ICE INTELLIGENT COMMUNITY ENERGY

Interreg France (Channel Manche) England

EUROPEAN UNION

DELIVRABLE ICE L3.2.1

SMART ENERGY SYSTEM

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Smart Energy System

Syndicat départemental d'énergie et d'équipement du Finistère, Keynergie, Association des Iles du Ponant, Université de Plymouth, Université d'Exeter, Université d'East Anglia, Pôle Mer Bretagne Atlantique, Technopôle Brest Iroise

About ICE

Supported by the Interreg VA France (Channel) England program, the Intelligent Community Energy (ICE) project aims to design and apply innovative intelligent energy solutions for isolated areas of the Channel. Islands and peripheral territories face specific energy challenges. Many islands are not connected to European electricity grids and are dependent on imported fossil fuels, especially oil-fired thermal generators. The energy systems on which they depend tend to be less reliable, more expensive and emit more greenhouse gases than on the European continental grid.

In response to these issues, the ICE project considers the entire energy cycle, from production to consumption, and integrates mature or new technologies to develop innovative energy solutions. These solutions will be tested and tested at two pilot demonstration sites (Ushant Island and the University of East Anglia campus), to prove their feasibility and develop a general reproducible method for other isolated smart energy systems. elsewhere. To transfer this methodology to other isolated territories, ICE will offer a global low-carbon transition commercial offer. This will include a comprehensive assessment of local energy resources and conditions, a tailor-made model proposal for the energy transition, and a set of low-carbon skills and technologies available in a consortium of selected companies. This ICE-certified consortium will promote this offer to other isolated territories in and outside the Channel area (5 territories initially). The ICE partnership brings together researchers and support organizations for SMEs and benefits from France – UK complementarity in terms of knowledge and technological and commercial development.

The involvement of local and European SMEs will help to strengthen competitiveness and transnational cooperation.

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1. Introduction

This document presents the technical solutions for an intelligent energy system (smartgrid) selected for design and deployment on the island of Ouessant, as part of the European ICE project of the Interreg France-Channel-England program.

This document first presents the solutions adopted which break down into three technical axes: at the level of energy production, at the level of energy consumption, and finally at the level of the link between energy production and consumption. The principle of each solution is presented with the initial context before the implementation of the solution. The equipment used is presented and detailed.

The second part of this report presents the actors mobilized in the energy transition project of the island of Ouessant, and therefore those who participated in supporting smart energy systems actions within the framework of the ICE project. It also presents the interventions of two experts on the specific subject of an isolated territory in energy transition.

2. Selected technical solutions

In this section, we present the various technical solutions retained within the framework of the development of the smartgrid in Ouessant. These technologies are divided into three categories according to their positioning in the smartgrid and in their scope of action. The three categories are:

1) Technologies that play a role in the production of renewable energy and its incorporation into the grid.

2) Technologies that have a role in energy consumption, that is to say technologies that provide information on consumption levels in order to provide information so that they can then act.

3) Technologies that make the link between production and consumption. These are technologies which act on consumption by controlling consumption in an automated fashion, or which integrate the consumer via an information system with the aim of moving towards the concept of consumer actor.

2.1. Production side: an Energy Management System on Ushant

The production of renewable energy, based on photovoltaics and tidal turbines by nature intermittent, involves variability of several time scales, ranging from the minute (passing cloud, swell) to the day or even the month (inclination of the sun according to the season, cycle of the moon and the sun). Therefore, it is necessary to be able to finely control the injection of renewable energy into the network, according to variations in production but also according to energy demand.

To this end, EDF SEI installed a control system for the Ouessant microgrid, called Energy Management System (EMS) in English. This technical solution was developed by the Store & Forecast subsidiary of EDF, and installed in parallel with the start of the ICE project. This solution includes a set of technological bricks namely:

An industrial PC (redundant) which embeds control algorithms, and which contains an interface (information exchange and control) with:

o The various renewable producers and the thermal power station

o The lithium-ion battery-based storage system

o Future flexibilities

The different roles of the EMS are multiple and are:

o Continuously ensure the supply-demand balance in terms of electricity

o Ensure that system services are maintained at all times (in particular quality of supply and protection plan)

o Maximize the share of renewable energy (RE) in the energy mix

o Possibly be able to restrain / disconnect renewable energy producers in the event of overproduction of non-controllable renewable energy, and low demand (arbitration role between producers according to the date of connection request)

o Be able to evolve over time: adding new producers, new flexibilities, improving optimization (consumption and production forecasts)

EMS technology is therefore at the center of the island's energy production, and plays the role of conductor between the production of the thermal power plant, the renewable production, the storage, and the demand for energy on the network (Figure 1).

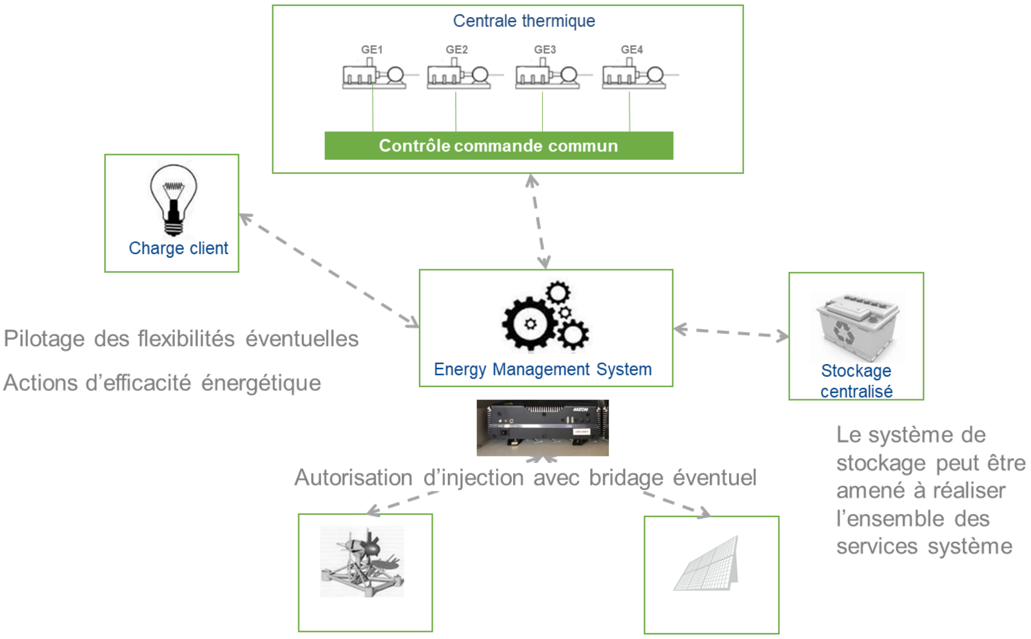


Figure 1 : EMS operating diagram within the Ouessant electrical system

The deployed electricity storage system is based on Lithium-Ion technology, and was first sized to develop a power of 1MW and store an energy of 500 kWh. This storage is sized in a network where the requested power ranges from 300-500 kW (off-season and summer) up to 1000-2000 kW (in winter). With an average daily consumption of 25MWh / d in Winter and 11MWh / d in September, the currently installed battery can store a maximum of 2 to 4.5% of the energy consumed daily in one charge. As the role of the battery is also to absorb variations in production and consumption, the amount of energy stored and released can be greater than 1 charge (500kWh).

Figure 2 : Photograph of the Ouessant electricity storage facility

All of these technical bricks, grouped together under the term EMS, therefore allow continuous management of electricity production and its distribution according to demand. This management is synthesized in the form of supervision (Figure 3) bringing together the means of production (power station, PV, tidal turbine), storage and demand with the quality of the electricity produced (voltage, frequency).

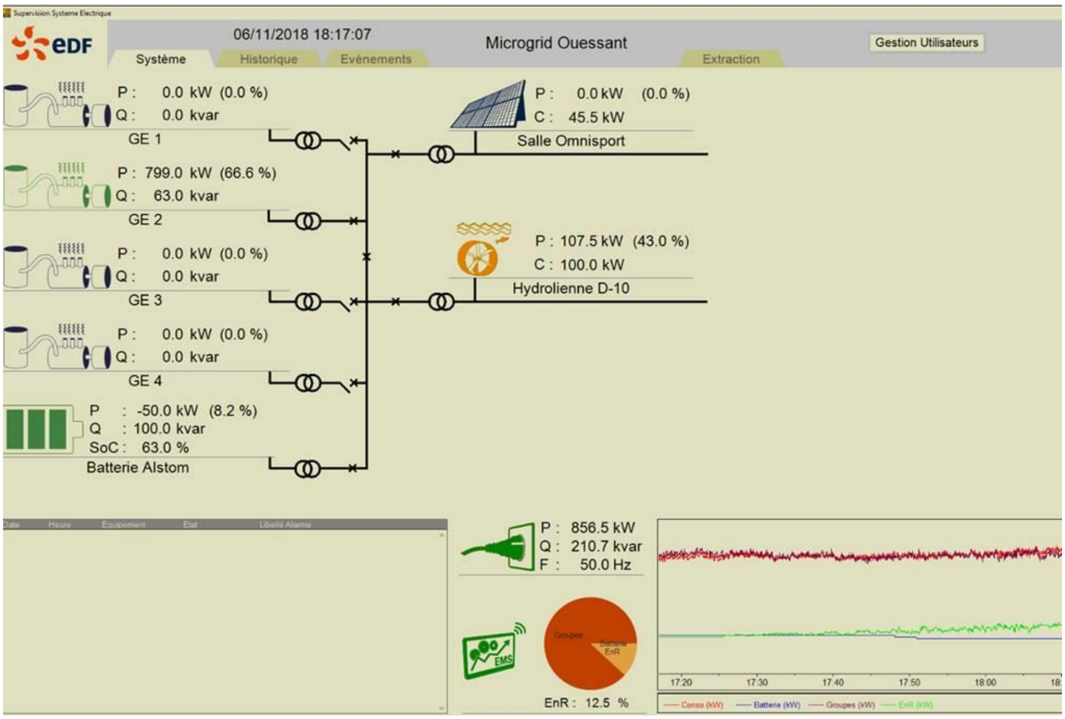


Figure 3 : Viewing the EMS control screen

This technological solution was deployed by EDF SEI. In France, the transmission of data relating to energy consumption is regulated and must comply with the criteria of the General Data Protection Regulation (RGPD) of the CNIL (Commission Nationale de l'Informatique et des Libertés). For example, in the case of electricity consumption data at an intraday time step, the size of the sample of consumers must be greater than 5,000 PdL (delivery points) for time periods greater than 1 day. In the case of Ouessant, the number of PdL is of the order of 1000, consequently, it is not possible for EDF to transmit to third parties (for example SDEF) the data of production and consumption in step of time 30min, for a full year.

