Detailed Use Case planning, including the district architecture requirements and tested innovations

Deliverable D9.1

V1

30/11/2017

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n°731289

ID & Title :	D9.1 Detailed Use Case planning, including the district architecture requirements and tested innovations		
Version :	V1.0	**Number of pages :**	143

Short Description

This first deliverable describes the first specifications of *Nice Smart Valley*, French demonstrator of the INTERFLEX project and details its three use cases. It is organized in three main sections, covering the three use cases of the demonstrator:

- Islanding of a portion of the distribution grid using local resources;
- Multiservice approach for grid-connected storage systems;
- Local flexibility system operated by and for the DSO.

In each section, the scope of the use case is described, as well as the processes between stakeholders. A special focus on the selected areas in provided, putting in perspective the impacts on the distribution grid. The next steps are listed for each use case.

Revision history

Version	**Date**	**Modifications' nature**	**Author**
V0	01/10/2017	First version	Drizard
	31/10/2017	Final version (confidential) taking into account the comments of AVACON	Drizard
V1.0	30/11/2017	Final version (public)	Drizard

Accessibility

☒ Public	☐ Consortium + EC	☐ Restricted to a specific group + EC	☐ Confidential + EC

Owner/Main responsible

Name(s)	**Function**	**Company**	**Visa**
Thomas Drizard	Project Manager	Enedis	

Author(s)/contributor(s): company name(s)

Drizard, Bruschi, Mulenet, Setti, Wolf, Desgrange, Gros (Enedis); Lehec, Pellizzaro (ENGIE); Chazottes, Jalmain, Casacci (EDF); Quillien, Bertrand, Hssaini, Contreau (GRDF); Boos (Socomec); Métivier (GE)

Reviewer(s): company name(s)

Company	**Name(s)**
Avacon	Gross

Approver(s): company name(s)

Company	**Name(s)**
Enedis, PC	Dumbs

Work Package ID	WP 9	**Task ID**	T9.1

EXECUTIVE SUMMARY

This document presents the detailed Use Case planning for *Nice Smart Valley*, the French demonstrator of the *INTERFLEX* project, which is deployed in the *Nice* area, in the South of France. This report is structured along three main axes, each corresponding to a Use Case. Each use case has a double approach, **practical and theoretical**. On the practical side, **trials will be performed on site** from mid 2018 onwards to **validate technical concepts** and obtain a **feedback from the field**. On the theoretical side, **simulations** will be processed and the **business models** and the associated **market design** will be analyzed.

The first months of the *Nice Smart Valley* have been dedicated to **select areas** for the tests and to **detail the specifications** associated to each use case. More specifically, **three areas** have been identified to test grid constraints mitigation on the MV level, corresponding each time to a part of the grid connected to a primary substation. For the islanding use case, ***Lérins*' islands** have been identified as an interesting playing field in the context of securing power supply.

The first use case is **islanding,** understood here as putting temporarily a part of the electrical network off-grid and ensuring its power supply with a local storage system and renewable production, either as a response to an abrupt failure of the surrounding grid. The sequences of the use case are presented, and the **first specifications are applied for the islanding of the two *Lérins*' islands**.

The second use case analyses a **multiservice approach for storage systems**, with a focus on self consumption. The idea is to share a large storage system among several *prosumers* (i.e. clients who are simultaneously ***producers*** and ***consumers***) under a self-consumption context and to aid the electrical grid under a multiservice approach. The different **services provided by the storage systems** are described.

The last use case is dedicated to the **use of flexibility by the distribution system operator**. These flexibilities, managed by aggregators, are from several types: B2B, B2C, gas/electric, storage flexibility. The document describes extensively the **power flow computation performed to estimate the flexibility utility for the DSO**. The technical solutions to provide flexibilities are presented as well the first steps of the **recruitment**. A first approach for the processes between DSO and aggregators is provided. Preliminary findings on the associated **market design** for local flexibilities are also presented

For each use case, the **next steps** are highlighted and the **planning is** detailed. The experiments in the project will start in 2018.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

