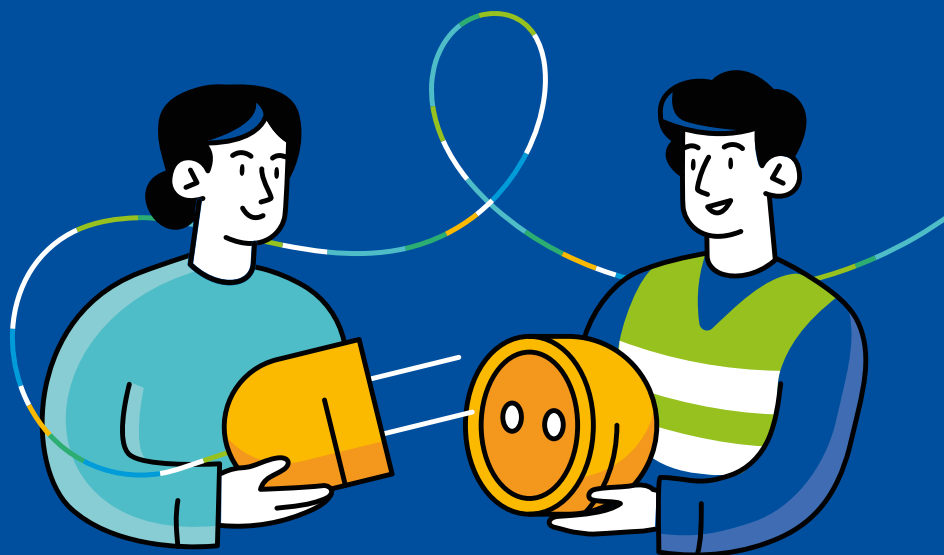




Enedis R&D and Innovation Programme

ENEDIS



REGULATORY PROVISIONS

The French Energy Regulatory Commission (CRE) has implemented an initiative aimed at providing Enedis with the means to carry out the R&D and Innovation projects necessary to design the electricity networks of tomorrow, while guaranteeing that there are no tariff-related obstacles. Enedis' operating expenses for R&D, included in the tariff for use of the network over the 2021/2024 period are €57 million per year on average. Moreover, every two years, a report aimed at giving electricity sector stakeholders greater visibility on the projects led by Enedis is published.

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Enedis, a leading distribution system operator in innovation

Enedis operates the public electricity distribution grid across 95% of mainland continental France. The grid belongs to the concession-granting authorities (local districts or groups of local administrative districts) which entrust Enedis with managing the grid through a public service delegation.

Enedis is therefore responsible for two major public service tasks:

- **Access to the grid without discrimination.**
- **Modernisation, development and operation of the grid.**

Since its creation in 2008, Enedis has been one of the four main European electricity system distribution operators, with 37.5 million customers and responsibility for the management of a large asset base: 2,300 primary substations, 1.4 million kilometres of power lines and 790,000 secondary substations.

The public electricity distribution grid is now at the crossroads of a large number of transitions worldwide: energy, environmental, digital, economic and societal.

All these transitions affect our business activities and the way we work.

We are moving from a centralised electrical system with controllable generation, which is matched to consumption, to a partially decentralised electrical system with intermittent, non-controllable means of generation, often located close to consumers.

Local logics are developing to match consumption as much as possible to generation, with the emergence of flexibilities, self-consumption and storage. Some autonomy logics will emerge, but this decentralisation will largely be based on the electricity grid, which truly becomes the backbone of the ecological transition that is underway.



At the same time, the deployment of 35.5 million smart meters and the digital transformation have brought to light a new role for Enedis as a data manager and opened up new prospects for major improvements in our industrial performance and the development of new services.

Finally, societal expectations lead us towards a public service that is closer to the regions, more ecological, more local and more inclusive.

In this context, innovation is clearly not optional.

Enedis relies on its R&D and its ability to innovate to carry out its tasks in an ever more efficient manner by inventing the grid of tomorrow, which will be smarter, more digital, more interactive, more inclusive, at the service of customers, electricity market players, and regions.

Enedis' R&D and Innovation Programme

Enedis has built an ambitious research programme, which benefits from the expertise of the men and women in the company, acquired over time and across all regions. It comprises a range of projects addressing the major electricity distribution challenges, carried out within the company, using its own resources - with the involvement of more than a hundred employees - promoting participatory innovation, but also with the support of recognised research laboratories, innovative companies, start-ups or in collaboration with European partners.



To implement this programme, the Energy Regulatory Commission has approved funding of €57 million per year over the period 2021/2024.

To ensure that our research and innovation priorities correspond to the expectations of players in the electrical energy sector, a public consultation was held at the beginning of the tariff period.

Enedis' R&D and innovation programme is structured around two key ambitions:

- Develop and operate a physical and digital network to support industrial performance.
- Transform the management of the grid to support the acceleration of the ecological transition.

These two objectives are on the one hand about building a long-term vision, anticipating technological or societal changes, identifying new services that are desired and, on the other hand, they concern designing meaningful industrial solutions within a controlled time frame.

Value creation and the ability to operationally use the products and services that have been designed are constant points of attention.