2.2.Consumption Side : Intelligent sensors to collect more informations

In this part, we present the technical solutions implemented on the energy consumption side, namely the establishment of a communication system and sensors to collect information concerning public buildings and in particular concerning their electricity consumption

2.2.1. A Smartgrid for an isolated territory

Smartgrid infrastructures are, a priori, intended for territories with significant needs in terms of communications, analyzes, services which therefore require significant infrastructures and financial resources ... and therefore smartgrid technologies seem to be reserved for large cities and agglomerations.

However, the ambition of the Finistère Smart Connect project is to offer the isolated areas of Finistère these same communications, analysis and service actions for municipalities and areas of small size and / or little or poorly served by technical communication solutions. .

With the collection of information concerning energy consumption, and environmental measurements (temperature, occupancy, humidity, CO2), it will be possible to establish energy and occupancy balances of buildings, which will therefore make it possible to quantify potential energy savings and to put in place an action plan such as, for example, the rationalization of the operation of radiators, or the implementation of building renovation actions.

2.2.1.1. Scope of the experimentation

As part of this smartgrid experiment in Ouessant, a selection of several public buildings or buildings used by the public was selected, in order to deploy different sensors. This list includes the following buildings :

- Town hall
- Multipurpose room
- Terminal
- Youth hostel
- Public Library
- School cafeteria
- Public school
- Medical home
- “Elderly Club” (2 rooms for associations)
- Assisted living facility for elderly people

2.2.1.2. Selected solution

The technical solution chosen for smartgrid infrastructures comprises several technological building blocks:

- The Data Center (storage and processing of data), located in Brittany near Rennes.

- LoRa antennas, installed in Ouessant on 4 buildings.

- The sensors, installed in Ouessant in the buildings.

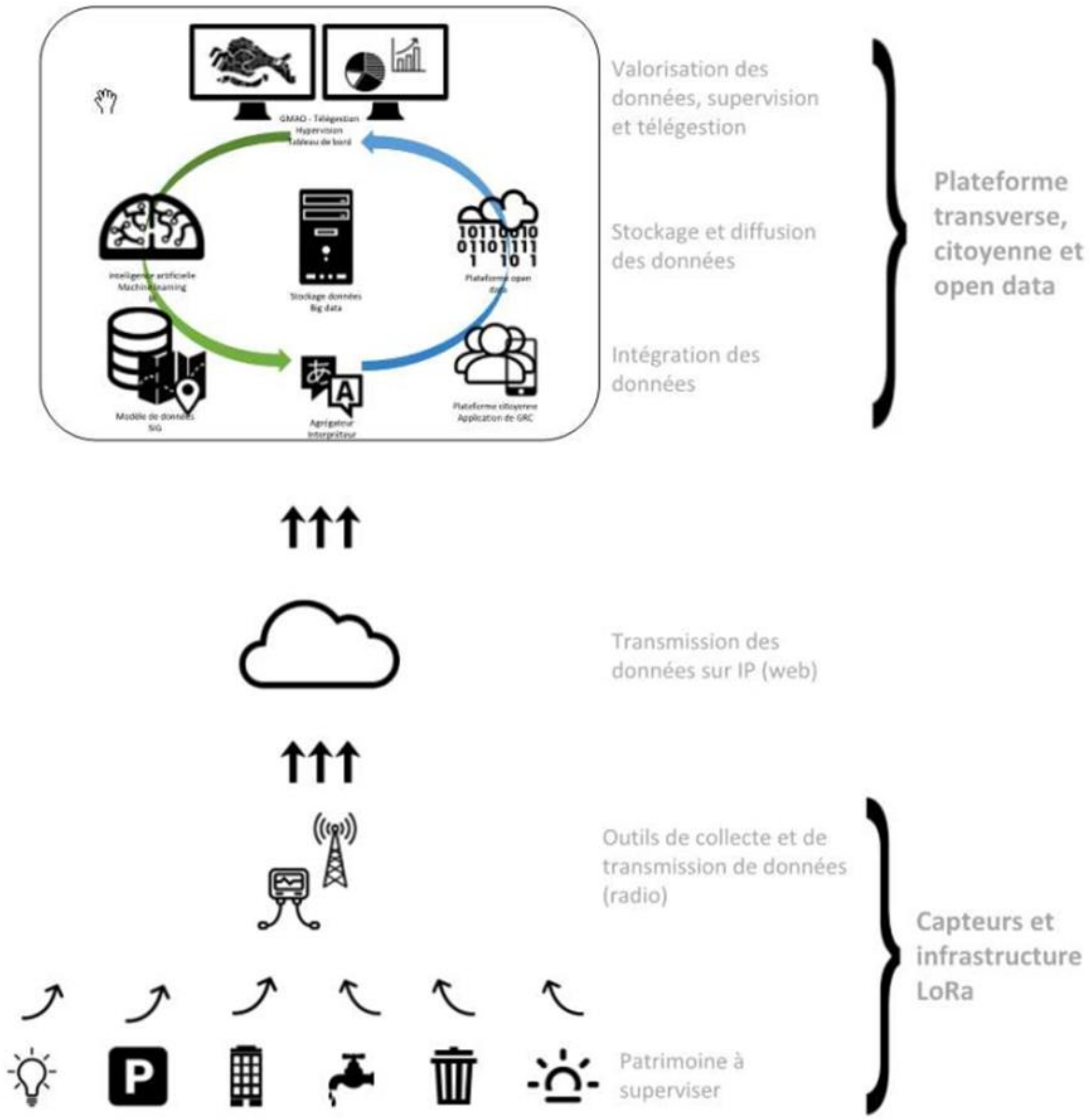


Figure 4 : Schematic architecture of smartgrid installations for Ouessant

2.2.1.2.1. Data Center

The data center consists of physical servers and network hardware used for interconnection and cyber security. It collects and stores information from the sensors, which has been transmitted by the antennas. It also contains all the data processing, formatting for dynamic display on online supervision. Certain data, processed and / or formatted, can be sent from the data center to specific connected objects: ex. the Boitaconso who receive the information of the color to display (cf 2.3.2 page 34).

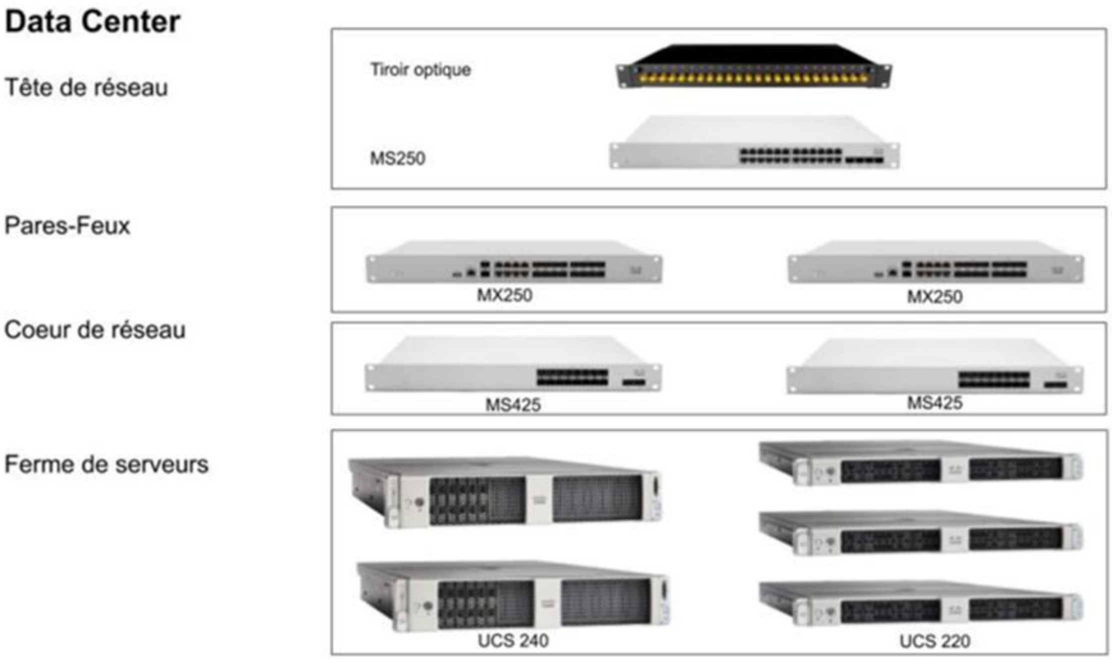


Figure 5 : Architecture schématisée du Data Center

2.2.1.2.2. Antennas

Antennas were installed on 4 high point buildings: water tower, gymnasium, town hall and semaphore of the Créac'h lighthouse. This deployment contributes to optimal coverage of the island of Ouessant by LoRa connectivity (figure below).

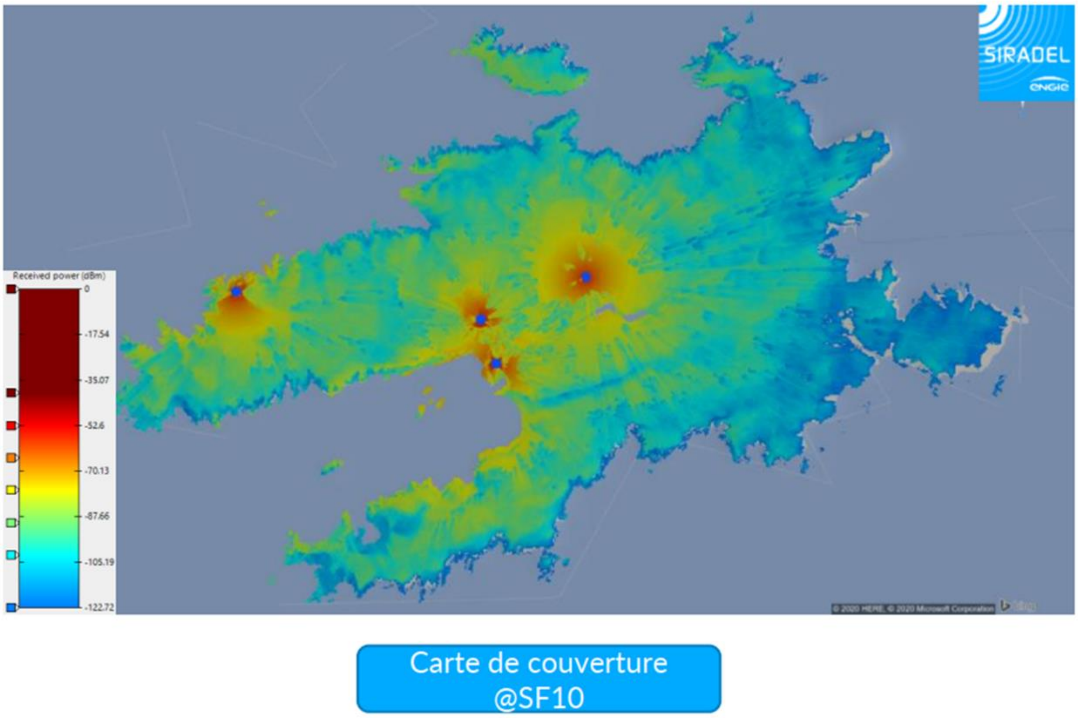


Figure 6 : Ouessant map with LoRa radio coverage with 4 antennas

The south-eastern part of the island appears to be a little less well covered, but there are no public buildings there and therefore the need for LoRa coverage for this area is less.

