and HV: the platform has not been operative for several years due to a lack of updates of the data published on it. **TURPE 7 HV provides for priority action on the overhaul of the platform by the 1st of January 2027, as well as incentive-based regulation on the handling of complaints. However, a deterioration of the historical platform, which is nevertheless essential for developers, is currently being observed and must be corrected pending this overhaul.**
- The mapping of connection pooling areas for consumption and distribution system operators published online by RTE[23]. It allows users to view all pooling areas under consideration or approved by CRE, along with their key characteristics (the commissioning date of the facilities creating the capacity, the unallocated capacity in an area and the financial contribution required to benefit from it).
- In 2025, SRD launched a map showing connection times for LV producers in order to inform stakeholders about areas that are favourable or unfavourable for producer connections. This map takes into account both connection capacities at substations and areas with local high voltage constraints requiring work.

CRE Takeaway no. 5

CRE welcomes the provision by system operators of several tools for visualising available capacity and invites them to ensure the quality of the data presented.

In particular, pending the essential overhaul of the Caparéseau tool, RTE must offer a temporary alternative, as grid users must have sufficient visibility to develop their projects in the meantime.

[23] https://www.services-rte.com/fr/home/publique/decouvrez-nos-services-dacces-au/consulter-la-localisation-des--1.html

5. New flexibilities and new tools for transforming grids

5.1. Mobilising 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:

Table 2 Certified cumulative power on the markets by asset type

Cumulative capacity in MW	**RTE**			
	2021	**2022**	**2023**	**2024**
Cumulative power of Electric Vehicle Charging Infrastructures certified for participation in system services (by market)	0,1	0,1	0,1	0,1[24]
Cumulative capacity of storage facilities certified for participation in system services (by market)	FCR[25]: 108 aFRR[26]: /	FCR: 332 aFRR: /	FCR: 497 aFRR: 28	FCR: 689 aFRR: 93
Cumulative capacity of storage facilities certified for participation in the adjustment mechanism and NEBCO	/	/	305,3	472,3
Cumulative power of load shedding certified for participation in system services (by market) with diffuse reserve entity	FCR: 6 aFRR: /	FCR: 14 aFRR: /	FCR: 14 aFRR: 5	FCR: 14 aFRR: 18
Cumulative power of certified load shedding for participation in system services (by market) with Public Electrical Transmission Grid [RPT- *Réseau Public de Transport*] sites	FCR: 126 aFRR: /	FCR: 126 aFRR: /	FCR: 110 aFRR: 26	FCR: 110 aFRR: 26
Cumulative power of consumption load shedding certified for participation in the balancing mechanism	5900	6200	6800	6600
Cumulative power of consumption load shedding certified for participation in the Notification of Exchange of Consumption blocks system [NEBCO - *Notification d'Echange de Blocs de Consommation*]	3700	5700	8600	10900
Cumulative power of Electric Vehicle Charging Infrastructures, storage facilities and certified load shedding systems participating in "Local Flexibility" Call for Tenders	0	0	0	0[27]

[24] Not programmable since < 1MW

[25] FCR: *Frequency Containment Reserve* – Primary Reserve

[26] aFRR: *Automatic Frequency Restoration Reserve* – Secondary Reserve

[27] RTÉ's experimental local flexibility call for tenders launched in 2022 has been awarded but is not yet operational.

Load shedding, which is already well developed, continue to grow, particularly through the Adjustment Mechanism (MA) and NEBCO, which now allows the valuation of load shifting. **The cumulative power of certified load shedding for participation in NEBCO has almost doubled, from 5.7 GW in 2022 to 10.9 GW in 2024, for a total reduction volume of 56 GWh in 2024[28].**

Initially supported by the long-term call for tenders[29] and the primary reserve, storage continues to develop, now driven by the secondary reserve capacity market and, in the medium/long term, by spot and intraday arbitrage. **The volume of storage certified for the primary reserve thus doubled between 2022 and 2024 to reach 689 MW in 2024 (for a national requirement of 486 MW and an additional 110 to 145 MW for export).**

The reopening of the secondary reserve in mid-2024 has created new opportunities for storage development. **Nowadays, a volume of 185 MW is certified, with batteries accounting for 8% of activations.** These volumes are expected to increase with the commissioning of new facilities of several tens or hundreds of MW in the coming months and years.

Finally, RTE has introduced new, more flexible certification frameworks to facilitate the participation of new sources of flexibility in system services.

The participation of Electric Vehicle Charging Infrastructures in these markets is not yet a reality, although it is technically possible.

For several years, RTE has noted a lack of downward modulation capacity to ensure the balance between supply and demand. This confirmed shortage leads to an increase in the occurrence of degraded mode activation due to insufficient downward supply on the adjustment mechanism, which illustrates RTE's need for additional means to manage the supply-demand balance. On the other hand, RTE regularly resorts to production cuts outside the adjustment mechanism. These events lead to system deoptimisation and higher operating costs.

Several measures have been taken to address this lack of resources:

- Mandatory participation of production sites, particularly renewable energy sites, whose power exceeds a threshold approved by CRE (10 MW), in both upward and downward adjustments. The implementation of this obligation involves setting up a remote-control system for renewable energy farms and will enable other needs to be met (shutdown due to negative prices, grid congestion, etc.);
- The creation of a new fast tertiary reserve capacity product as of April 2026, with an estimated average requirement of 1.5 GW in the long term. The aim is to encourage the development of downward bids for RTE's balancing needs.

CRE Takeaway no. 6

New sources of flexibility continue to develop and are accelerating:

- **The volume of certified battery capacity has doubled for primary reserves (or Frequency Containment Reserves, FCR), which can now be supplied entirely (including exports) by batteries, while they already account for 8% of activations on secondary reserves (or Automatic Frequency Restoration Reserves, aFRR);**
- **The cumulative power of certified load shedding for participation in NEBCO has almost doubled, from 5.7 GW in 2022 to 10.9 GW in 2024, for a shedding volume of 56 GWh in 2024.**
- **System operators must continue to adapt the rules for accessing the various markets in order to facilitate the development and participation of new capacities.**

5.2. Flexibilities for resolving local congestion

Flexibility can also be used to resolve local congestion on the grid. Such congestion may arise due to an excessive imbalance between generation and consumption in a given area, or to meet an immediate

[28] Source: https://www.services-rte.com/

[29] Calls for tenders launched by the Ministry for Ecological and Solidarity Transition in 2019 to develop new storage and load shedding capacities.

and temporary operational need (for example, to avoid local power cuts if the grid situation does not allow all customers in an area to be supplied due to the accidental or planned unavailability of a facility) or to schedule works (to avoid the mobilization of generators). In this case, flexibility complements or replaces grid investment.