Mainly composed of applied research activities, experimental development and supplemented by an "Open Innovation" framework to build collaborations with promising start-ups, the R&D and innovation programme is enhanced by experiments carried out in demonstrators.

R&D and innovation activities are carried out with numerous partners:

- About fifteen universities and research laboratories, including EDF R&D, Grenoble INP, CEA-Liten, Laboratory L2EP, Mines ParisTech, École Polytechnique, École Normale Supérieure, CentraleSupélec, Datastorm-GENES, Paris Dauphine.
- 40 innovative start-ups and SMEs.
- Many industrial players, particularly in the context of smart grid collaborative projects (demonstrators, European projects).

Each project presented in the rest of the report is characterised by indicators that specify the outcome of the work, its nature and its state of progress

Indicator for the outcome of the work:



Industrial performance



Safety, resilience and security



Ecological transition



Services to customers



Employees

Indicator relating to the nature of the research (TRL - Technology Readiness Level):



Exploratory R&D



Modelling and concept validation



Demonstration



Pre-industrialisation

Indicator for the progress of R&D actions:

Scoping

In progress

Finalisation

Completed

1 “Develop and operate a physical and digital network to support industrial performance”

Enedis has committed to having one of the best quality-price ratios in Europe by 2025 and to restoring power to 90% of its customers within 48 hours in case of a major climatic event on the grid.

To meet these commitments, we design and develop innovative solutions to provide high-performance components, to manage our assets as effectively as possible, to observe, control and operate our MV and LV systems, to forecast the electricity balance and assess losses, and to ensure the resilience of the grids in the face of climate change and the growing interdependence between the electrical and the IT systems.

Our customers expect Enedis to provide high-performance service and improved communication, particularly regarding connections, maintenance or incidents. But our customers also expect new services, in particular in relation with the digital revolution, the ecological transition and the associated new uses for electricity.

The ecological transition and the digital revolution are changing the way we work and changes in society are affecting expectations not only externally, but also within the company: we set ourselves the objective of strengthening confidence and putting initiative and responsibility of our employees at the centre of our organisational methods. We will combine contributions from social science and IT to prepare for change, improve performance and safety and support transformation.

3 challenges structure the R&D and Innovation programme for Industrial Performance:

- Improve operational performance
- Better meet customer needs and develop new services
- Support the evolution of our business and transform our management practices

1.1 Improve operational performance

Using drones for operational performance



TRL
8-9

The drone has many qualities that make it play an increasing role in the maintenance of electrical infrastructure: lightness and compactness make it easy to move and quick to deploy; it enables to quickly get close to infrastructure located far from access roads. Furthermore, the quality of image capture is now acceptable. The photos taken by these devices now make it feasible to assess the condition of an equipment item. By combining them with analysis tools based on Artificial Intelligence, diagnostics can now be established automatically in a large number of cases. The drone is a new industrial tool in the range of maintenance support solutions at Enedis.

Today, new uses for the drone are emerging: initiatives are under way to use drones to install bird warning systems or anti-icing devices to prevent the formation of ice sleeves on overhead lines.

Scoping In progress **Finalisation** Completed

New solutions without SF₆ for grid switchgear



TRL
8-9

Sulphur hexafluoride, commonly referred to by its chemical formula “SF₆”, has been used in medium and high voltage equipment for more than 40 years. Its electrical characteristics, still unsurpassed, have led to improvements in equipment size, reliability, performance and maintenance. Due to its particularly high global warming potential, the aim is now to limit its use. Without waiting for the reinforcement of the regulatory constraints, Enedis has initiated, in partnership with several manufacturers, the development of alternative solutions that do not use fluorinated gas. Therefore as of July 2021, the first solutions of medium voltage vacuum circuit breakers for primary substations have been industrialised. All new Enedis primary substations are now equipped exclusively with this generation of circuit breakers. Continuing this approach, a development contract was signed in 2022 with two suppliers for the supply of medium-voltage switches for distribution secondary substations.

Scoping In progress **Finalisation** Completed



Anticipate the impacts of climate change on grids



TRL
1-3

The overhead and underground electrical distribution network is naturally exposed to climate hazards. These are not new and are fully taken into account by Enedis for development and operation of the grid.