The antennas (also called gateway) are installed in an IP66 waterproof box measuring 357x189x150mm for a weight of 3kg including the fixing kit. The receiving antenna is attached to a metal support bolted to the antenna mounting frame. The assembly is powered by a 60W 48V POE (PowerOverEthernet) power supply via a category 6A STP (U / FTP) or SSTP (S / FTP) AWG26 Ethernet cable minimum. The antenna cable is protected by a surge arrester, as is the POE link from the injector to the antenna.

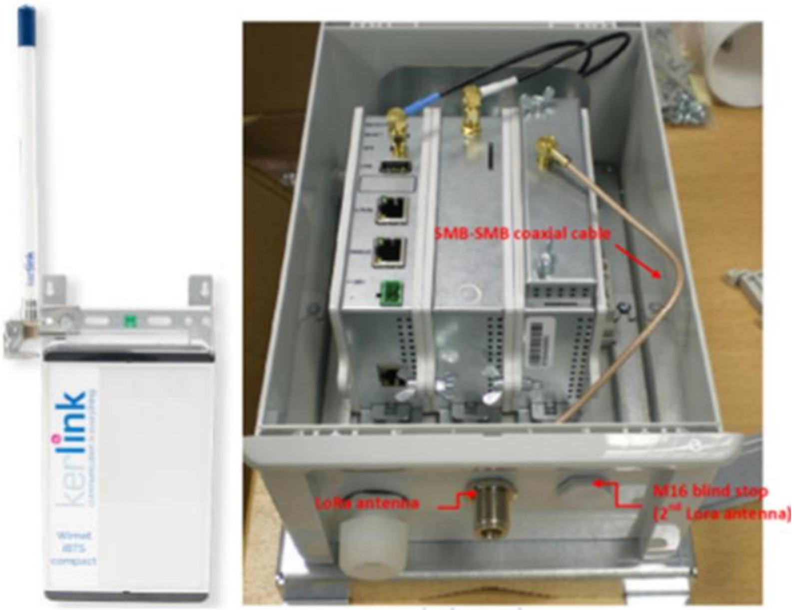


Figure 7 : Image of an antenna used for the LoRa network

The antennas collect, via LoRa radio wave, the data transmitted by the sensors. The antenna is connected either to a telephone connection (3G-4G) or to an internet connection, on an initially existing network. The data collected is then transmitted to the server by the existing communication infrastructure (telephony or internet).

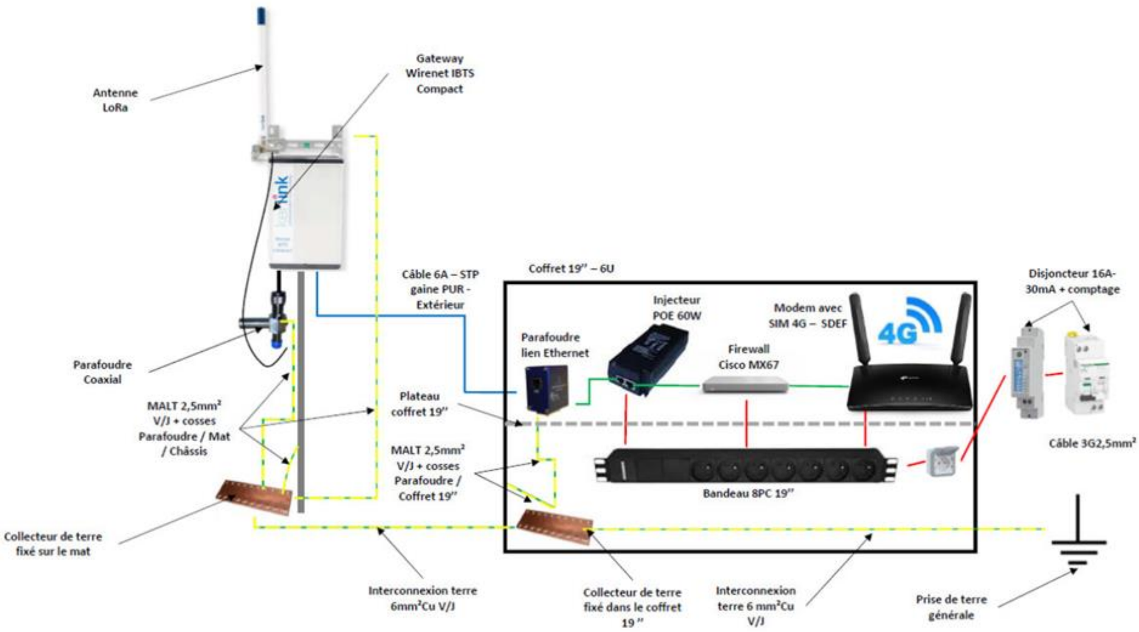


Figure 8 : Example of connection of a LoRa antenna to a 4G connection, for data transmission to the server

2.2.1.2.3. Sensors

The sensors installed in public buildings in Ouessant are grouped into two themes:

- Electricity: Sub-metering of specific consumption (eg heating, lighting, ventilation, etc.), reporting of Linky ICT data,

- Ambient data: Temperature, humidity, brightness, presence, and for some, measurement of CO2.

The sensors used were already existing and available on the market. We present in the table below the sensors set up as part of this project in Ouessant.

Name	Image	Description	Characteristics
Sensor Ambiance Ewattch		Temperature measurement, humidity level measurement, presence detection, and light level. There is also a model including a measurement of the CO2 rate, with a red LED on the front flashing when the measurement exceeds 1000 ppm.	Presence detection distance 5 meters / 130 ° angle Brightness measurement From 0 to 65535 Lux Temperature measurement From 5 ° C to 60 ° C Relative humidity measurement 0 to 100% CO2 measurement (for the model concerned) 0 to 5,000 ppm Communication Wireless LoRa® or LoRaWAN ™ sensor Food The LoRa® Ambiance sensor is powered by two 2700mAh lithium batteries (included - autonomy from 2 to 10 years, depending on the rate of feedback).

			An external 5VDC to 12VDC power supply is available as an option. Sensor dimensions 86 x 86 x 25.5 mm3 (H x W x D) Fixing methods The Ambiance sensor is installed by wall mounting. Double-sided tape attachment is available as an option.
Squid Lora Ewattch		The SQUID is a connected sensor which allows the sub-metering of electricity consumption. It is equipped with 12 current measuring clamps (toroid type). Each clamp allows current measurement in 1 cable, which implies that equipment with a three-phase power supply mobilizes 3 clamps for sub-metering.	Pliers 4 sizes of current clamps available: 10mm, 16mm, 24mm and 36mm. Running 600A effective max. by clamp. For larger current measurements, use a TyNess Rogowski. Accuracy class 5% maximum. Communication LoRa® or LoRaWAN ™ wireless. Congestion 5 standard modules (90mm). Food External connector 5VDC +/- 5%. Operating temperature 0 ° C to + 50 ° C Consumption

			3 watts maximum Dimensions 90 x 88 x 62 mm3 Fixing method DIN rail or wall mounting
TIC PME/PMI NKE Watteco		The TIC PME PMI sensor allows data transfer from PME-PMI meters to a remote server using the LoRaWAN communication protocol and transforms the meter into a connected object. Telemetry, energy management Real-time monitoring of electricity consumption at PME-PMI meters PME : Small-Medium Enterprise PMI : Small-Medium Industry TIC : Tele Information Client	Ease of deployment and use 1U DIN rail External RF antenna can be deported Power supply: 230VAC mains or 3.6V-24V continuous 6 distinct report configurations configurable from the remote server Data transmission "Demand / response" Periodic and / or on variation Decoding and analysis of the 74 fields of the PME-PMI ICT flow Class IP 20 Compression of digital data before transmission Extension to remote collection on Linky historical channel meter (50kHz input) or blue electronic meter

2.3. Interactions Consumption-Production

In this part, we present the technical solutions to link the production side with the consumption side, thus offering the first bases of what a smartgrid is. We present the solution for the automated control of electric heaters, then the solution for transmitting information to consumers, making them pronsumers.

2.3.1. Control and Monitoring of electric heaters in public buildings

One of the smart grid actions in Ouessant, linking production and consumption, consists of the deployment of a technical solution allowing automatic control of electric heating in public buildings. These buildings are occupied at a rate known in advance but can also have occasional uses.

2.3.1.1. Initial Context

The experiment focused on four public buildings on the island of Ouessant, namely the Town Hall, the canteen, the library, and the Alumni club (communal room with 2 rooms). These buildings, heated by electric radiators, represent a diverse panel of types of public buildings as well as their uses: occasionally or intensively.

Table 1 : Summary of the electrical consumption of the 4 buildings intended to be equipped for piloting, as well as the number of electric heaters in the buildings.

Buildings	Annual Electrical Consumption – kWh/y (2017)	Heaters Number	Regular occupancy days	Hours of occupancy
Townhall	25 988	16	M-Tu-W-Th-F	8:00 – 18:00
Canteen	6 865	3	M-Tu-Th-F	11:00-14:00
Elderly Club	18 565	6	M-Tu-Th-F	14:00-18:00
Library	4 610	2	M-Tu-W-Th-F	9:00-18:00

For each building, a preliminary analysis based on the consumption curve reading from the Linky smart meter was carried out by the Keynergie design office. This analysis includes the electrical consumption in 30min time steps of the buildings from January 1, 2019 to November 25, 2021. From this data, we can establish the reference consumption profile for each building, as well as specific data such as the temperature sensitivity of these buildings, or the average daily consumption.

We present below the consumption profile of each building over the reference period, as well as the calculated data..

Townhall

The City Hall's consumption profile clearly shows seasonality with a period of high consumption from November to March, and low consumption from April to September. This property is the consequence of cold temperature in winter in the northern hemisphere, and therefore represents the heating period by the use of electric heaters. We also note that consumption in winter is continuous, with some periods of greater consumption, in particular from 8 a.m. to 12 p.m., and more occasionally in the afternoon.