Table 1. List of acronyms in the document

ACRONYM	CATEGORY	DEFINITION
ACR	Stakeholder	Regional Control Agency (in its French acronym)
BRP	Stakeholder	Balancing Responsible Party
CHP	Technology	Combined Heat and Power
CIM	Technology	Common Information Model
DER	Technology	Distributed Energy Resources
DFS	Technology	Distributed Flexibility System
DSO	Stakeholder	Distribution System Operator
GFU	Technology	Grid Forming Unit
GSU	Technology	Grid Supporting Unit
HWT	Technology	Hot Water Tank
ICE	Technology	Internal Combustion Engine
LV	Indicator	Low voltage
PACA		Provence-Alpes-Côte d’Azur
PCS	Technology	Power Conversion System
RTE	Stakeholder	French Transmission System Operator
SCADA	Technology	Supervisory Control And Data Acquisition
SGAM	Technology	Smart Grid Architecture Model
SOC	Indicator	State of Charge
TSO	Stakeholder	Transmission System Operator
VLL	Indicator	Value of Lost Load
V2H	Technology	Vehicle To Home

1. INTRODUCTION AND SCOPE OF THE DOCUMENT

1.1. Context of LCE-2 – H2020

INTERFLEX is a response to the Horizon 2020 Call for proposals LCE-02-2016 of the European Commission[1] ("Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system"). The project receives funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No 731289 — *InterFlex* — H2020-LCE-2016-2017.

1.2. INTERFLEX

INTERFLEX is built upon a twofold approach. Six demonstration projects are conducted in five EU Member States (Czech Republic, France, Germany, The Netherlands and Sweden) in order to provide deep insights into the market and development potential of the orientations that were given by the call for proposals, i.e., demand-response, smart grid, storage and energy system integration.

In the long run, *INTERFLEX* prepares the deployment of the validated solutions where:

- business model options have been identified;
- policy recommendations are built thanks to the BRIDGE process initiated by the EC-DG ENER and now continued operationally by four working groups (business modeling, data management, consumer engagement and regulations) which will be nourished by the demonstration results;
- Replication rules will be proposed based on the studied use cases.

Nice Smart Valley is the French demonstrator of *INTERFLEX*.

NICE SMART VALLEY

Figure 1. Graphical identity of Nice Smart Valley

1.3. Geographical context

Located in the southeast of France, the region known as PACA (an acronym which stands for Provence-Alpes-Côte d'Azur) provides the ideal place for *Nice Smart Valley's* experiments. For most of its recent history, its connection to the rest of the high-voltage grid laid on a single 400 kV transmission line. This connection has only been reinforced recently (2015) by a second 225 kV cable. However, the lack of other connections makes PACA still vulnerable to black-outs. Compounding to the problem is the fact that the region is highly dependent on electrical energy generated elsewhere. According to RTE's (France's transmission system

---

[1] http://cordis.europa.eu/programme/rcn/700612_en.html

operator) annual report, the region generates about half of its own energy consumption, which totaled 38 TWh in 2016[2].

The region is currently investing in smart grid projects, such as the FlexGrid project. Smart Grids can facilitate the local generation of solar energy and help balancing the supply and the demand of electrical energy locally. The area offers exceptional conditions for solar production, averaging 2.724 sun hours per year[3]. It has over 33,000 photovoltaic installations[4], bringing the solar installed capacity of the area to 945 MW, growing 9% only in 2016[5]. Nice, the largest city participating in the French demonstrator, has also been consistently considered one of the "smartest" cities in the world, being ranked 4th worldwide by Juniper Research[6], a digital consultancy company. It has electric buses, a smart car-sharing service and has already hosted another smart-grid solar neighborhood project (Nice Grid as part of the Grid4EU project).

1.4. Regulatory context

1.4.1. Energy Transition for Green Growth Law[7]

France's Energy Transition for Green Growth Law (LTECV in its French acronym) was approved on August 17, 2015. It establishes ambitious goals in terms of renewable energy consumption, the reduction of the emission of greenhouse gases and the development of electric vehicles. It determines that renewables will represent 23% of final electric energy consumption by 2020 and 32% by 2030. It also imposes a 40% cut in the emission of greenhouse gases by 2030, compared to 1990 emission levels. Finally, the law set the legal precedent to self-consumption in France.