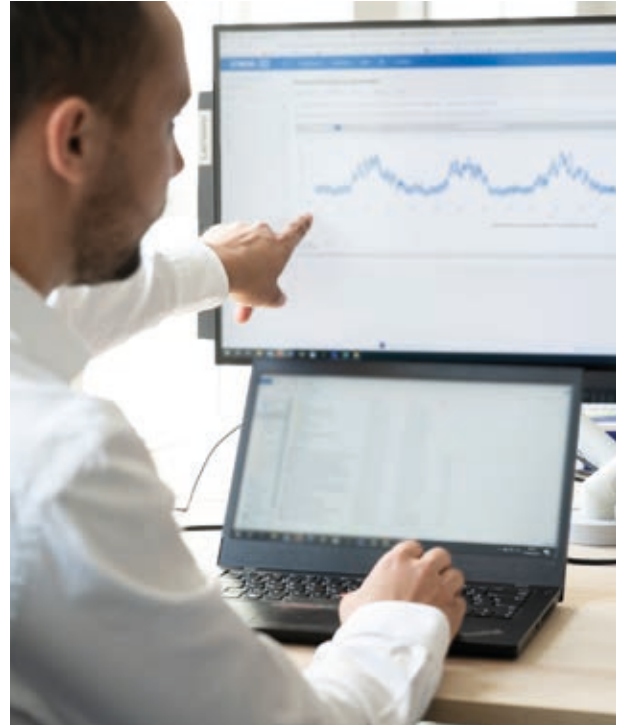
However, the consequences of climate change on the distribution and intensity of climate hazards raise questions about future risk levels, and possible differences from those considered when the grid was designed. With the help of the Ecole Polytechnique’s dynamic meteorology laboratory, using the latest models and with the finest geographical mesh, Enedis has characterised the impact of global warming of about 3°C on wind intensity and direction, the frequency of sticky snow events and floods. In this way the robustness of the grid’s design was assessed. These studies will be updated periodically, to take into account new information on climate change and its modelling as it becomes available.

Scoping

In progress

Finalisation

Completed



Reduce non-technical losses by using data from smart meters



TRL
8-9

Linky (the Enedis smart meter) data can be used to develop new approaches for detecting non-technical losses. For example, it is possible to cross-reference consumption data and Linky meter alarms such as opening of terminal covers, voltage values, power consumption and power generation. This Big Data approach means that cases where the existence of non-technical losses are suspected can be identified, which will guide the field teams in charge of addressing them in an effective way.

The approach can be applied to non-technical losses of any kind. Particular efforts are being made to deal with fraud, given that this is increasing. The aim is to avoid placing the cost burden on all users of the grid.

Scoping

In progress

Finalisation

Completed



1.2 Better meet customer needs and develop new services

Reduce grid connection time



TRL
8-9

Connection to the grid is at the heart of Enedis' public service mission. The commitment to "cut connection leadtimes by a factor of 2 by the end of 2022" by the company's Industrial & Human Project has accelerated the transformation of our connection services and reduced delays significantly. To achieve this, innovation is a powerful lever for providing new ways of doing to our customers and employees.

Among the achievements, the REVE system, which uses video conferencing to assess the electrical work to be carried out following a request to modify the connection. A quote can then be generated in a few hours. Another example, to facilitate commissioning of new connections for private individuals and business, is the new "ready to use remote operation" service, which, as soon as the connection is completed, prepares for remote commissioning. Finally, digitisation of the web portal devoted to connections for individuals and



business means we can now offer the customer a full-digital pathway, providing online services: quote for a simple connection, signature, payment and schedule.

Scoping In progress **Finalisation** Completed

1.3 Support the evolution of our businesses and transform our management practices

More efficient customer interventions thanks to AI



TRL
8-9

A certain number of customer requests for work to be done on-site, sent by energy suppliers, end up with an Enedis technician being sent out in vain: the request may be poorly qualified, too vague, or may be subject to an additional technical issue. This generates a financial and environmental cost for Enedis as well as customer dissatisfaction.

To identify work requests that have a high risk of unsuccessful intervention and to prevent it beforehand, AI language recognition models adapted to Enedis' technical vocabulary have been trained on thousands of job requests.

Using this approach, tested in several Regional Divisions for some types of services, 15,000 unsuccessful or unnecessary trips have already been avoided in just under a year. Given the success achieved, the scope is likely to be extended.

Scoping In progress **Finalisation** Completed

2

“Transform the management of the grid to support the acceleration of the ecological transition”

The energy transition is accelerating: by 2030, 50 GW of additional renewable energy (RES) are expected to be connected to our grids, as well as 7 million charging points supplying 5 million electric vehicles, 6 GW of flexibilities, 8 GW of self-consumption, etc. The Hydrogen sector is receiving massive public support, energy communities are growing and coupling between energy vectors is set to increase.

These transformations will be largely based on the electricity distribution grid, which is the backbone of the ecological transition. To facilitate the massive integration of renewable energy and electrification of end-uses while guaranteeing the quality of supply at the lowest cost, we must in particular prepare for the use of new flexibilities and storage, adapt the network development approaches and develop new operating tools in order to fulfill our new role regarding local grids.

Listening to the regions expectations, we will continue to develop solutions matched to everyone’s expectations and challenges. We will develop the 21st century public service, with improved considerations in terms of social and environmental responsibility: moving from the energy transition to the ecological transition means adopting a new economic and social model that renews our ways of consuming, working and living together.

Enedis will also contribute, for its own activities, to reducing their impact on the environment, preserving biodiversity and developing the circular economy.

While the transport sector accounts for 31% of greenhouse gas emissions, its rapid and massive electrification is a priority for decarbonisation. Transition to cleaner and more sustainable mobility is already well underway and forging ahead. Enedis is actively contributing by preparing innovative solutions to facilitate the development of electric mobility.

With 35.5 million Linky meters, 1.5 million remote operations every month, 770,000 concentrators, 150,000 connected objects on the grid, 72 Open Data datasets, Artificial Intelligence solutions implemented every day in numerous industrial processes, the use of digital twins, Enedis has initiated the digital transformation of its business.