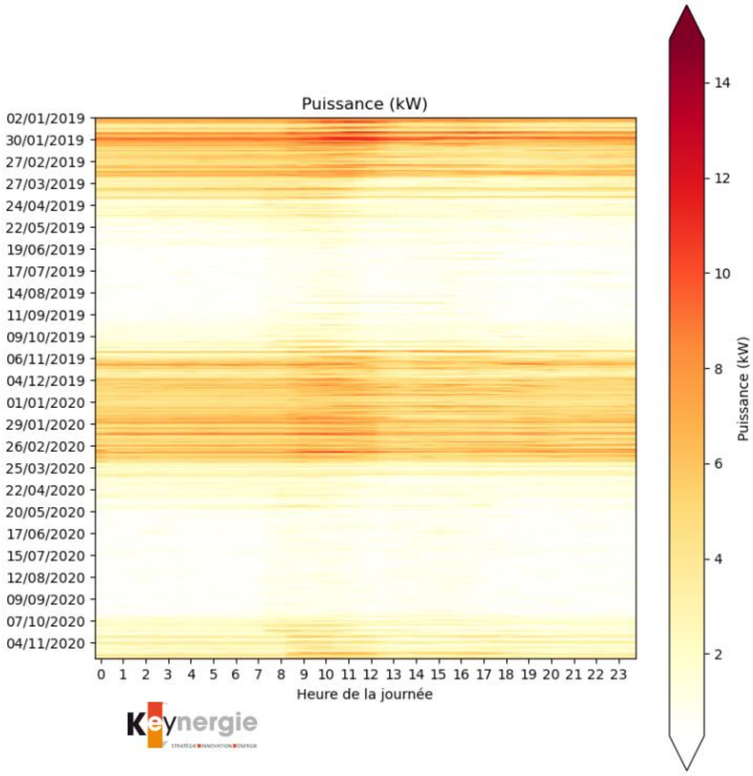


Figure 9 : Electricity consumption profile at the Town Hall of Ouessant - Power called in kW

The power demand in winter is of the order of 8 to 14 kW, while in summer it is 2 to 4 kW. The average daily consumption is 61.8 kWh / day. Heating is estimated to represent 76% of total consumption.

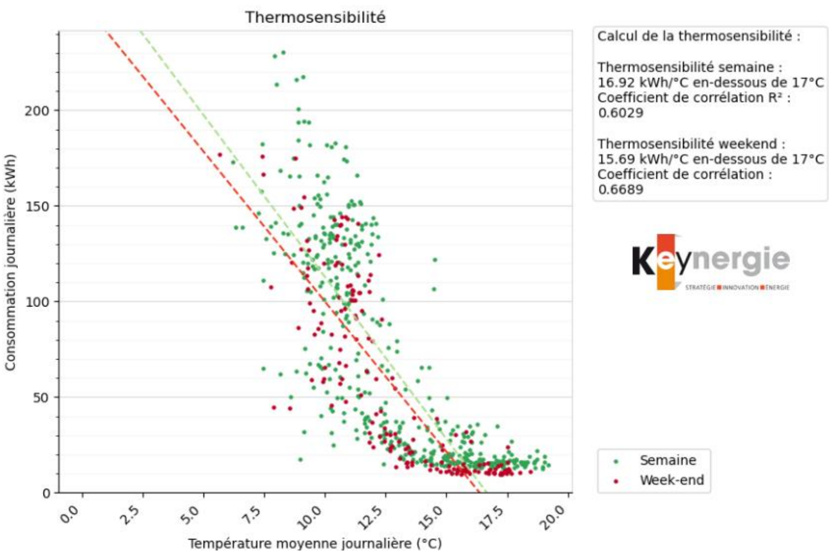


Figure 10: Thermosensitivity analysis for Ouessant City Hall - Daily consumption according to the average daily outside temperature

The detailed analysis of the town hall's consumption as a function of the average daily outdoor temperature makes it possible to estimate the dependence of electricity consumption as a function of the outdoor temperature, which is called thermosensitivity.

The arrangement of the points in Figure 10 is typical of a temperature sensitivity of countries with an oceanic climate, i.e. a consumption plateau for temperatures around 15-20 °C, then increasing consumption values. for lower and lower temperatures. If an air conditioning or cooling system is used, an increase in consumption could be observed with temperatures above 25 °C.

By imposing 17 °C as an average outdoor reference temperature, the temperature sensitivity of the Town Hall (below 17 °C) is of the order of 17 (kWh/d)/°C, or even at each degree below 17 °C, the daily consumption of the Town Hall increases by 17 kWh/day. For information, a building equivalent to RT 2012 standards would a priori display a temperature sensitivity of less than 4 kWh/day/°C.

Library

The Library's consumption profile clearly shows seasonality with a period of high consumption from November to March, and low consumption from April to September. This property is the consequence of cold temperature in winter in the northern hemisphere, and therefore represents the heating period by the use of electric heaters. We also note that consumption in winter is continuous, with some periods of greater consumption, in particular from 10 a.m. to 12 p.m. and from 4 p.m. to 6 p.m. Outside of winter, there is also occasional consumption in these slots, with the exception of March-April-May 2020 and November 2020, periods of confinement in France and therefore non-occupation of the Library.

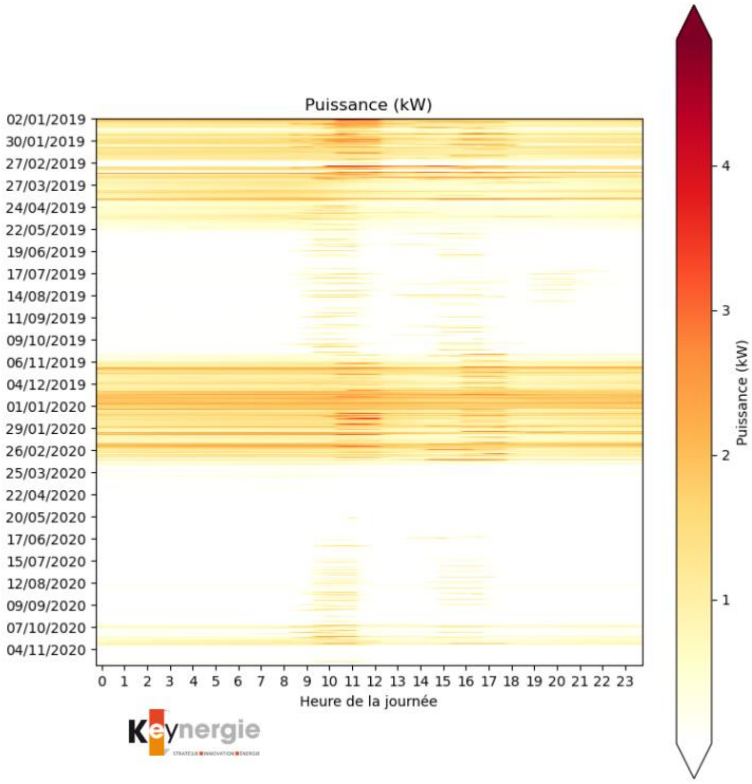


Figure 11 : Electricity consumption profile of the Ouessant Library - Power demand in kW

The power demand in winter is of the order of 2 to 5 kW, while in summer it is 0 to 1 kW. The average daily consumption is 11.95 kWh / day. Heating is estimated to represent a share of 78% of total consumption.

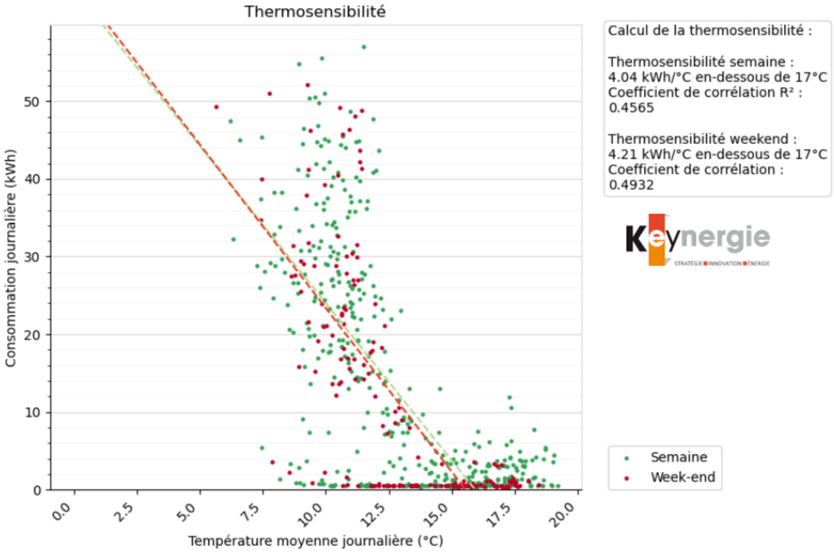


Figure 12: Thermosensitivity analysis for the Ouessant Library - Daily consumption as a function of the average daily outside temperature

The detailed analysis of the Library's consumption as a function of the average daily outdoor temperature makes it possible to estimate the dependence of power consumption on the outdoor temperature, which is called thermosensitivity.

By imposing 17 °C as an average outdoor reference temperature, the temperature sensitivity of the Library (below 17 °C) is of the order of 4 (kWh/d)/°C, or even at each degree below 17 °C , the daily consumption of the Library increases by 4 kWh/day. For information, a building equivalent to RT 2012 standards would a priori display a temperature sensitivity of around 1.5-2 kWh/day/°C.

Elderly Club

The consumption profile of the Elderly Club clearly shows seasonality with a period of high consumption from November to March-April, and low consumption from April to September. This property is the consequence of cold temperature in winter in the northern hemisphere, and therefore represents the heating period by the use of electric heaters. We also note that consumption in winter is only discontinuous from 8 a.m. to 12 p.m. (or 9 a.m. to 2 p.m. in summer but due to the time change, not taken into account in the analysis). Outside of winter, there is also occasional consumption in these slots, with the exception of March-April-May 2020 and November 2020, periods of confinement in France and therefore non-occupation of the Elderly Club.

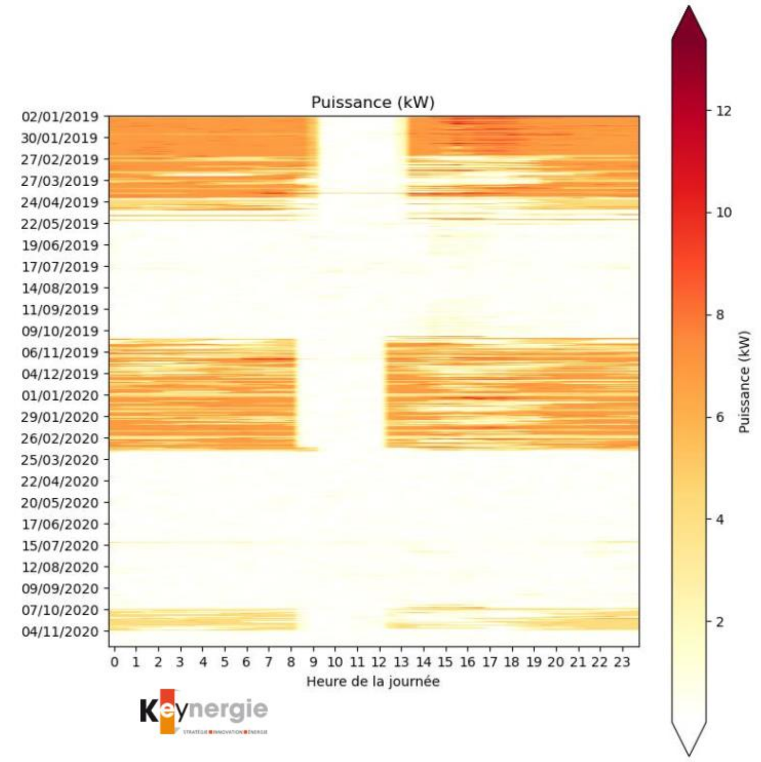


Figure 13 : Electricity consumption profile of the Elderly Club in Ushant - Power called in kW

The power demand in winter is around 5 to 8 kW with peaks at 12kW, while in summer it is 0 to 2kW. The average daily consumption is 48.66 kWh / day. Heating is estimated to represent 76% of total consumption.