RTE and Enedis tested several solutions during the TURPE 6 period to use flexibility for the needs of their grids: launch of the first calls for tenders in 2020 for Enedis, initially for immediate and temporary operational needs, then as part of Reflex from 2024, or use of a battery as an alternative to investment with RTE's experimental call for tenders in Perquié.

TURPE 7 should enable the widespread use of these solutions. CRE has therefore changed the regulatory framework by introducing a financial incentive for Enedis and RTE to use flexibility when it is profitable, awarding them a bonus proportional to the savings achieved using flexibility. However, it will be necessary to ensure that the methodologies adopted by Enedis and RTE are consistent and value the use of flexibility at its fair value. To ensure that system operators make good progress on these issues, CRE has introduced several incentive regulations and priority actions, including:

- **Monitoring the application of CritFlex[30] by Enedis** (no financial incentive);
- **Monitoring the pace of deployment of the Reflex project by Enedis** (financial incentive);
- The implementation of a new contractual framework for **call for tenders for local flexibilities by RTE** (allowing the use of flexibility to replace investment and/or renewable energy curtailment, making the call for tenders technologically neutral and, where possible, accessible to connected distribution capacities) and the publication of at least four calls for tenders for local flexibility by the 31st of July 2029, including at least two before the 1st of August 2027;
- **Ensuring compatibility across the entire territory of NAZA** (New Adaptive Zone Controllers) **and the Reflex project by Enedis and RTE** in order to optimise the activation of renewable energy curtailment and maximise the value of grid flexibility for the community, by 1 January 2026;
- Publication by Enedis and RTE, after consultation with market players, of rules for managing simultaneous activation requests on the various market mechanisms for supply-demand balance or grid flexibility, by the 1st of September 2026.

The volumes of flexibility contracted and activated today remain very low (see graph below). Furthermore, 59 MW were contracted by RTE in 2024 (via the call for tenders for the 63 kV Perquié electrical substation in the Landes department) but they will not be connected and available until 2029. The flexibility contracted for 2023 and 2024 consists solely of contracts without capacity reservations and with low activation probabilities. **The widespread adoption of Reflex and the launch of new call for tenders to replace (or delay) investments by RTE should result in growth in contracted and activated volumes.** Similarly, the development of a joint platform by RTE and Enedis will encourage the transition from a system of annual calls for tenders to a continuous market, enabling players to constantly adapt the prices and volumes of their offers.

[30] Method already implemented by Enedis, consisting of calculating the 'willingness to pay' for flexibility, i.e. the savings made possible by using flexibility compared to an investment scenario (in terms of investment cost, additional losses and residual non-quality).

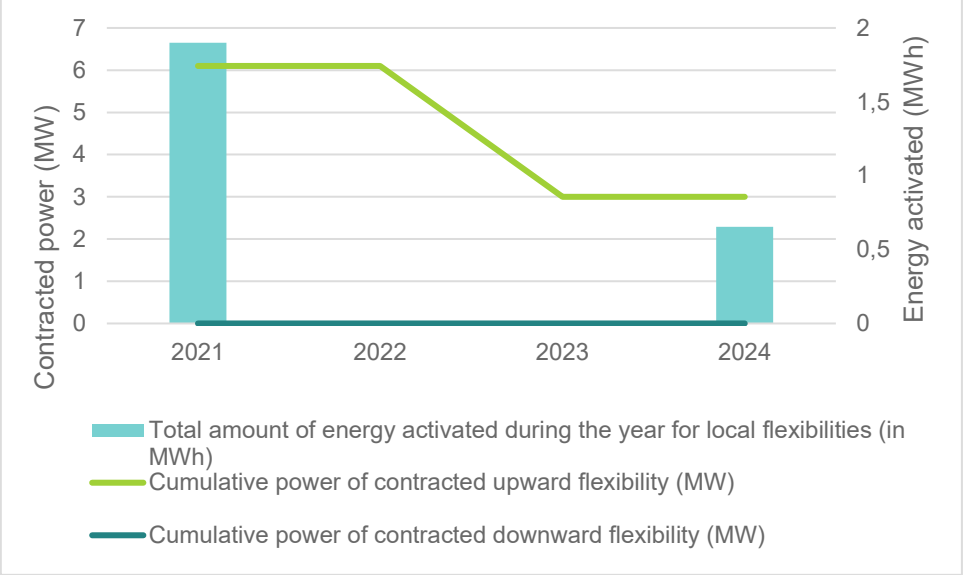

Figure 2 Capacity for local flexibility contracted and mobilised within the framework of the calls for tenders

At the same time, the period 2023–2024 witnessed a **doubling in the number of high-voltage lines equipped with DLR** (Dynamic Line Rating), which optimises wind power generation capacity while limiting the need for grid adaptation (see graph below).