But this transformation has only just begun. The collection, transmission, storage and processing of data and making it secure have become central tasks and skills for the company and we must anticipate future changes, increasing the resilience of our information systems which are at the heart of a now cyber-physical system, and facilitating exchanges with external players. We must make full use of the solutions offered by advances in artificial intelligence, while preserving the place of the human being in a digital world.

6 challenges structure the R&D and Innovation programme for the ecological transition:

- Integrate large quantity of RES
- Integrate energy storage and develop flexibilities
- Electrify end-uses
- Enable new local optimisations
- Consume less and better
- End-to-end digitisation

2.1 Integrate large quantity of RES

Grid hosting capacity mapping to support the energy transition



TRL
8-9

To facilitate development of renewable energies and electric mobility, Enedis has designed a solution that enables stakeholders in the regions (planners, local authorities) to have a dynamic overview of the hosting capacity of the public electricity distribution grid. This map of the grid's hosting capacity enables them to identify in advance areas that are conducive to the integration of their projects: charging stations for electric vehicles, generation facilities or any other connection. This map, depending on the type of project tested, identifies the available power of the grid on the medium and low voltage systems.

Available on the Enedis Business and Local Authority Portal, the map of grid hosting capacity is a simple and unique tool that provides an immediate way for planners to anticipate the implementation of projects supporting the energy transition in their region.

Scoping

In progress

Finalisation

Completed



Prepare innovative solutions for the integration of RES using DC



TRL
1-3

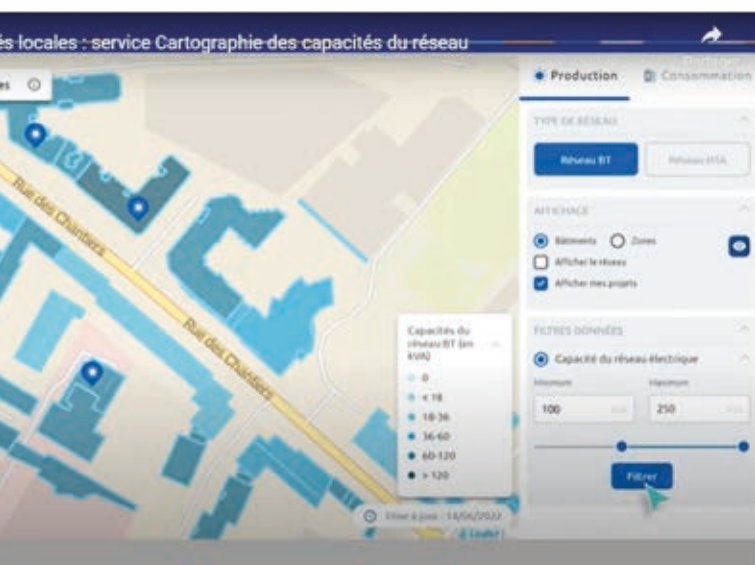
The development of renewable energy and new uses for electricity, that natively use direct current (DC), combined with advances in power electronics, are leading to a growing interest in DC. Its potential benefits, particularly in terms of improving the overall energy efficiency of the system, have to be weighed against the challenges generated by a technology whose use in distribution grids is relatively limited - except for MV DC point-to-point connections - and with a normative framework that is incomplete at this time. The challenges involved in integrating direct current into the public distribution grid are many fold: availability of robust, suitable and standardised equipment, operation, protection and maintenance, long-term impact of inserting DC architectures into an AC grid. In this context, Enedis has started work, particularly in the framework of academic partnerships, on the architecture of hybrid AC/DC distribution grids and on issues of electricity quality, metering and protection of low-voltage DC grids.

Scoping

In progress

Finalisation

Completed





5G to simplify implementation of production facilities remote protections



TRL 6-7

To prevent islanded operation phenomena in the event of a grid fault, some MV producers must be equipped with remote protection devices so that their generation facilities are decoupled without delay from the primary substation. Until now, only wired connections, which are quite expensive and time-consuming to install, could be used to perform this function.

Enedis, in collaboration with Nokia, Orange and Schneider Electric, is developing a 5G solution that will accelerate and simplify connection of these producers, preserve the security of the grid and reduce costs substantially. After validation in the laboratory, this solution is currently being tested in the field before being rolled out in 2024.

Scoping **In progress** Finalisation Completed

2.2 Integrate grid storage and develop flexibilities

European projet OneNet to simplify and optimise management of flexibilities

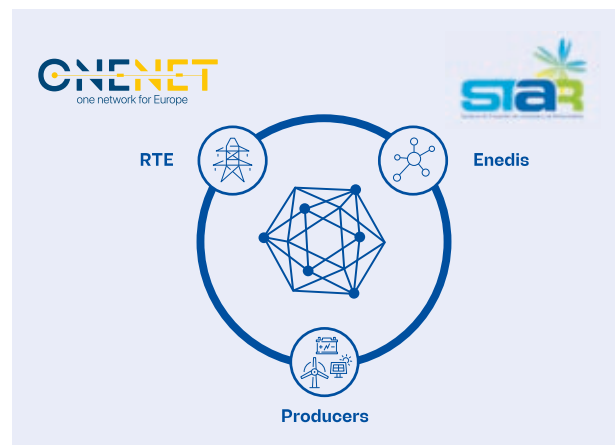


TRL 6-7

Enedis is participating in the OneNet project with the STAR demonstrator (Renewable Activation Traceability System). This demonstrator, carried out in partnership with the French TSO RTE, aims to simplify and optimise the management of flexible RES, from activation of generation limitation to compensation of producers, including control of achievement. The solution, based on Blockchain makes it possible to dematerialise, ensure the traceability and automate the activation process in the case of generation curtailment. In particular, the project entails including in Enedis’