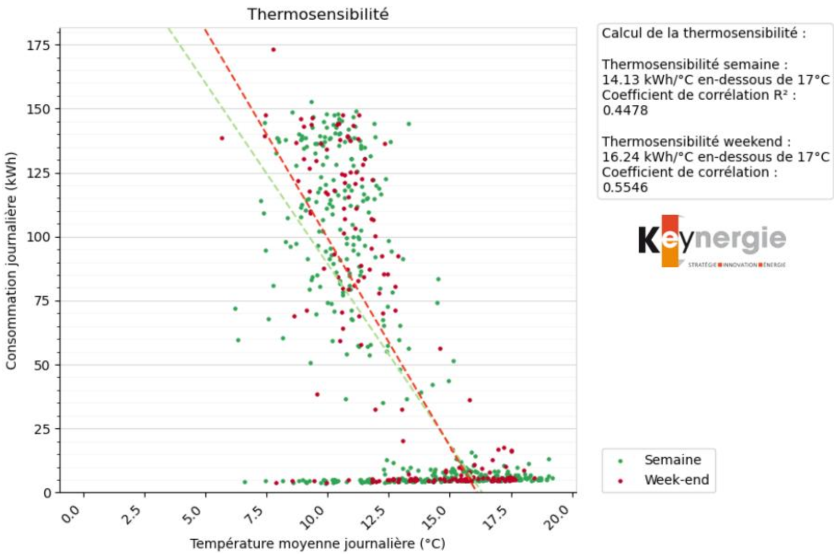


Figure 14: Thermosensitivity analysis for the Elderly Club - Daily consumption as a function of the average daily outside temperature

The detailed analysis of the consumption of the Elderly Club as a function of the average daily outside temperature makes it possible to estimate the dependence of electricity consumption on the outside temperature, which is called thermosensitivity.

By imposing 17 °C as the average outside temperature of reference, the temperature sensitivity of the Elderly Club (below 17 °C) is of the order of 14 (kWh/d)/°C, or even at each degree below 17 °C, the daily consumption of the Elderly Club increases by 14 kWh/day.

Canteen

Contrary to the other buildings, the consumption profile of the canteen shows almost no seasonality, but rather a concentrated consumption between 11 am and 2 pm. Occasionally in winter, there are days of continuous consumption on powers of the order of 2kW, probably linked to electric heating. Outside of winter, there is also occasional consumption in these slots, with the exception of Spring 2020 and November 2020, periods of confinement in France and therefore non-occupation of the canteen.

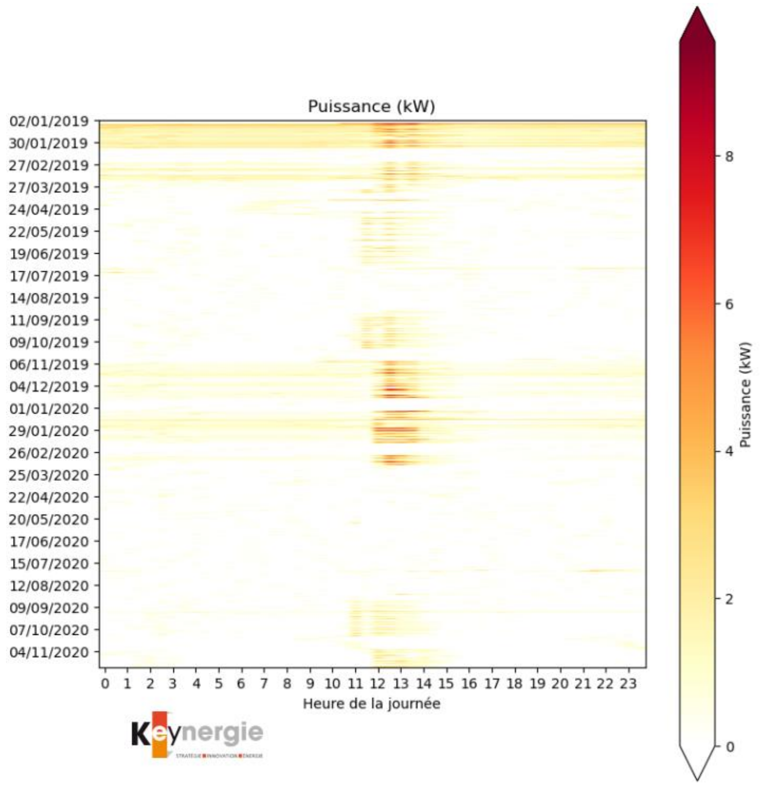


Figure 15 : Electricity consumption profile of the Ouessant canteen - Power demand in kW

The power demand in winter from 11 a.m. to 2 p.m. is of the order of 3 to 7 kW with peaks at 9kW, while in summer it is 0 to 2kW. The average daily consumption is 7.44 kWh/day. Heating is estimated to represent 55% of total consumption.

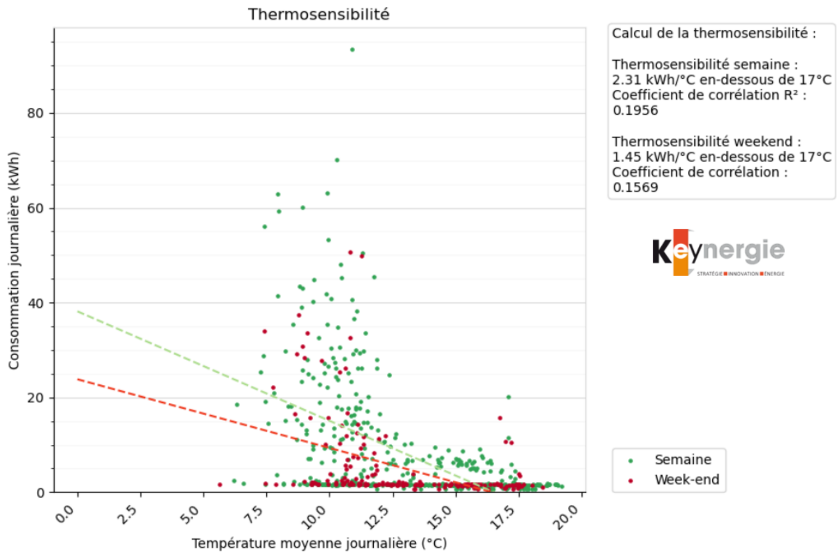


Figure 16: Thermosensitivity analysis for the Ouessant canteen - Daily consumption as a function of the average daily outside temperature

The detailed analysis of the consumption of the canteen as a function of the average daily outside temperature makes it possible to estimate the dependence of the electricity consumption on the outside temperature, which is called thermosensitivity.

By imposing 17 ° C as an average outdoor reference temperature, the temperature sensitivity of the canteen (below 17 ° C) is of the order of 2.3 (kWh / d) / ° C, or even at each degree below 17 ° C. ° C, the daily consumption of the canteen increases by 2.3 kWh / day.

Summary of the initial context :

Building	Average daily consumption (kWh)	Estimated share of heating (%)	Consumption profile
Library	11,95	78,21	Seasonal Continue in winter visible occupancy rate No heating programming a priori
Canteen	7,44	55,71	Concentrated at noon Some heating omissions in winter
Elderly Club	48,66	76,37	Seasonal Bad programming Incorrect heating programming a priori

Townhall	61,88	76,55	Seasonal Continue in winter visible occupancy rhythm No heating programming a priori

2.3.1.2. Selected Solution and methodology

Description

The SDEF launched a public consultation and it was Eiffage Energie Système, a subcontractor with Sensing Vision, that won the contract.

The architecture of the chosen solution consists of a platform for controlling electric heating equipment, made up of:

- A management platform accessible via the Internet, bringing together the information transmitted by the building equipment (temperature, presence, electricity consumption), as well as the building use schedule, with the possibility of adding or removing time slots. occupation

As well as for each building:

- Local supervision making it possible to adjust the operating mode of the heating equipment (comfort, reduced, off, or in control mode), as well as to view the information transmitted by the equipment of the buildings (temperature, presence, electricity consumption), as well as as the planning of use of the building, with the possibility of adding or removing occupancy slots

- A LoRaWan gateway making the link between the local PLC and the Finistère Smart Connect infrastructure, and allowing the information from the sensors and the local calendar to be fed back to the software platform, as well as to go down from the platform to the buildings with reservations made from a distance.

- A PLC comprising the program for regulating and controlling the heating equipment. This PLC communicates with the local sensors and actuators via an EnOcean Radio protocol (short range i.e. approx. 20m).

- Actuators positioned on the electrical circuit at the level of the heating equipment, in order to be able to control them

- Sensors (temperature, presence) transmitting data useful for heating regulation

This configuration is based solely on LoRaWan communication between a building's PLC and the control platform integrated into the Finistère Smart Connect platform. The use of an internet connection could have made it possible to increase the transmitted computer data rate, and therefore increase the functionality of the solution.

However, the idea is to test a low-speed technical solution (such as LoRaWan) which can be replicated in an isolated territory, not necessarily benefiting from an internet connection, and of which LoRaWan technology or similar could be only the only one. telecommunication network.

Therefore, it is necessary to understand that we are voluntarily placing ourselves in a situation constrained by a data rate limited by the technique: as a reminder in LoRaWan, 1% maximum occupancy rate, or for a given device, 36 seconds of transmission max per sliding hour.

Principle of operation

A) Local heating control :

The heating is regulated locally by the controller, based on the local temperature measurement, by controlling the heating power of the radiators in each zone. The operating principle of the regulation is described schematically below.