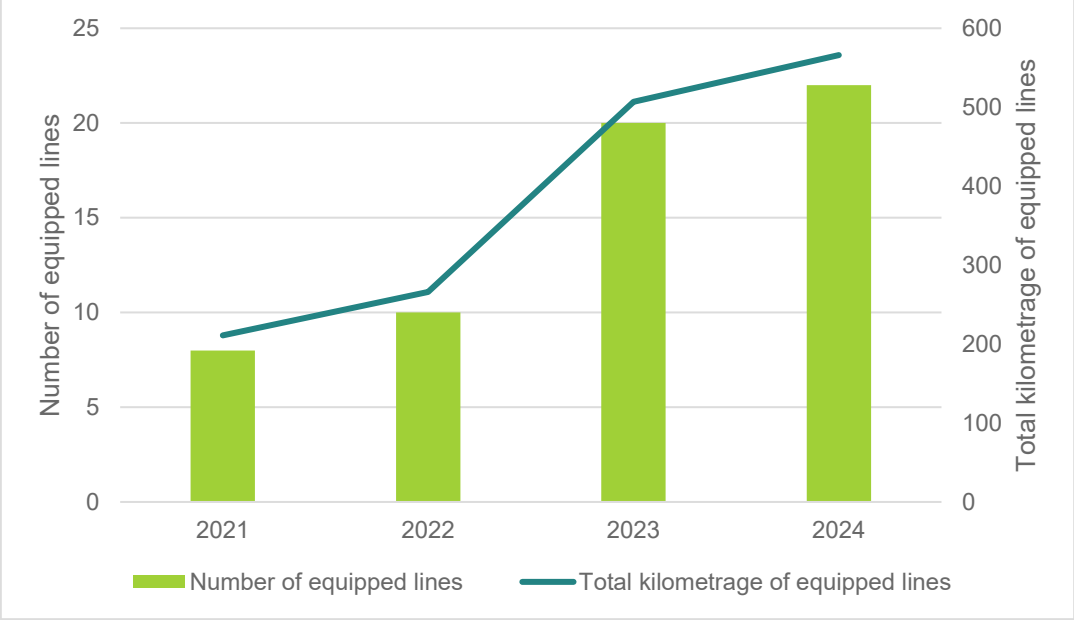

Figure 3 DLR Deployment

CRE has also noted an **acceleration in the pace of deployment of NAZA** controllers (which enable renewable energy production to be reduced temporarily in the event of a surplus, increasing from 3 at the end of 2022 to 15 at the end of 2024). **This acceleration should be continued, in line with the trajectory for new NAZA controllers set by CRE in TURPE 7 HV** (10 in 2025, 10 in 2026, 15 in 2027 and 15 in 2028).

CRE Takeaway no. 7

The acceleration in the pace of deployment of NAZA controllers and the doubling of the number of HV lines equipped with Dynamic Line Rating are positive developments.

On the other hand, CRE notes that the contracted and activated volumes of flexibility for resolving localised grid congestion are still very low but will increase with the proliferation of calls for tenders for local flexibilities.

5.3. Modulating renewable energy production to optimise grid sizing

The main sources of renewable energy with high development potential (wind, solar) have variable production, which depends on weather conditions (wind or sunshine) and rarely reaches the installed capacity of the production units. This means that a grid designed to distribute all the output from renewable energy installations would rarely be used at maximum capacity. From an economic perspective, it therefore makes sense to design grids in a way that allows for the possibility of not being able to always inject the entire installed capacity.

RTE was the first system operator to incorporate this principle into its grid sizing methods. RTE's methodology consists of accepting occasional adjustments to the output of certain sites in order to avoid the construction or reinforcement of new grid infrastructure that would be rarely used except during very occasional peaks. This methodology is based on finding the economic optimum between (i) the use of occasional production curtailments, in particular by assessing their economic and environmental impact, and (ii) the development or reinforcement of grid infrastructure. According to RTE's latest estimate, **the use of optimal sizing has made it possible, without additional investment, to offer 18 GW of grid capacity between 2021 and 2024, representing approximately €1.8 billion in investment savings over this period** (for a curtailment cost of approximately €15 million/year). In practice, this is made possible by curtailing renewable energy generation, but the use of other sources of flexibility is preferable, as provided for in the future European Grid Code on Demand Response (NCDR), currently in the comitology phase.

For its part, with the Reflex project, Enedis has been experimenting from 2020 to 2024 with taking flexibility into account (overlapping between consumption and generation and between sectors, curtailment, local flexibility) to optimise grid size in order to accept more renewable generation at a constant level of investment. Over the 10 substations involved in the experiment, **Reflex generated savings of €5.8 million in 2023 and 2024. Enedis has since begun rolling out Reflex more widely, with an initial wave of implementation starting in 2025 and the aim of deploying it across 100 transformers by the 1st of January 2028.** This roll-out trajectory is subject to incentive-based regulation.

CRE Takeaway no. 8

RTE's optimal sizing strategy has already made it possible to free up 18 GW of additional capacity on the grid without any work. Enedis' Reflex project is yielding excellent results and is expected to reach 100 transformers in 2028 (vs. 10 in 2024).

Curtailment should not be the only lever for flexibility. Enedis and RTE will need to quickly implement solutions that enable the mobilisation of storage and demand flexibility as an alternative to modulating renewable energy production when it is economically relevant.

Focus on low-voltage renewable energy generation management

System operators must be able to rely on the modulation of all renewable energy production, regardless of whether the installations are connected to low, medium, or high voltage. Sites that can be controlled and curtailed are equipped with an Operating Information Exchange System [*DEIE - Dispositif d'Echange d'Information d'Exploitation*], which automates the transmission of information concerning the operating status of the installation. **While most sites connected to medium and high voltage grids are now equipped with this solution, this is not the case for installations connected to low voltage grids, even though technical solutions exist.**