information systems a process for proactively proposing a compensation solution when generation is restricted.

Scoping **In progress** Finalisation Completed



Increasing the hosting capacity of primary substations through flexibilities



TRL
6-7

Through the Reflex project, Enedis is experimenting with a new design rule on 10 primary substations (located in Picardie and in the Landes regions) enabling the connection of generation facilities with a total power exceeding the rated capacity of the transformers. The hosting capacity has thus been increased by more than 200 MW. Equipment safety and operation of the grid remains within limits at all times, by implementing flexibilities or injection curtailment orders whenever a risk of congestion is anticipated. A cost-benefit analysis demonstrated the collective value of this approach, with a net gain of €250 million by 2035. Implementation of this approach is planned in relation with the federation of energy producers, the local authorities (AODE), the TSO (RTE), the energy regulatory authority (CRE) and the ministry in charge of energy.

Scoping In progress Finalisation Completed



New approaches to facilitate development of grid flexibility

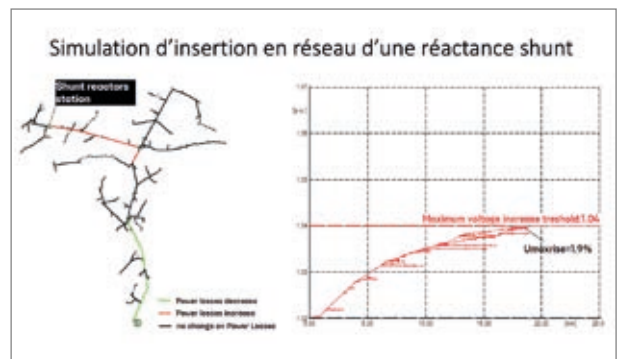


TRL
8-9

In 2023, after identifying sources of flexibility by using a digital twin of the grid, Enedis launched its fourth call for tenders for local flexibility services (flexibilities for managing congestion in the grid) with the same aims: move towards simplification

of the purchase process, standardise the services requested and take into account feedback from stakeholders and the energy regulatory authority. Among the new features, Enedis now allows sites in the process of being connected to participate, including those interested in connections with power modulation. In terms of processes, more time is given to stakeholders to recruit sites that can contribute to the flexibility service. Enedis is also continuing the work so that as many players as possible can participate. Therefore, for future calls for tenders with capacity reservation, players will have the possibility to offer bids with a capacity provision as low as 100 kW.

Scoping In progress Finalisation Completed



Integrate Energy Storage



TRL
6-7

Enedis is working on optimising integration of storage facilities on the grid, for different use cases. An experiment studying temporary MV isolated operation using local resources already connected and storage is underway in the French Department of Nord. The aim is to ensure the power supply a portion of a MV network following an incident by using a 1 MW battery, a biogas producer and 4 LV PV producers. The technical challenges involved the design and implementation of an Energy Management System to ensure restart after an incident ("black start"), management of the resources allocated to meet a local supply/demand balance, and development of a protection scheme suited to this configuration. After the design work, operational commissioning is planned for mid 2023.

Scoping In progress Finalisation Completed

2.3 Electrify end-uses

Anticipate the charging needs of heavy mobility and its impacts on the distribution grid



TRL
4-5

To support the development of long-distance heavy electric mobility and meet the electrical demand associated with fast charging infrastructure on motorways, Enedis, Total Energies and Vinci are conducting a joint study to anticipate the needs for grid adaptation. In addition, at a more general level, Enedis and RTE are continuing impact studies on heavy electric mobility to prepare for the networks reinforcement that will be necessary. Enedis is also modelling recharging requirements (fast and slow) for local and regional heavy electric mobility, particularly in logistics depots.

Finally, Enedis is working with manufacturers on the technologies of the future that could impact the grid: dynamic wireless charging in urban areas or on motorways, very high power charging stations, power to boats at the dock,...

Scoping In progress Finalisation Completed

Assess the impact of charging on wave quality



TRL
6-7

Guaranteeing our customers an electricity supply that meets quality standards is part of Enedis' missions. New end-uses with power electronics and electric vehicles may degrade the quality of the wave. Conversely, some harmonic or high frequency interference can affect the quality of the charging service. Measurements have therefore been taken to characterise the behaviour of a large number of models of electric vehicles and to ensure in particular that the massive deployment of electric mobility will not lead to a deterioration in the quality of the voltage wave delivered to customers.