1.4.2. Self-consumption

Important regulatory barriers were lifted in France as a consequence of the Energy Transition for Green Growth Law. Two legal texts provided the first framework for self-consumption in France: the "Self-consumption Ordinance"[8] and the "Self-consumption Decree"[9]. They encouraged self-consumption by establishing a reduction in the national Distribution Grid Utilization Tariff ("TURPE", in its French acronym) for structures having an installed capacity not exceeding 100 kW. The ordinance imposes that self-consumption installations be declared to the DSO.

France's Energy Code also incorporated the notion of "collective self-consumption", an essential feature of Use Case 2. It also determines that, in the case of collective self-consumption, there needs to be a legal person binding all prosumers. This legal person is responsible for calculating the partition of the produced energy among all participating prosumers.

---

[2] http://www.rte-france.com/sites/default/files/ber_paca_2016.pdf(in French)
[3] http://www.meteofrance.com/climat/france/nice/06088001/normales
[4] http://oreca.regionpaca.fr/production-denergie-regionale/solaire-photovoltaique.html
[5] http://www.rte-france.com/sites/default/files/ber_paca_2016.pdf (in French)
[6] https://www.juniperresearch.com/press/press-releases/barcelona-named-global-smart-city-2015
[7] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000031044385&ategorieLien=id (in French)
[8] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000032938257&categorieLien=id (in French)
[9] https://www.legifrance.gouv.fr/eli/decret/2017/4/28/DEVR1707686D/jo/texte (in French)

1.4.3. The Clean Energy Package

Also called “the Winter Package”, it consists of several proposals by the European Commission in terms of energy efficiency, renewable energies and the rights of energy consumers. It consists of the Electricity Directive, the Electricity regulation, the Energy Efficiency directive, the Energy Performance of Buildings directive and the Renewable Energy directive

It aims at favoring energy efficiency measures, empowering consumers and making the European Union a leader in the renewable energy sector. The proposal is currently being negotiated by the members of the European Parliament and the European Union member states. New rules governing local energy communities, network tariffs, flexibility, demand response and storage are under discussion.

1.5. Overall planning

This 3 year-long project consists of three Use Cases, each with its own calendar. As an illustration, the calendar of Use Case 2 is shown below:

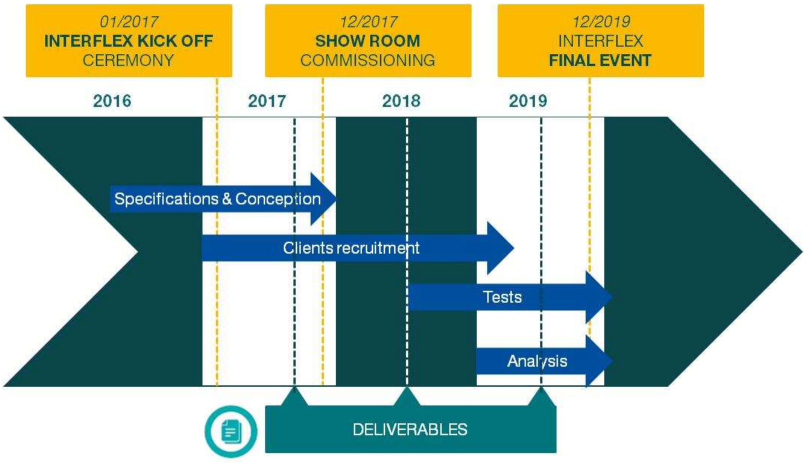


Figure 2. Overall planning of the demonstrator

1. Project set-up and specifications, from January to September 2017, which includes the selection of specific target areas for the project, the conception of an innovative business plan, the definition of KPIs, the writing of the three use cases and of the technical specifications;
2. Recruiting, during which the aggregators will look for prospective clients in target areas and recruit them for the project. The recruitment offers will be done accordingly to the services required by the DSO in order to test the capacity to meet DSO requirement thanks to local flexibility
3. Installation and operation, expected to begin in July 2018, which consists of the installation of all necessary technical equipment, the operation including flexibility providing to DSO, local portfolio optimization and the collection of data;
4. Analysis and reporting, expected to begin in March 2019, in which all data collected is analyzed, KPIs calculated and recommendations emerging from the project are formalized into a final document to be sent to the European Commission.