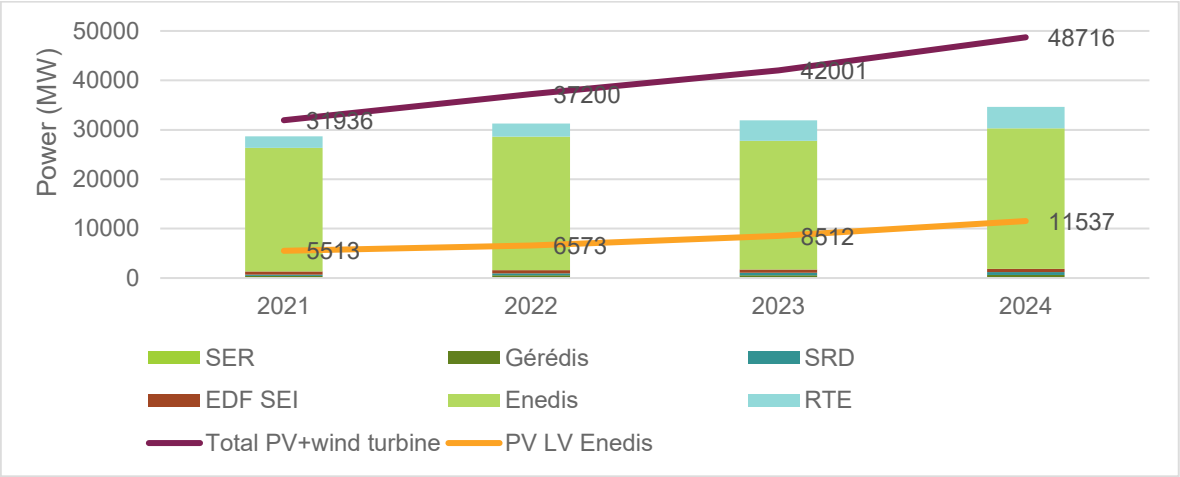

Figure 4 Total maximum power of curtailed renewable energy sites

However, the growth of LV PV (from 5.5 GW in 2021 to 11.5 GW in 2024) is now leading Enedis and RTE to face situations where, **locally, the share of controllable renewable energy production (MV/HV) is insufficient to resolve congestion issues** arising from optimal sizing or linked to the early connection of LV producers, **thus creating risks for system operation**.

Although CRE had requested this as early as 2022, Enedis and RTE did not sufficiently anticipate the issue of LV PV control. However, system operators have been responsive in managing the constraints observed in certain areas since the summer of 2025, which has now led to the implementation of remedial solutions (launch of a call for tenders to manage constraints, retrofitting of voluntary LV producers with devices enabling their limitation in return for compensation). The cost of these solutions is then financed by TURPE and Enedis.

It should be noted that SRD is already able to control LV installations with a power above 36 kVA and includes this technical requirement for these producers when they wish to benefit from an early connection (see section 4.2).

CRE Takeaway no. 9

The reference technical documentation for distribution system operators must include, by default, the possibility of requiring the installation of a technical device to limit the power injected into the grid for low-voltage producers. Exemptions for very small installations or those connecting in areas without constraints must be considered.

5.4. Grid observability, a necessity for dynamic control

Energy transmission and distribution system operators collect data on the structures that make up these grids: substations, public distribution stations, transformers, pylons, cables, metering devices and other measuring equipment, sensors, etc. The modernisation of equipment now makes it possible to manage them in the most precise and automated way possible.

To carry out their tasks of operating and developing electricity grids, system operators use geographic information systems. Fed by numerous sensors measuring energy flows at grid facilities and infrastructure, these tools enable operators to build a detailed description of the grids they operate, potentially down to the level of individual pieces of equipment. This data is of considerable importance to system operators, as it enables them to improve the observability of the electricity system and thus improve its operation, maintenance, and development.

As already observed in 2022, system operators have access in near real time (i.e. in less than 30 minutes) to metering data from sites or transit points in source substations and medium and high voltage lines. Near real-time data reporting is developing in LV with the widespread deployment of smart meters, but **the main challenge remains the integration of these massive new data flows into system operators' information systems in order to be able to exploit them**.

In addition to data collection and reporting, the challenge for system operators is to be able to control assets remotely in order to facilitate grid management. In the case of MV-LV substations, system operators can install a remote-controlled operating device (OMT) to make them remotely operable. The decision to install such a device is based on a local technical and economic assessment that takes into account factors such as the probability of incidents, the number of customers affected, and the investment and maintenance costs of the device. The figure below shows the proportion of remotely operable HV-LV substations on the various distribution grids:

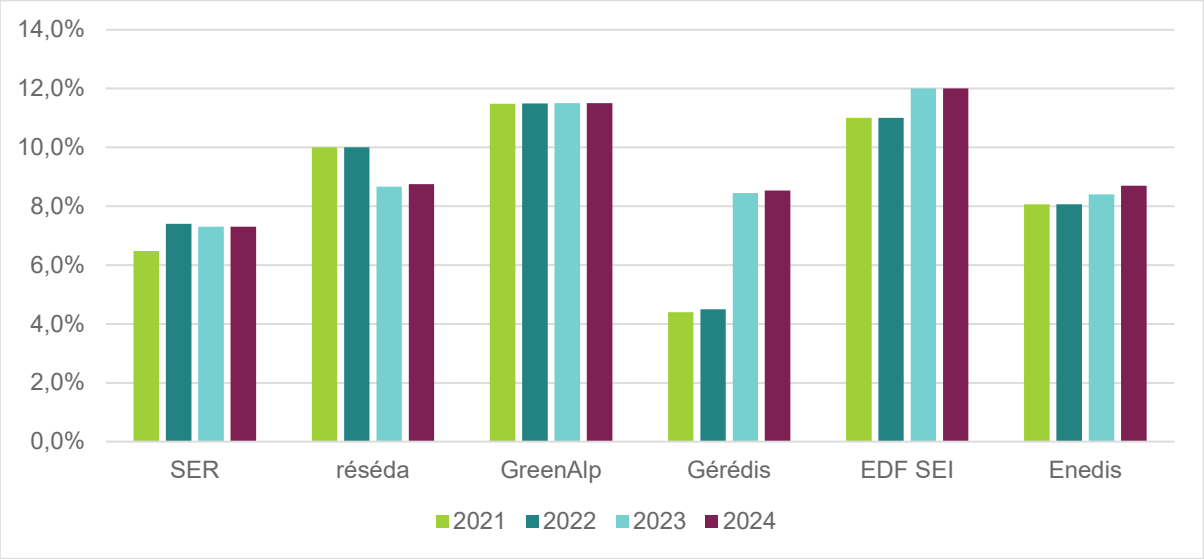

Figure 5 Percentage of MV-LV stations that can be operated remotely

5.5. Tools that need to be adapted to ensure an optimised grid management

Data collection is necessary but not sufficient to operate the grid as close as possible to its capacity and thus limit costs for users. The management of renewable energies and the widespread use of new sources of flexibility for grids needs require the **adaptation of management tools capable of handling the ever-increasing flow of incoming data and integrating new operating levers.**

Enedis is developing an IT solution (**DERMS**, distributed energy resources management system). This grid management optimisation tool is designed to assist regional control agencies (ACRs) in **managing constraints on the RPD, help remove constraints on the RPT, and identify relevant levers to remedy them** (including flexibilities). This tool is essential for the effective management of the Enedis grid and with the prospect of the mainstream use of flexibility.