The tests include emission measurements in the harmonic and supra-harmonic bands and immunity tests under different supply conditions (normal or degraded, smart charging situations,...).

Scoping In progress Finalisation Completed

Encourage smart charging of electric vehicles



TRL
6-7

Control of charging electric vehicles may create value, for the end user, for the grid and the electrical system as a whole. Smart charging facilitates the integration of charging infrastructure into the grid and limits the need for investment (grid, peak generation means, etc.).

Through the aVEnir demonstrator supported by ADEME, Enedis has tested smart charging solutions with the ecosystem players and is experimenting with the flexibilities provided by electric vehicles. Enedis is studying how the DSO can transmit instructions to charging systems to reduce power or postpone charging. This could be useful in the event of an electrical system crisis, to respond to specific and local constraints on the grid, or to facilitate synchronisation between photovoltaic generation and charging of electric vehicles.

Scoping In progress Finalisation Completed

Developing Zero Emission Generators



TRL
6-7

Essential tools for quality of service to customers, mobile generators are installed by Enedis when they are the best alternative to ensure continuity of electrical power in the event of an incident or maintenance work. The company is now experimenting with several industrial partners

innovative solutions of zero-emission generator sets which are low carbon and also reduce local disturbances caused by conventional generators (noise, smell, etc.).

Several technologies are being tested, such as Li-Ion batteries and hydrogen fuel cells. The objective of the ongoing experimental phase is to enable Enedis to identify by the end of 2024 technologies suitable for gradual replacement of part of its mobile generators with solutions that are CO₂ free.

Scoping In progress Finalisation Completed



2.4 Enable new local optimisations

Anticipate the impact of hydrogen on the distribution grid



TRL
1-3

Significant efforts are being made at European level to develop hydrogen produced from carbon-free sources. That is why Enedis is studying, with the support of CEA Liten, the opportunities and impact of a future deployment of electrolyzers on the public power grid.

To assess potential needs for grid adaptation, load profile simulations for different anticipated

application cases are being carried out, such as provision of hydrogen for a bus depot, centralised generation of hydrogen for a group of manufacturers or a hydrogen filling station for a fleet of lorries. To identify the most realistic options for future deployment of these application cases, the key technical and economic parameters are considered.

We are clearly taking a predictive approach: the simulations cover the period 2025-2050. Lessons already learned include the importance of the price of electricity and its variability on optimal design of the facility.

Scoping In progress Finalisation Completed

Facilitate Energy Communities



TRL
4-5



To simplify the customer’s experience and the management of collective self-consumption, Enedis is experimenting with a service that enables the management of a collective self-consumption operation to be digitised, from declaration of the project to commissioning. Enedis is also studying setting up a service for energy suppliers and market players that enables individual self-consumers to synchronise their use with generation.

Finally, Enedis is partnering with the city of Dijon in the framework of the European collective self-consumption project “Response” (2020-2025). This project is part of the development of intelligent cities and communities. 53 European partners from 13 different countries are involved in the deployment of new technologies to bring positive energy places into existence.

Scoping In progress Finalisation Completed

2.5 Consume less and better

Reduce the environmental impact of grid equipment



TRL
6-7

The environmental impact of its activities is a constant concern to Enedis, which is fully in line with the objectives set by the European Union in terms of ecodesign of grid equipment. The aim is to reduce the environmental impact of equipment throughout its life cycle.

For distribution transformers, several sets of electrical losses requirements have successively been laid down. To meet the highest expectations, studies of new technical solutions have been initiated, involving the use of high-performance components operating at temperatures above conventionally allowed limits.

This ambitious final objective requires reconciling a transformer footprint compatible with the structures

of existing substations, the search for optimal energy efficiency and the ability to accept overloads that match the changes in electricity uses, without impacting the life duration of the transformer.

Scoping In progress Finalisation Completed

Supporting local authorities in energy efficiency



TRL
8-9

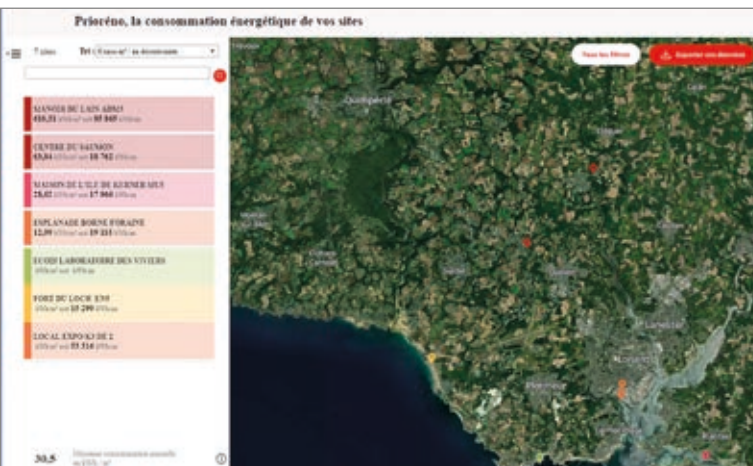
The energy renovation of buildings is an essential lever in achieving carbon neutrality by 2050. To help local authorities focus their investments on their most energy-intensive public buildings, Enedis is contributing to an accessible and practical solution: Prioréno.