2. USE CASE 1: ISLANDING OF A PORTION OF THE DISTRIBUTION GRID USING LOCAL RESOURCES

This use case is dedicated to the **islanding of a portion of the distribution grid using local resources**. It will be studied in two approaches:

- **Testing on field**

The experiments, forecasted for the beginning of 2019, will allow for:

- Using **storage system** in order to improve the power supply quality of the customers of the national distribution grid.
- Determining the **conditions to start islanding manually or automatically and remotely** to minimize the duration of a blackout.
- Determining the **technical link between the different assets** contributing to islanding accordingly to the contracts.
- **Assessing customers' contribution** to support the islanding.
- For the aggregator assets, **optimizing the storage management accordingly to the contracted maximum duration** and to the forecast loads and productions within the islandable area.
- For the DSO's asset, **optimizing the state of charge of the storage system** over the year in order to maximize the duration of potential islanding.

- **Simulation, business models and market design approach**

On the other hand, this theoretical approach should:

- Evaluate **business models** for district islanding purpose and the associated offers and contract with local flexibilities and local power suppliers.
- Assess **consumers and producers' interest** of an islanding service.
- **Approach a pricing structure** for such product in order to maximize the value for the system.

- **Note**

At the time of writing this deliverable, the islanding area is not yet selected. The project has a preference for the *Lérins*' islands, and a there is a pending application for installing PV systems. Alternative areas are presented in section 2.2.2, but the document is written in the scenario of the *Lérins*' Islands.

2.1 Description of the use case

This section details the different **actors and equipment**. The scenarios and the list of KPIs of the use case are described in *Appendix 4*.

2.1.1 Definitions / Roles

Table 2. Actor names and description

Actor Name	Actor description
Customers	Customers involved can contract with the aggregators (EDF and ENGIE) in order to decrease the net consumption of the islanding area and to increase the theoretical duration of the islanding.
Enedis	Enedis is the French national DSO and as responsible for the grid power quality and people's safety, Enedis is the islanding system's operator, in charge of the GFU, voltage and frequency on the grid.
EDF	From local PV generation, EDF sells levers to Enedis on the islandable area to increase, if needed, the duration of the islanding.
ENGIE	ENGIE sells levers to ENEDIS from PV generation, Demand side management and storage which are available on the district. For the demonstrator, ENGIE will recruit customers and install a storage system in the demonstration district. ENGIE will also install an EMS designed to get order from the GFU and adapt the load level accordingly, by acting on the customer's equipment
Regional Grid Supervisor (Enedis)	Regional Grid Supervisor can remotely activate the islanding, connect and disconnect assets on the islanded area, order any measure to protect people's and equipment's safety

Table 3. Equipment names and description

Equipment Name	Equipment description
Grid forming unit (GFU)	Storage system that maintains the frequency and the voltage magnitude of the local grid at the appropriate levels.
Grid supporting unit (GSU)	Storage system enslaved by the GFU to use its energy and capacity to increase the duration of the islanding.
Islanding breaker	Equipment that is able to remotely connect or disconnect the islandable subgrid.
GSU's sensors	Sensors able to measure the voltage magnitude and the phase of the voltage.
Islanding control system	GFU's regulation that maintains the voltage and frequency stability of the islanding.

2.1.2 Scope of the use case

Islanding consists in **disconnecting a part of a distribution grid from the main distribution grid while enabling its power supply with local energy resources for a limited duration of time**. In the context of *Nice Smart Valley*, these resources are:

- Two storage systems (GFU & GSU);
- Customer's levers ;

- Local photovoltaic generation.

The project plans to go beyond NICE GRID demonstrator:

- Perform **innovative, replicable, ecological** islanding (no greenhouse emission);
- Start **MV islanding** and start islanding beyond the smart meter (1-site scale);
- Use a **main storage system** (GFU) as master of the islanding which controls and maintains the frequency and the voltage in the thresholds;
- Remotely start an **automatic and maneuverable islanding** by Enedis' technicians from the Regional Grid Supervisor;
- Use **the support of aggregators** through the clients' load management to increase the theoretical duration of the islanding by delivering a service to Enedis;
- Use a **secondary storage system** (GSU) owned and operated by ENGIE to deliver a service to Enedis.

2.1.3 Step by step analysis of the scenarios

This section describes the **step by step analysis of different scenarios of actors and equipments**. The primary scenarios describe the normal/expected situation whereas secondary scenarios describe what would happen in case of an incident.