- Enedis plans to develop this tool in two stages: an initial roll-out in all ACRs in the first half of 2027, followed by developments taking into account improvements to existing functions and additional functions, both identified and future.
- Enedis had already developed the **STC** (Remote Control Simulator), an R&D tool that was deployed around five years ago in ACRs for basic driving assistance functions (e.g. load transfer management, load flow calculation). The tool was subsequently enhanced with more advanced features for identifying and processing grid constraints in injection and withdrawal. The STC is therefore a prototype for testing the functions that Enedis needs to manage the electricity system operating at its limits. The feedback gained from the STC led Enedis to capitalise on numerous technical and functional elements to begin developing the DERMS.

Historically operated by RTE, flexibility solutions will be used by both RTE and distribution system operators. Close coordination and cooperation between system operators is essential for the relevant and effective development and use of these flexibilities. This requires adapting not only tools (such as the DERMS) but also processes. **Enedis** and **RTE** are therefore working together on the **NIO** (New Operational Interface) project, which aims to modernise and renovate all grid management processes between RTE and Enedis, from the three-year advance planning to real time, with the aim of coordinating the management of constraints, the use of levers on the RPD and acting to balance supply and demand

in coordination with grid constraints. Proceedings began in 2025 and the new processes will be rolled out gradually between 2027 and 2029.

CRE Takeaway no. 10

Work on coordinating RTE and Enedis must continue and intensify in order to ensure joint, relevant and effective management of flexibilities.

In addition, the following new projects can be mentioned:

- The **SOLMATE** (Material SOlutions to Accelerate the Energy Transition) [*SOLutions Matériel pour Accélérer la Transition Energétique*] project launched in mid-2022 by Enedis, which aims to install equipment on the MV grid to balance the high voltages generated in certain areas by abundant renewable production on the RPD. These devices, which are currently being tested or qualified, are part of the more general 'Voltage Plan' project launched by Enedis in 2024 to, among other things, maximise the integration of renewable energies into the RPD.
- Enedis' **RAPTOR** tool, which uses artificial intelligence methods to identify the high-voltage lines that need to be replaced as a priority, deployed and used in regions since 2024.
- Enedis' **CARTOLINE BT** (LV) tool, which uses data collected by Linky meters and artificial intelligence software to detect potential faults, deal with them and thus preventively secure the power supply to customers. This decision-making tool, which has received positive feedback in the field, has led Enedis to develop a similar tool for high-voltage power lines, CARTOLINE HTA (MV), which is now deployed in 25 regional divisions to pre-locate potential incidents on the overhead medium-voltage grid.
- Other Linky big data processing tools can identify meters with a high probability of failure in order to target meter replacement operations, avoiding unnecessary interventions when poor communication with a meter is not related to a malfunction.
- The **DORA** tool ("*Diagnostic d'ouvrage des réseaux aériens*" or Overhead Grid Diagnostics), deployed on the Enedis and EDF SEI grids, uses artificial intelligence to detect anomalies in the overhead medium-voltage grid based on photographs.
- The **AGATH** tool, which enables Enedis to receive real-time information via optical fibre on the status of transformers and secondary equipment at its HV/MV substations in order to determine maintenance requirements.
- Regarding other local distribution companies (ELDs), one example is the testing of new MV fault detectors that use partial discharge measurement and enable technical teams to respond more quickly to faults on the SRD grid.

The increase in the volume and type of data available to system operators gives them the opportunity to apply artificial intelligence and big data tools and methods to optimise grid development and operation. These tools are particularly useful for carrying out maintenance and identifying faults in grid equipment in a predictive manner However, there are still relatively few sufficiently mature applications. This can be explained in particular by the need for high-quality, accessible data, i.e. data that can be extracted from information systems, processed and formatted so that it can be used to train artificial intelligence models. It is also necessary to ensure that the technical infrastructure of system operators' information systems is suitable.

6. Data at the heart of new user services

6.1. Advanced meters: 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 smart meters was subsequently reinforced by Directive 2009/72/EC of 13 July 2009, since replaced by Directive (EU) 2019/944 of 5 June 2019, which regulates, in particular, the implementation of smart metering systems for electricity 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, is still ongoing today, but accelerated in 2023 and 2024 with several ELDs already reaching a roll-out rate of 70% (see Figure 7). CRE has made a positive assessment of this massive rollout phase and considers the Linky project to be an industrial success for our country[31]. The graphs below show the deployment rates of advanced smart meters by distribution system operator in 2021 and 2024.