Born of a collaboration between the French Government, the “Banque des Territoires”, Enedis

and GRDF (main French gas distribution network operator), with the common aim of supporting local authorities in their energy renovation projects, this online platform enables public decision-makers to obtain a global view of their real estate assets (property data, electricity and gas consumption, etc.), in the form of an interactive map.

With its algorithms, Prioréno is able to analyse the sum of available data and propose a list of the most energy-intensive buildings. In just a few minutes, communities can get an initial view of the energy performance improvement priorities.

Scoping In progress Finalisation **Completed**



Reduce energy consumption for public lighting with Linky



TRL
8-9

To help local authorities to reduce their energy consumption, Enedis is proposing “Mon éco-éclairage public”, a solution for automatically turning off public lighting within four different selectable time-slots.

This solution, enabled by the Linky smart meter and developed by Enedis, is implemented by the energy suppliers. Several municipalities have already successfully deployed the system. In Aurons, in the Bouches-du-Rhône region, “Mon éco-éclairage public” has enabled the city to reduce its street lighting energy consumption by 46%*. “Mon éco-éclairage public” also has a feature that allows the settings to be overridden, for example in the context of specific events.

* Supplier data on the scope concerned

Scoping In progress Finalisation **Completed**

2.6 End-to-end digitisation

Undertake a frugal AI approach



TRL
4-5

Artificial intelligence is being used to train a predictive model for a specific use-case and then to use this model to make choices in the intended context. But this first stage of training is very data-intensive, as well as taking a lot of computation time (and therefore being resource-intensive: energy, IT infrastructure, etc). Techniques have emerged from the image

recognition field to reuse pre-trained models: generic models trained on huge databases are used and then specialised for a specific use case with the corresponding data (e.g. recognition of a grid installation).

Enedis used this approach to create a “reusable” LinkyNet model. This model, pre-trained on Linky consumption data, can then be reused on new use cases (classification between secondary or main residence, filling in missing measurements, etc.) and requires much less resources for each new application.

Scoping **In progress** Finalisation Completed

Anonymise consumption data using AI



TRL
6-7

With the deployment of smart meters on the grid, the nature and volume of data that Enedis has on its customers’ consumption and production is substantial.

Enedis is developing technological solutions to provide data for the benefit of grid users, stakeholders in the electrical system and local authorities, guaranteeing confidentiality of customer data.

In particular, Enedis has developed Differential Privacy methods applied to time series to protect confidentiality of Linky load curves. These are, for example, needed by developers (design offices, local authorities, etc.) of collective self-supply projects to ensure the profitability of a project and to size the solar panels.

Scoping **In progress** Finalisation Completed

Prepare the substations of the future



TRL
4-5

Enedis is preparing a new step of digitisation of the instrumentation and control system for substation equipment and the associated Management System.

It will support the ecological transition by taking advantage of all opportunities for digitisation and by relying on international standards (standard IEC 61850) while ensuring the necessary cybersecurity.

This new phase concerns control systems of both primary and secondary substations, imagining new functions linked to massive incorporation of RES and development of new uses for electricity - electric mobility in particular. In 2022, end-to-end testing of EMIS, a new generation of remote-controlled actuating devices for secondary substations, enabled its deployment to start.

Scoping **In progress** Finalisation Completed

Data analysis to optimise the life of HV/MV transformers



TRL
8-9

The HV/MV transformers operated by Enedis in its primary substations, which may last more than 40 years, are key components of the distribution system. Monitoring the health of primary substation transformers and their accessories is an important issue.

Enedis has developed a system for monitoring physical and chemical parameters so that any discrepancies that could reduce transformers performance or even cause failures can be detected quickly. This system consists of a number of sensors installed on the transformer and a control unit that processes information using specific algorithms developed by Enedis and transmits the results to a remote server. For example, clogging of air coolers, loss of effectiveness of dryers or malfunction of the transformer tap changer are detected early. Enedis thus has a real industrial performance tool for optimising maintenance and implementing an optimal scheduled upgrade policy.

Today, a thousand monitoring systems have been installed and it is planned to equip the 4,500 primary substation transformers in the Enedis fleet within 5 years.

Scoping In progress **Finalisation** Completed










Experimenting with smart grid demonstrators

To extend research studies and projects, it is necessary to experiment with different smart grid solutions, in real situations, using a system approach. The aim of Enedis' smart grids demonstrator programme is to incorporate these results into a global vision of the grid of the future.

Demonstrators, a number of which are supported by ADEME (French Environment Agency), are distributed across France to test various local contexts.

Enedis is also involved in several projects co-financed by the European Union and in collaboration with national and international partners, players in the electricity and IT markets, equipment manufacturers, innovative start-ups, research organisations, universities, etc.