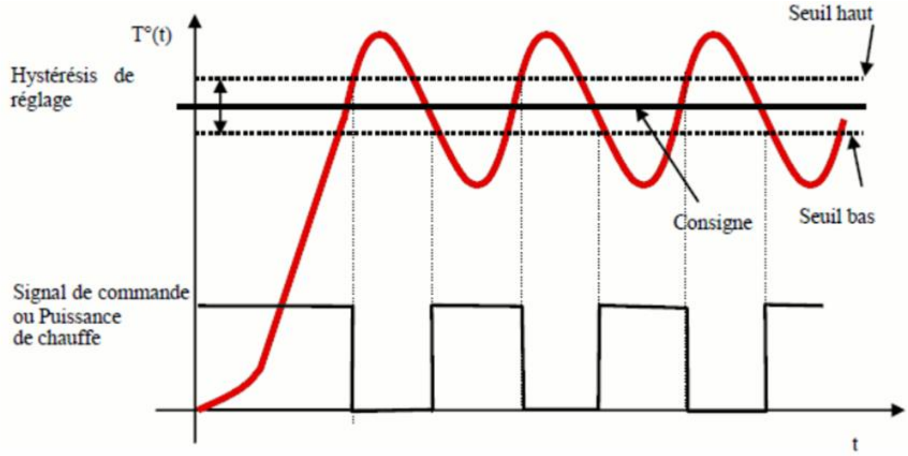


Figure 17: Heating regulation principle according to a setpoint, with variations around the setpoint

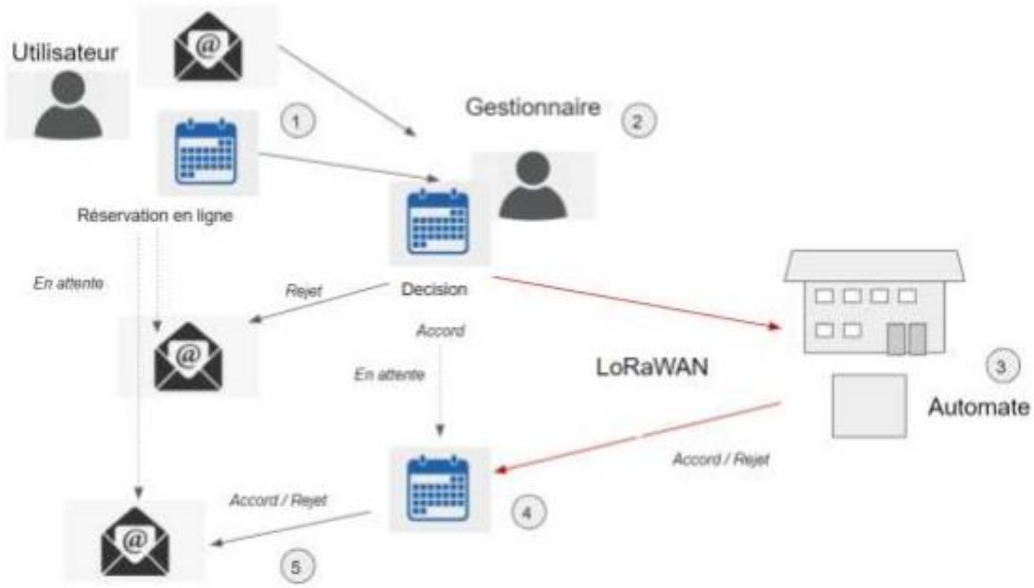
In a simplified manner, as long as the temperature is below the upper threshold of the setpoint, the radiators are in operation. Once the upper threshold is reached, the radiators are switched off. The inertia of the radiators causes the temperature to continue to rise slightly and then to drop again, due to heat loss to the outside. When the temperature is below the lower threshold of the setpoint, the radiators are put back into operation. The inertia of the radiators causes the temperature to continue to decrease slightly, and then to increase, until it reaches the upper set point, and so on.

There are two setpoint temperatures, namely the "comfort" setpoint, which is the desired temperature when the building must be occupied, and the "reduced" setpoint which is the temperature when the building is unoccupied..

B) Remote Slot Reservation :

The purpose of remote slot reservation is to be able to give both municipal staff and external users the possibility of reserving a one-time slot for the use of a building which is added to the regular planning of the building's use.

The five-step schematic operating principle of slot reservation is detailed below:



Etape	Description
1	L'utilisateur fait une demande de réservation via l'interface web. Le statut de la demande est mis en attente.
2	Le gestionnaire accepte ou rejette la réservation. Si la demande est rejetée, l'utilisateur est informé par mail. En cas d'acceptation, la demande est envoyée à l'automate.
3	L'automate est informe via LoraWAN de la demande, et l'accepte ou la rejette selon son calendrier local. (L'automate a la décision finale sur la demande.)
4	L'application cloud est informée de la décision de l'automate. Intégration de la réservation sur le calendrier si celle-ci est acceptée.
5	L'utilisateur est informé du statut (acceptée ou rejetée) de sa réservation par mail.

Figure 18 : Schematic description of remote slot reservation

In order to limit blockages and requests from the manager, it has been decided to set up an automatic validation of slot requests, which can be deactivated by the manager.

Architecture and list of equipment: sensors, actuators, PLC

The architecture of the solution with the various technical equipment is shown schematically below

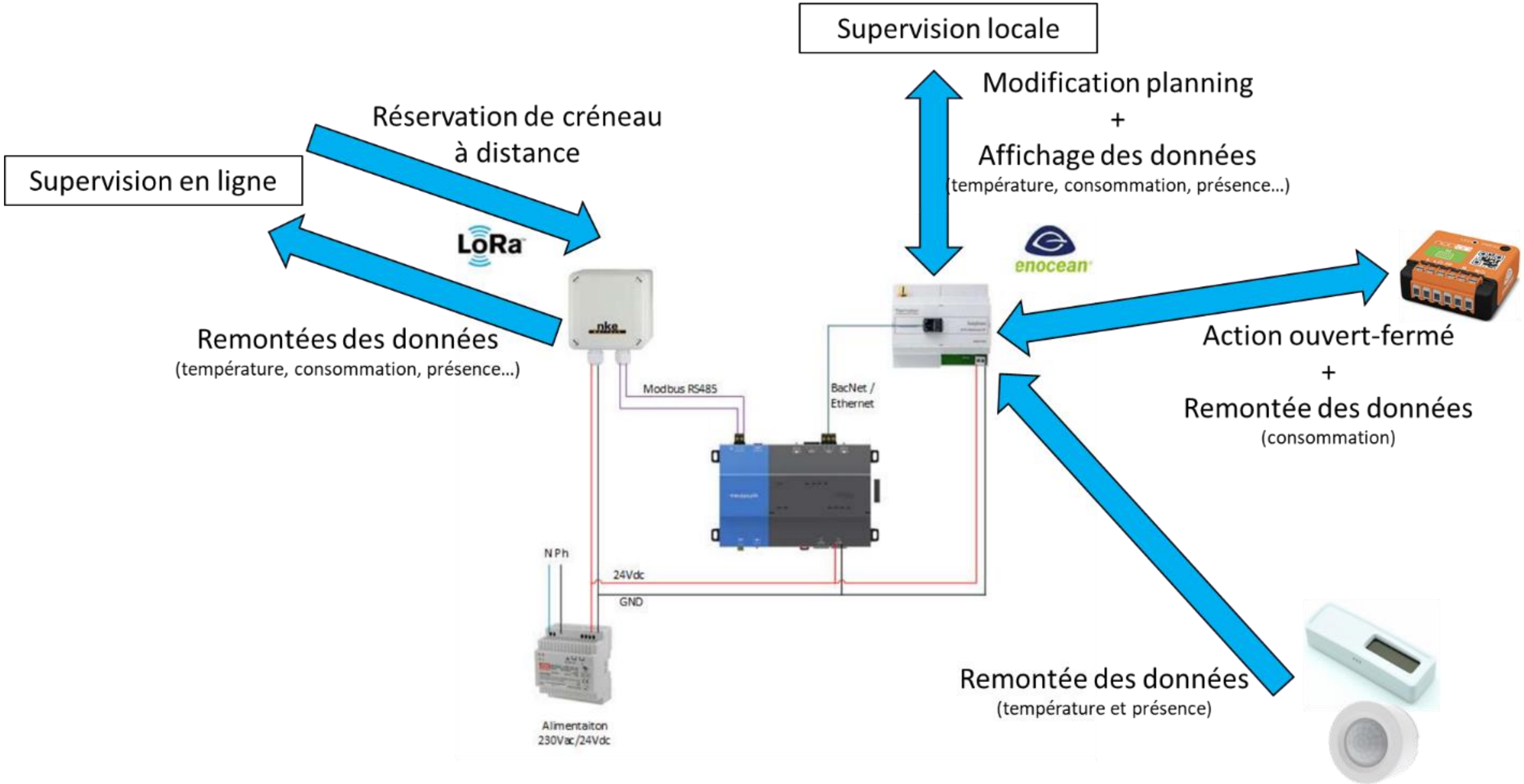


Figure 19 : Schematic architecture of the pilot heating monitoring solution

EnOcean technology has been developed since 2001 and allows the control of radio frequency equipment. The EnOcean radio protocol is a technology using several frequency bands including 868 MHz in Europe as well as LoRa.

Table 2 : Description of the equipment selected for the management solution

Name	Image	Description	Characteristics
JACE 8000 Tridium		The JACE® 8000 is a compact, on-board Internet of Things (IoT) controller and server platform for connecting many diverse devices and subsystems.	TI AM3352: ARM® Cortex ™ -A8 1000 MHz 1 GB DDR3 SDRAM Wireless Configurable radio USB Type A connector RS-485 Ethernet ports
Thermokon EnOcean		Bidirectional gateway for sensors and actuators based on EnOcean as well as controllers and control systems with BACnet IP interface for local supervision.	Field network: BACnet IP technology Radio: EnOcean Technology Frequency: 868 MHz with external antenna Bidirectional transmission Mounting: DIN rail
LoRa/ModBus NKE		The LoRaWAN ModBus RS485 sensor collects data from ModBus RTU equipment. It transforms existing equipment into communicating objects via a public or private LoRaWANTM network. The Sensor can modify the behavior of the ModBus RTU equipment by writing to its registers.	Modbus protocol: RS485 physical link - 3 wires. Management of all variables (read and write) of local supervision from an LNS server. 10 different ModBus profiles Frequency: 868 MHz LoRaWAN: Class A or Class C Transmission cycles: 15mn, 1h, 12h or configurable from the remote server

			Activation method: Activation by Personalization (ABP) or Over-The-Air Activation (OTAA)
Actuator Nodon		The actuator makes it possible to connect electric radiators and water heaters and to automate the management of the heating to achieve energy savings. The pilot wire sensor will be used to control the equipped radiators (switch to comfort / reduced / frost protection, etc.). The multifunction sensor (on-off) will control the old generation radiators, but also the hot water tanks. Its operation makes it possible to cut off the power directly.	Reference: SIN-2-FP-01 (pilot wire) and SIN-2-1-01 (on-off) Power supply: 230V AC ~ 50Hz Consumption: <1W Max radiator power: 3680 W (pilot wire) and 2300W (on-off) Instantaneous Power (W) and Cumulative Energy (Wh) measurement Radio frequencies: 868.0 to 868.6 Mhz Maximum radio power: + 10dBm Range: up to 30m indoors
Temperature sensor Nodon		The temperature probe measures the temperature in a room and sends the information (movement / no movement) back to the controller, via radio wave.	Power supply: CR123A 3V battery Measuring range: 0 ° C to 40 ° C (Resolution 0.16 ° C) Indoor use Wireless range: Up to 30 meters
Presence sensor Nodon		The motion detector detects movement and sends the information (movement / no movement) back to the controller, via radio wave.	Power supply: CR123A 3V battery Lifespan: 5 years Radio frequency: 868.3 MHz Max radio frequency power: + 3dBm Wireless range: Up to 30 meters Detection range: Up to 5 meters Sensitivity: 0 to 1000Lux

2.3.2. Information to the consumers : prosumer profile

One of the smart grid actions in Ouessant making the link between production and consumption consists in the deployment of informative connected objects which aim to transmit the state of the electrical network to the inhabitants, so that they can consume energy with knowledge. of cause. In other words, it involves providing real-time information on the state of the Ouessant electricity network, namely the power requested and the proportion of renewable energy, in order to be able to orient consumption. controllable (oven, washing machines, dishwashers, etc.) towards the most favorable periods.