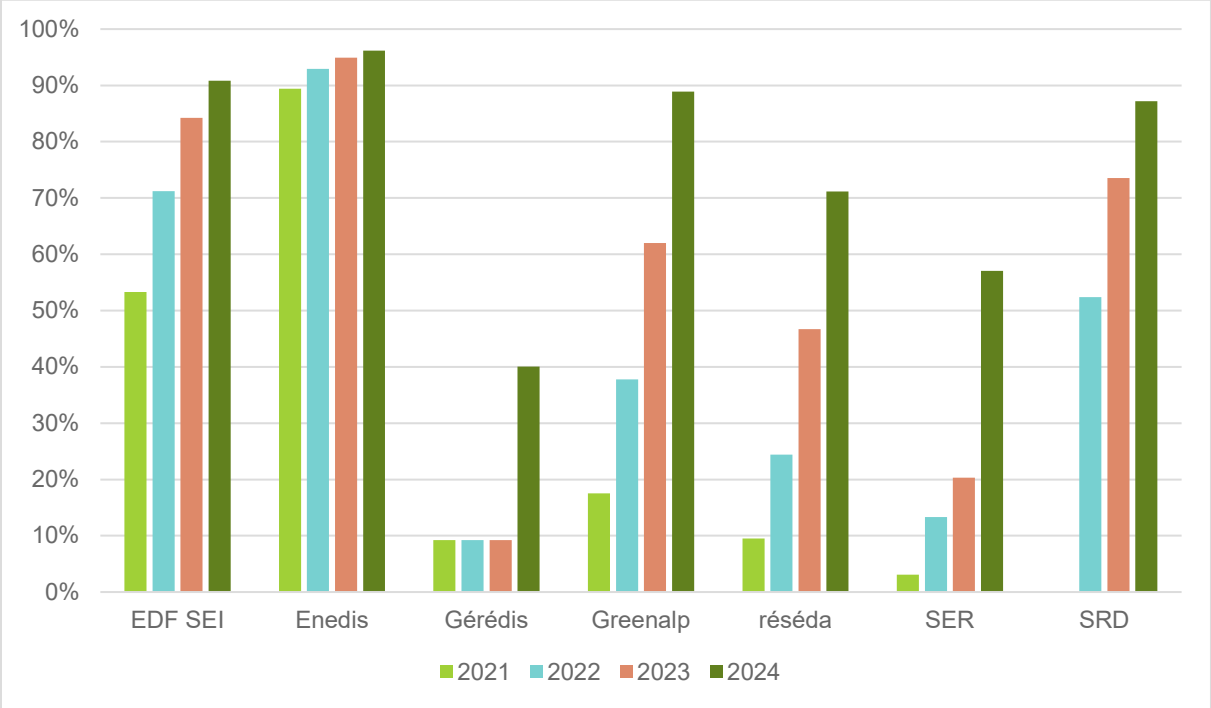

Figure 6 Deployment rate of smart meters with daily report

One of the objectives of deploying advanced metering systems is to enable the gathering of metering data and make it available, quickly and automatically, to the relevant parties (transporters, suppliers, consumers, etc.), as well as to enable remote operations by distribution system operators (these operations are made possible by the bidirectional nature of the meters).

Performing these operations remotely, which previously required an agent to travel to the site, **has generated significant savings (€1.7 billion over the period 2017-2024)**, contributing to the financial balance of the advanced meters rollout.

Advanced meters allow consumers and authorised third parties to access their load curves free of charge. CRE notes that a growing number of users are requesting this service and that this trend is accelerating. Third parties authorised to access consumption data report a high level of satisfaction with the services provided by advanced metering. Indeed, this has enabled the development of new commercial activities that provide services to users, including consumption optimisation, device control and automation, consumption monitoring for multi-site customers, self-consumption and flexibility services, as well as energy audits. **The amount of low-voltage delivery points (PDL) for which load**

[31] CRE Deliberation No. 2022-82 of 17 March 2022 on the incentive-based regulatory framework for Enedis' advanced metering system in the LV ≤ 36 kVA (Linky) voltage range for the period 2022-2024

curve reporting is enabled is increasing among all distribution system operators (except GreenAlp, where the service is not yet available) and now exceeds 30%.

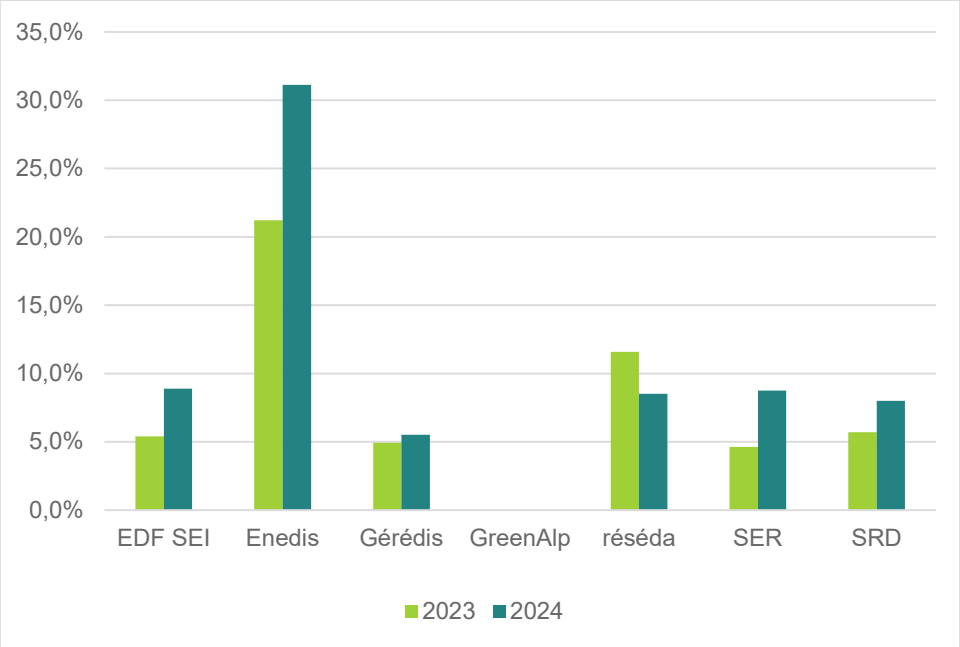

Figure 7 PDL rate for LV< 36 kVA (segment C5) with enabled load curve reporting

Tableau 2 PDL rate for LV< 36 kVA (segment C5) with enabled load curve reporting

	EDF SEI	Enedis[32]	Gérédis	GreenAlp	réséda	SER	SRD
2023	57 074	7 000 000	1 923	Service not yet available	10 019	9 872	6 000
2024	103 986	11 277 503	3 412		11 348	29 655	10 000

The availability rate of load curves at D+1 at 9am for points subscribing to this service is currently monitored by all distribution system operators offering the gathering and provision service. It varied between 84.0% and 99.7% in 2023 and between 88.3% and 99.7% in 2024.

Moreover, alongside the availability of this data, **its quality** is also an important factor to monitor. Load curves play an essential role in the provision of certain tariff offers and flexibility services, as they serve as the basis for flow reconstruction and even billing. **CRE has introduced a new incentive indicator in TURPE 7 MV-LV on the 'Comprehensiveness of load curves' measured on D+3 for Enedis.**

To fully exploit the potential of advanced meters, distribution system operators need to upgrade their information systems (IS) to collect and process the new data measured and share it with them. With the rollout of these meters, the amount of data to be exchanged and processed has exploded, and past IT systems have had to be updated or replaced.