DEMONSTRATOR	PROGRAMME	SYNOPSIS
	H2020	Design of an IS architecture that allows the European electricity system to function as a single system in which a variety of markets operate
	H2020	Connection of renewable generation facilities to the grid, within the framework of energy communities, in Europe and India
	H2020	Development and testing of innovative solutions to contribute to the deployment of "positive energy neighbourhoods" in Europe by 2050
	H2020	Implementation of interoperable digital solutions to regulate the electrical consumption of buildings according to the needs of the electricity system
	ADEME	Experiments with smart charging use cases
	Horizon Europe	Improvement of charging infrastructure for electric vehicles to prepare for their mass deployment
	H2020	Development of innovative technologies needed to meet the expectations of users and communities for deployment of electric mobility

Academic partners to explore cutting-edge topics with the best experts

A dozen universities and research laboratories have been chosen for the excellence of their teams as part of a structured partnership policy.



Some examples:



Preferred Partnership - SmartGrid Chair

- Integration of renewable energy and network operation
- Big Data for electricity grids
- Training in SmartGrid skills



- Consumption forecasts



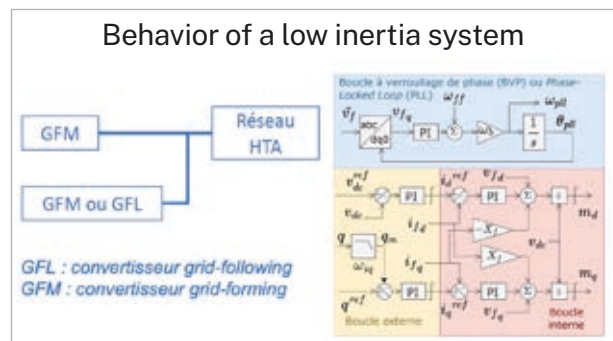
- Prospects for hydrogen-power networks interaction
- Local energy systems



- Electric mobility



- Statistics
- RES generation forecasts



- Economy and regulation



- Economics and sociology
- Public service and energy efficiency



- Management innovation



- Climate change and resilience

Open innovation at Enedis

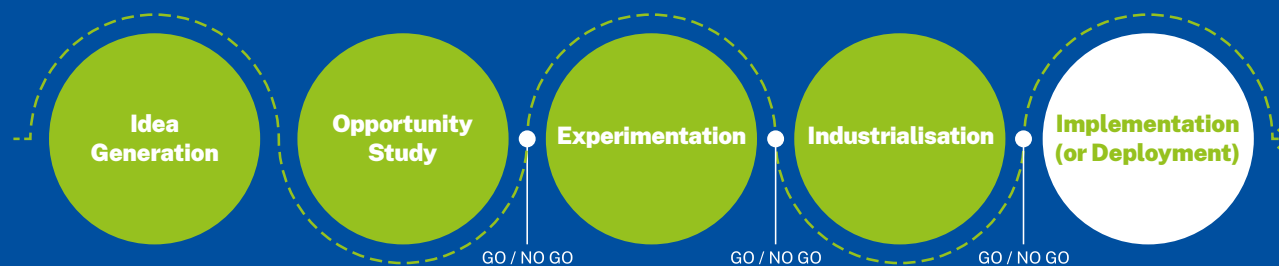


Enedis wants to accelerate the development of new solutions.

Therefore, in addition to its R&D and demonstrator programme, Enedis has been relying on innovative start-ups and SMEs for several years to identify and experiment with new solutions to improve the performance of our various distribution business lines, develop training or on-the job support tools, improve safety of work operations, customer relations, etc.

The responsiveness of our partners, their skills that complement those of the Enedis teams and the stimulation of collective intelligence are the strengths of this approach.

AN END TO END PROCESS



With the start up AMA, Enedis offers an innovative tool that simplifies the work of technicians and communication with customers

The REVE application simplifies and accelerates technical studies prior to performing the work requested by our customers (change from single phase to three phase, moving a metering switchboard, modifying or removing a connection, etc.): the Enedis technician can view remotely what the customer is filming with his phone.




This simple and ingenious application can also be used between Enedis technicians in the field and remote experts, or in the relationship with local authorities or our partners to gather information quickly and better understand a practical situation. By avoiding unnecessary travel, this solution also reduces CO₂ emissions.



Supporting decarbonisation of agricultural machinery with Naïo Technologies

Is it possible to conceive of recharging robotised electric agricultural machinery as close as possible to where it is used, in the open field? This is the challenge that Naïo Technology is trying to meet with Enedis and the support of other partners. To this end, Enedis will create the first distribution substation connected to the MV network to test charging of electric agricultural robots in the open field using direct current. « *The first communication tests between the machine and the Enedis equipment are very promising. By anticipating the arrival of a new technology that will contribute to the decarbonisation of an economic sector, we are right at the centre of our public service mission* » explains Patrick Morel, Deputy Director in charge of Ecological Transition, Innovation and Digital at Enedis Lorraine Regional Division.

Enedis is a public service company that manages the electricity distribution grid and employs 39,000 people. Serving 37 million customers, it develops, operates and upgrades 1.4 million kilometres of low- and medium-voltage (230 V and 20 kV) power lines, and manages the associated data. Enedis connects customers to the grid, provides a 24/7 repair service, reads meters, and carries out all necessary technical maintenance. Acting on behalf of local authorities and grid owners, it is independent of energy suppliers, who are responsible for electricity sales and supply contract management.

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