2.3.2.1. Initial Context

Electricity consumption variability on the island of Ouessant is very high over one year, with a period of high consumption in winter (electric heating), and a period of low consumption in summer. The months of July and August show higher consumption than in June and September, due to a high number of tourists (summer school holidays).

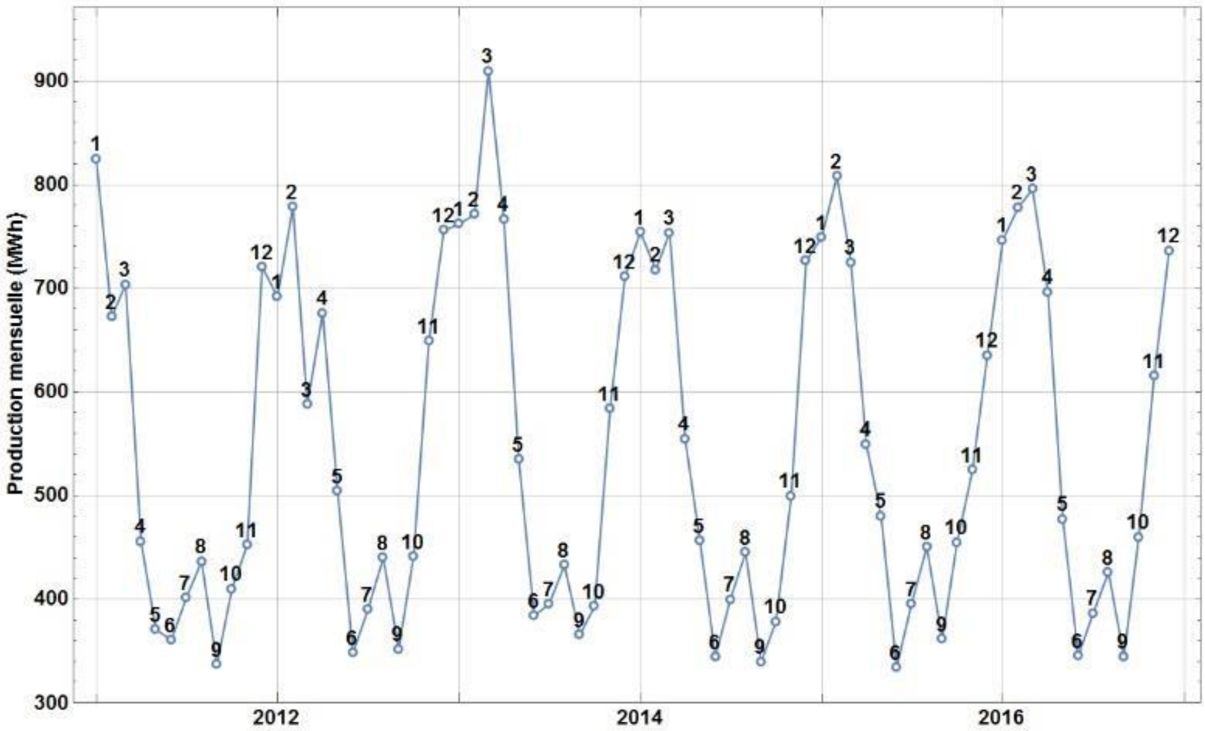


Figure 20 : Evolution of electricity production (in MWh) - monthly step in Ushant from 2011 to 2016

Consumption also varies on a day-long scale and shows periods of high electricity consumption in the morning and evening. In particular, there is a rapid increase in consumption in the evening at 11 p.m., which corresponds to the transition to off-peak hours, and which results in the start-up of domestic hot water production equipment.

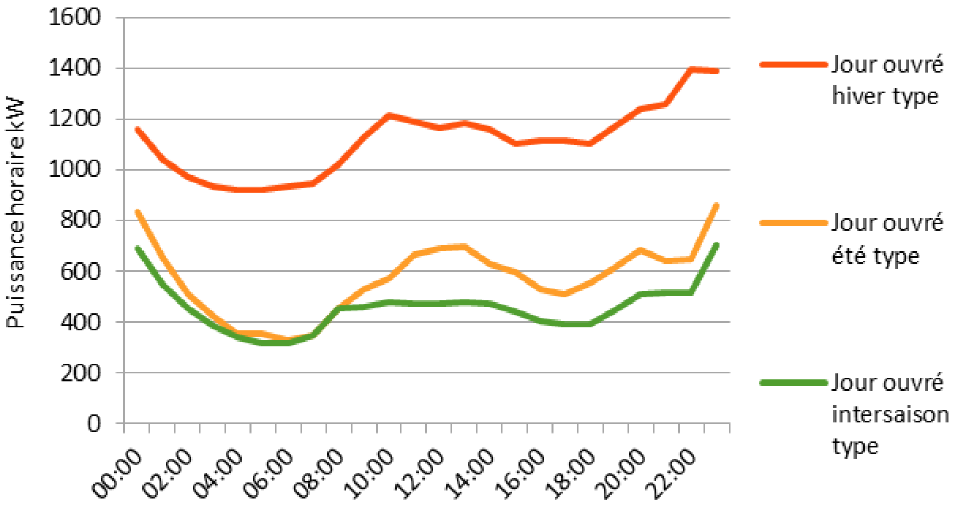


Figure 21 : Evolution of the average daily electricity consumption for January and August

The variability of consumption is therefore intra-day and seasonal. The production of electricity by an oil-fired generator is particularly suited to these variations and makes it possible to guarantee optimum security of supply but represents a very high cost and emissions of pollutants and GHGs.

The management of consumption on the island can allow better integration of current and future renewable energies. The objective is twofold: to reduce consumption by identifying unnecessary excess consumption (control of heating in buildings that are not permanently used) and by shifting consumption to periods when renewable production is the most important, this which makes it possible to limit the heating needs.

For Ouessant, the idea is in particular to shift consumption to periods of low demand coupled with high production of renewable energy, eg. tidal or photovoltaic production (intermittent but predictable).

2.3.2.2. Selected solution and methodology

Description

The SDEF launched a public consultation and the company Sensing Vision was chosen for the market.

By using the LoRa infrastructure deployed as part of the SDEF Finistère Smart Connect project, the goal is to deploy connected objects to the inhabitants of the island of Ouessant.

Connected equipment aims to inform consumers of the state of the network (maximum power demand during peak periods, share of renewable production on the island depending on the time of day), summarized in a simple signal, understandable by all.

The objective is to encourage residents to shift the electricity consumption that may be in order to avoid consumption during periods when the network is in high demand and the electricity produced is very polluting (fuel oil plant). Two types of objects were selected:

• A colored indicator: simple and educational object that changes color according to a signal sent by the LoRa network.

Figure 22 : Photos of the colored indicator according to the 4 possible states

• A display: an object that presents more information for more informed consumers; it takes the inhabitant's consumption information via its Linky meter and displays it on a screen, and also displays a color according to a signal sent by the LoRa network. More precise information allows the user to quantify their impact.

Figure 23 : Photo of the display (A), of the radio module (B), and of the radio module installed on the Linky (C)

These items will be deployed in as many homes as possible on the island, with the aim of:

- 50 households equipped with indicators;

- 30 homes equipped with displays

The first step is therefore to create and design these tools within a period of relatively small-scale experimentation, but such objects are likely to have large-scale utility.

Online supervision

Regarding the color qualifying the state of the electrical network, the data must be retrieved from the EDF SEI Ouessant site, and transmitted to objects via the LoRa infrastructure. This procedure is supervised and organized by an online platform, on the Finistère Smart Connect portal.

This platform makes it possible to record the values of the color indices (Figure 24), in order to keep the history for a later analysis, as well as to modify the messages associated with each color (Figure 25in order to double the information transmitted. These messages, being transmitted in LoRa, are limited to a maximum size of 30 characters..

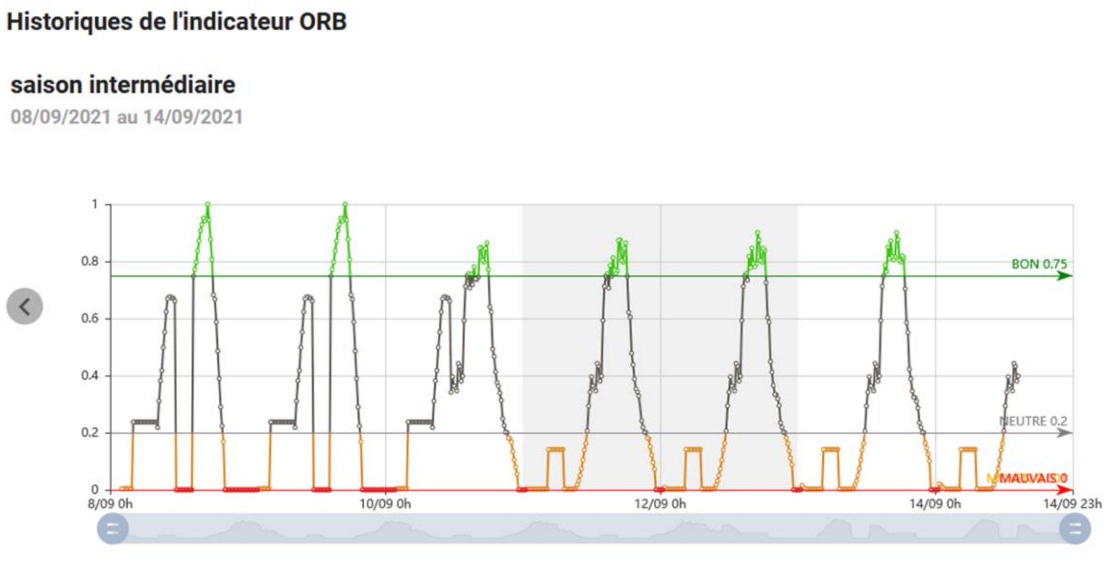


Figure 24 : history of the values of the indices qualifying the state of the network, with the positions of the color change thresholds