Initially designed to collect load curves from 20% of PDLs, Enedis recently had to begin upgrading the associated IS to increase this to 50%, even though 30% of consumers have already activated daily reporting of their load curves.

Similarly, in order to take full advantage of the metering capabilities of advanced meters, Enedis has had to upgrade its IS, with the final stage being the commissioning of the Target System for flow recovery in October 2024, providing greater accuracy and better real-time visibility for billing. For example, this

[32] The data for Enedis are respectively dated from June 30, 2023, and June 17, 2025.

system allows for better energy allocation to balance managers [*Responsables d'équilibre* – REs] by moving from monthly to daily accuracy. It also makes it possible to provide new, more comprehensive and faster data services to REs.

Focus on the impact of smart meters on the retail market

By the end of 2024, around 15 million residential consumers (i.e. 47%[33]) had signed up for an offer exposing them to flexibility tariff signals. Most of them, i.e. 12.9 million households (40%[34]), have signed up for the 'peak/off-peak' option, which means that the price of electricity is reduced during certain periods of the day, at night or during midday hours, in order to encourage consumption during less tense periods. In recent years, thanks in particular to the introduction of smart meters, suppliers have been able to develop supply offers with up to 10 time indices, creating so-called 'personalised' supplier schedules. These offers provide more precise time-based differentiation: cheaper electricity on weekends, peak and off-peak hours differentiated between summer and winter, reduced prices during the summer midday hours, etc. According to Enedis, as of the 31st of December 2024, nearly 2.2 million residential sites had subscribed to a supply offer that sends a more precise signal than the 'peak/off-peak' option.

CRE supports the development of this type of offers, which make it possible to combine lower bills with contributing to the proper functioning of the electricity system and capitalises on the widespread deployment of smart meters. Since the end of 2023, CRE has undertaken several initiatives to develop flexibility:

- Optimising the allocation of peak and off-peak hours in the TURPE 7 MV-LV tariff, given that the development of solar capacity makes consumption during certain hours of the year particularly favourable for the electricity system (mainly midday hours from April to October);
- Methodological changes in the construction of TRVEs [*Tarifs Réglementés de Vente d'Électricité* – Regulated Electricity Sales Prices] aimed at maintaining the attractiveness of the HPHC [*Heures Pleines/Heures Creuses* – peak/off-peak] option compared to the Base option[35];
- Changes to the TRVE to further mobilise the flexibility of residential consumers, in particular the removal of the TRVE Base option for consumers subscribing to power ratings above 18 kVA, and the phasing out of this same tariff for consumers subscribing to more than 9 kVA;
- The implementation of an experiment on the TRVE Base option aimed at determining and mobilising the ability of these consumers to adapt their electricity consumption in response to tariff signals.

CRE clarified these analyses in its report on the functioning of the French retail electricity and natural gas markets in 2023 and 2024[36].

Finally, thanks to advanced meters, suppliers are able to offer supply deals that allow consumers to choose their contracted power in 1 kVA increments, compared to 3 kVA previously. This development, combined with the analysis of consumption history (made possible in particular by access to the load curves mentioned above), enables consumers to tailor their supply to their needs and make savings. However, very few suppliers currently offer their existing supply options with a choice of contracted power in increments of 1 kVA[37].

CRE Takeaway no. 11
The widespread deployment of smart meters has made it possible to:

[33] Calculated based on Enedis' scope, only taking into account sites equipped with a Linky meter (95% of residential sites will be equipped with these by August 2024).

[34] ibid

[35] CRE Public Consultation No. 2024-10 of 10 July 2024 on changes to the method for setting regulated electricity sales tariffs

[36] CRE Report No. 2025-08 of 16 October 2025 on the functioning of the French retail electricity and natural gas markets in 2023 and 2024

[37] https://www.quechoisir.org/actualite-facture-d-electricite-pourquoi-c-est-le-moment-de-verifier-que-vous-avez-souscrit-a-la-bonne-puissance-n168776/

- **Firstly, generate significant savings (€1.7 billion over the period 2017-2024), thanks in particular to the implementation of remote operations, which previously required to send an agent on location;**
- **Access to new services such as load curves, now activated for more than 11 million delivery points;**
- **The development of personalised supplier schedules with up to 10 time indices, enabling innovative supply offers to be made;**
- **The possibility for consumers to choose their contracted power in 1 kVA increments, compared to 3 kVA previously, allowing them to tailor their offer to their needs and make savings.**

6.2. Open data: an increasingly attractive offer

System operators generate a large amount of energy data that is of interest to many stakeholders, including local authorities, the Government, domestic and professional consumers, energy producers, suppliers and balance managers, service providers, etc. Of all the sectors of the energy industry, energy data valuation is one of the most dynamic and has experienced strong growth in recent years. It relies in particular on the efforts made by public services and system operators to make anonymised or aggregated data available as open data.

Nowadays, **there are several open data platforms dedicated to energy in France. Some are specific to a system operator, while others are the result of a joint initiative between several partners.** This is particularly the case for the ORE Agency (Energy System Operators), which brings together some 127 energy distributors and, through its open data, provides multi-stakeholder data sets in harmonised formats covering both gas and electricity. The ORE Agency has worked to standardise and centralise access to data from distribution grids by launching a project to share open data and creating a joint access portal for the open data platforms specific to distribution system operators. Similarly, the Open Data *Réseaux Énergies* (ODRÉ – Open Data Energy Grids) platform also offers multi-energy, multi-operator and multi-system data. It is the result of collaboration between GRTgaz, RTE and Teréga, which joined forces within '*Réseaux d'Énergies*' to create it. They have since been joined by AFGNV (now *France Mobilité Biogaz*), Weathernews France, Elengy, Storengy and Dunkerque LNG. All French system operators therefore contribute to these two open data platforms. At the same time, some system operators have their own platforms, notably Enedis, RTE, EDF SEI and SRD.

The increase in traffic to the main open data platforms observed at the end of 2022 was confirmed in 2023 and 2024 (see figure below), **with average monthly traffic to open data sites rising from 10,000 monthly visitors in 2021 to 38,500 in 2024.**

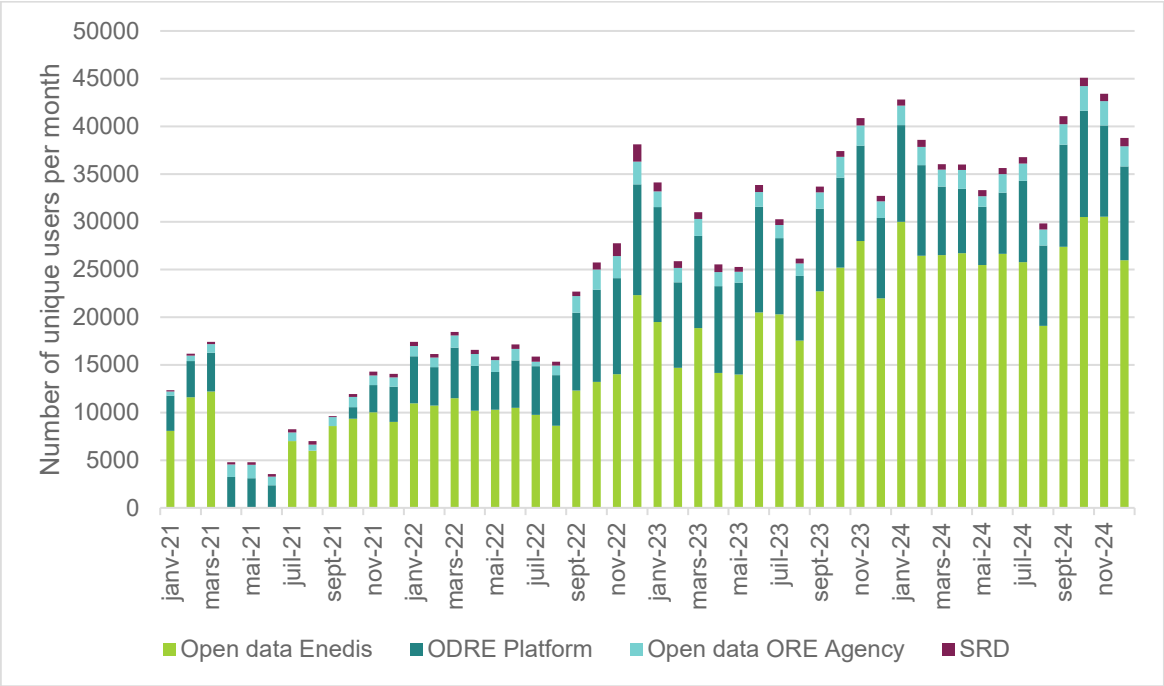

Figure 8 Monthly open data traffic

The range of accessible data is now substantial, but it can still be improved through access to new data sets (e.g. access to source station load curves, for which CRE has provided financial incentives to Enedis in TURPE 7 MV-LV) or by improving the reliability of published data (e.g. by redesigning Caparéseau, see section 4.5, or improving the comprehensiveness of load curves, see section 6.1).

CRE Takeaway no. 12

CRE welcomes the range and diversity of data made available by system operators, particularly through the ORE Agency and ODRE: several hundred datasets covering a wide range of topics such as grid mapping, grid capacity, production and storage, consumption, and the deployment of Electric Vehicle Charging Infrastructures.

The increase in average monthly traffic to open data platforms from 10,000 visitors per month in 2021 to 38,500 in 2024 illustrates the importance and success of these platforms developed by French system operators.

7. List of recommendations

Flexible connections with permanent limitations are still marginal but growing for renewable energies

- In order not to hinder the development of these offers, CRE renews its request to the public authorities to loosen the framework (especially by removing the 30% cap of installed capacity) designed in the decree of July 12, 2021.
- Distribution system operators who have not yet included these offers in their Reference Technical Documentation [*DTR-Documentation technique de référence*] must do so as soon as possible.

Customised flexible connection solutions for storage facilities are developing but can still be improved

- RTE's publication of available capacities with or without limitations on Cartostock is an important step forward. However, these capacities were very quickly requested, highlighting two issues:
    - the need to find new capacities to offer with a template format, i.e. a standardised format for optimised connection offers incorporating limitations;

- the need for rigorous enforcement of the recently approved queue management rules to ensure that only projects demonstrating progress remain in the queue, and if this is not sufficient, to move them forward.

Consumers do not have access to innovative connection offers

- Connection offers for consumers need to be improved: offers with permanent limitations must at least be provided for electric vehicle charging infrastructures. CRE asks distribution system operators to include these offers in their reference technical documentation. The case of motorway service areas, where complementary uses (heavy and light vehicles) lead to diverse charging needs (during the week vs. during weekends and holidays), is an excellent illustration of this.
- Such offers for other consumers, particularly industrial users, can also be relevant. Given the cost and time savings that these solutions can bring, CRE recommends that manufacturers who wish to do so express their interest in such offers to system operators, especially in saturated areas.

CRE considers that reliable open data tools are necessary to support connections

- CRE welcomes the provision by system operators of several tools for visualising available capacity and encourages them to ensure the quality of the data presented.
- In particular, pending the essential overhaul of the Caparéseau tool, RTE must offer a temporary alternative since grid users need enough visibility to develop their projects in the meantime.

New sources of flexibility continue to develop, supported by CRE

- System operators must continue to adapt the access rules for the various markets in order to facilitate the development and participation of new capacities.

Modulation of renewable energy production remains a pillar of grid management for optimal sizing

- Curtailment should not be the only flexibility tool. Enedis and RTE will need to quickly implement solutions that enable the mobilisation of storage and demand flexibility as an alternative to modulating renewable energy production when it is economically relevant.

Control of low-voltage production is becoming a local necessity

- The reference technical documentation for distribution system operators must include, by default, the possibility of requiring the installation of a technical device enabling the limitation of the power injected into the grid by low-voltage producers. Exemptions for very small facilities or those connected in areas without constraints will need to be considered.

Grid observability remains a requirement for dynamic management

- Work on coordination between RTE and Enedis must continue and intensify in order to ensure joint, relevant and effective management of flexibilities.

Table of figures