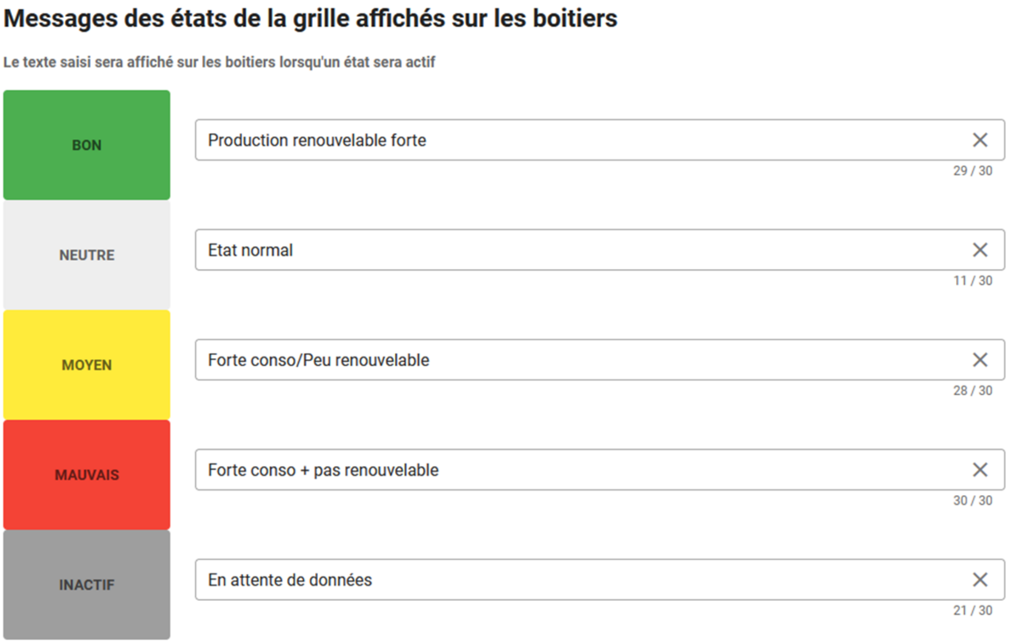


Figure 25 : Messages accompanying the color change - changeable messages, up to 30 characters

Analysis of the impact of the object

The impact of objects, and more particularly of communication on people's consumption, will be assessed by analyzing individual load curves before and after objects. A comparison of the consumption profile with the displayed color will be carried out, in order to identify whether changes in consumption (increase, or reduction) can be correlated with the corresponding color (green, or red, respectively).

3. Project Structuring: A good practice for the project

In this part we present the structure put in place for the ICE project, with the description of the already pre-existing dynamics of the "Smart Island Ouessant" group.

We then present the interventions of experts outside the partners of the ICE projects, which made it possible to provide essential skills on specific subjects relating to islands and the energy transition.

3.1.« Smart Island Ouessant » : Dynamics of Ouessant's energy transition

The term "Smart Island Ouessant" brings together public and institutional players in the energy transition of the island of Ouessant, which has set itself the objective, via the Pluriannual Energy Programming (PPE), of achieving a mix energy based 100% on renewable energy for 2030, with a first step at 50% for 2023.

This term groups together different actors, which are specified in Figure 26 (blue circles). Note that ENEDIS was one of the players until early 2020, when EDF SEI reintegrated the Ponant Islands ZNIs into their scope of action..

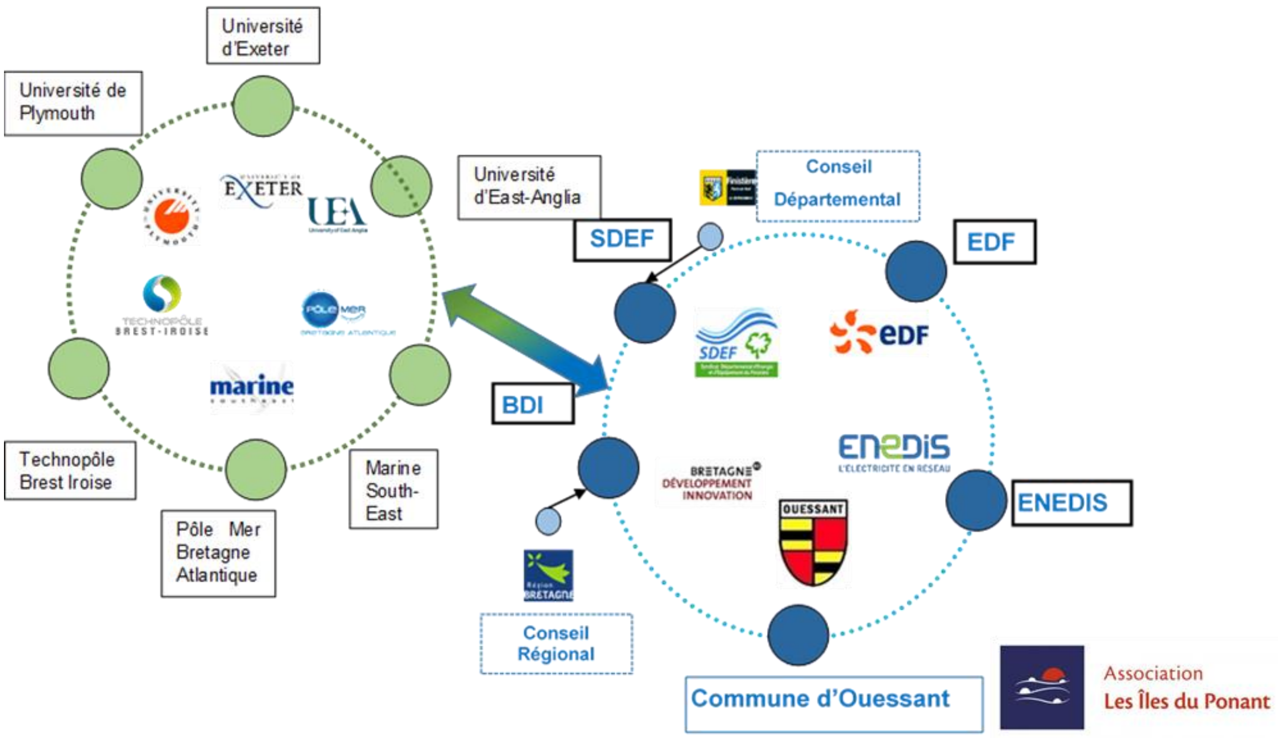


Figure 26 : Circle of partners of the ICE project (left, green) and circle of partners of the "Smart Island Ouessant" project (right, blue)

This dynamic, which has been established around these players, is the result of the various energy and ecological transition actions that have taken place in Ouessant.

Among these actions, we can note the European Interreg France-Channel-England project "MERIFIC", which took place from 2011 to 2013, aimed to advance the adoption of marine energies in the two regions of Cornwall and Finistère and the island communities of the Iroise Marine Natural Park and the Scilly Islands.

Other projects have been carried out with the same actors, such as the Positive Energy Territory for Green Growth (TEPCV) project at the national level, or the "Local Energy Loop Energ'Enez" at the regional level. These last two projects have implemented actions to reduce and control energy consumption, which has made it possible to reduce fuel consumption by 25% on the 3 islands of Ouessant, Molène and Sein, and therefore to reduce fuel consumption by the same amount. greenhouse gas emissions. As part of these projects, the actors were able to work together on a regular basis, resulting from a general dynamic aimed at making these three non-interconnected islands autonomous.

As part of the ICE project, steering meetings (COPIL) were set up at a periodic rate of around 6 months, in order to establish the link between the “ICE” actors and the “Smart Island Ouessant” actors. through actors common to the two circles (BDI, SDEF). These meetings made it possible to define the action plan to be implemented in Ushant, which will allow both to respond to the issues raised by ICE, and also to be part of the island's overall energy transition project.

These meetings made it possible to pool information from each actor, and to identify what was missing and which could be collected as part of the ICE project. This made it possible to define the specifications for the SDEF Contracting Authority assistance missions for the design and implementation of the actions of the ICE project in Ouessant. The two

In addition to these steering meetings, technical meetings (COTECH) were set up in the second part of the project (from the second half of 2019), during the design phase of technical smart grid solutions, as well as during the design phase of smart grid technical solutions. of the deployment phase of these solutions.

The arrival of COVID-19 in France (1st containment in mid-March 2020) impacted the pace of meetings, which were able to continue at a distance through video meeting tools.

3.2. Expert intervention

In addition to these institutional players, we also called on experts on specific subjects in an isolated territory undergoing energy transition. The SDEF thus launched a public consultation to find two project management assistants for the ICE project, firstly on knowledge of island environments, and secondly on knowledge and analysis of the energy system. With regard to Island specificities, the Ponant Islands Association was chosen, and for the energy system part, the Keynergie design office was chosen. In this section, we present the scope of action of each of these two players.

3.2.1. Association des Iles du Ponant (AIP)

The Association "Les Îles du Ponant" brings together 15 French islands on the Atlantic coast and the English Channel: Chausey, Bréhat, Batz, Ouessant, Molène, Sein, Saint Nicolas des Glénan, Groix, Belle-Île, Houat, Hoëdic, île d'Arz, Ile aux Moines, Yeu and Aix.

The members of its board of directors represent the islands and several levels of communities involved in the governance of the islands. The Breton islands, which constitute the majority of the Ponant islands, are enriched by exchanges between all the Ponant islands, but also from their partners within the European network of small islands (ESIN) representing a large number of islands with which they share many common points leading to solutions to face the challenges of the islands at the beginning of the 21st century.

The role of the Association in this project was to carry out surveys among the inhabitants of Ouessant on their perception of energy, in particular on the different means of renewable energy production and their application in Ushant. The results of these surveys are grouped together in deliverable ICE 5.2.1. The association also made it possible to liaise with the inhabitants during the ICE project, during public events (meetings, workshops, mobile exhibition) but also in supporting technical actions by liaising with the inhabitants.

3.2.2. Keynergie

The Keynergie design office is an engineering and innovation consulting company specializing in the energy sector. Keynergie has implemented its energy data collection and analysis capacities first of all on the context of the island of Ouessant and in particular on its energy mix in a 100% renewable context. They then participated in the implementation of the island's energy transition action plan, and in particular the actions relating to the ICE project.

Among the actions selected, consumption audits were proposed for voluntary residents and municipal buildings, and carried out by Keynergie on the basis of consumption data from the Linky smart meter, which made it possible to highlight certain malfunctions / errors in the system. consumption programming.

The audits therefore made it possible to identify actions to be taken to correct the dysfunctions, but also to increase the connection of the "consumption" part to the "production" part. The result was to offer technical tools for automated control of certain electrical consumption (control of electric heating), but also tools to circulate information and in particular to consumers (information objects).

Once the actions have been designed, deployed and put into service, Keynergie performs analyzes of the performance of these new technical solutions, which are grouped together and presented in deliverable 3.4.1.