Table 4. List of the scenarios

Scenario No.	Scenario Name	Scenario Description	Triggering Event	Pre-Condition	Post-Condition
PS1	Short-term islanding required by the DSO	Due to an incident, the DSO needs to start an islanding in order to maintain the power supply of the islandable area	The DSO needs to start an islanding		**Islanding started**
PS2	Mid-term islanding scheduled by the DSO	The DSO needs to schedule an islanding in order to maintain the power supply of the area for works needs for example	The DSO needs to schedule an islanding		**Islanding scheduled & Aggregator informed**
PS3	Automatic islanding to overcome a blackout	A blackout occurs upstream, the GFU assesses whether an islanding is possible. If yes, the islanding starts with a black start.	A blackout occurs upstream	GFU's indicators are good & Regional control room authorizes the islanding & Failure comes from upstream	
PS4	GFU's state of charge is too low	The islanding's life is in danger because the GFU does not have enough charge to supply the clients in the islandable area (consumption	Islanding in progress	Low state of charge of the GFU & overconsumption on the islanding area	**Increase of islanding duration**

PS5	GFU's state of charge is too high	The islanding is in danger because the GFU has no more space to charge the storage system (generation >	Islanding in progress	High state of charge of the GFU & overgeneration on the islanding area	**Increase of islanding duration**
PS6	Enedis requires a reconnection of the islandable area	The islanding must be stopped to be reconnected to the main distribution grid.	Voltage upstream & Enedis' requirement	Islanding in progress	**Islandable area reconnected to the main grid**
PS7	Net load exceeds the GFU's capacity	The local net load is too high in comparison with the GFU capacity. The islanding is in danger.	Islanding in progress	Overconsumption on the islanding area exceeding the GFU's capacity	**Islanding lasts longer**
AS1	**A fault appears into the islandable area**	**The GFU detects a fault in the islanding area.**	**Detection of a fault**	**Islanding in progress**	**End of islanding OR fault elimination**

The scenarios are further described in Appendix 4.

2.1.4 KPIs

The KPI are described in Appendix 4.

2.2 Location of the tests

Two areas are studied for the islanding purpose. The first option concerns the **islanding of *Lérins*' islands**. The definitive choice will depend on two applications from ENGIE and EDF to a call from ERDF[10] (*European Regional Development Fund*) to install **self consumption systems** including photovoltaic generation and an additional storage system on the islands. If both applications are successful, the islanding area will be *Lérins*' islands. If not, *Lérins*' islands will not have enough generation for islanding purpose and the islanding area will be chosen among a certain number of secondary substations in the West of the city of *Nice*.

2.2.1 *Lérins*' Islands

This section describes the *Lérins*' islands area and the applications of EDF and ENGIE to ERDF fund.

---

[10] http://ec.europa.eu/regional_policy/en/funding/erdf/

2.2.1.1 General information

The *Lérins*’ islands are an archipelago of several islands, in the south of *Cannes* City, France. It is constituted of **two main islands**: “*Sainte-Marguerite*” and “*Saint-Honorat*”. The first one is 2.1 km^2 and the second one 0.37 km^2. The other islands are very small and are not inhabited. “*Sainte-Marguerite*” is the biggest and nearest island to Cannes. It is located at 1.1 km from the coast. Both islands are protected natural areas. They present forests and historical monuments (“*le Fort royal” and “l’abbaye de Saint-Honorat”*) which means that every change on these islands must be studied by an organization to assess whether it denatures the landscape.

Figure 3. Helicopter view of Lérins' islands[11]

2.2.1.2 Grid situation on Lérins’ islands

The islands are supplied by a transformer in Cannes through a **single submarine cable** of 10 kV of nominal voltage. Today, there is **no “N-1” configuration** that can supply the customers on these islands in case of a **loss of the submarine cable**. In *Nice Smart Valley*, islanding the *Lérins*’ islands will allow an **autonomous operation of the islands** in case of grid’s works or incident on the upstream grid. There are **56 customers** connected to the LV grids on the islands who get their power supply from **5 secondary substations** (thereof only one on Saint-Honorat. There are 4 customers on that island including a monastery). The maximal consumption of the islands is about **350 kVA**. Today, there is **no generation on these islands**. As the duration of islanding depends on the balance generation and consumption, **generation is recommended to increase the theoretical maximum duration of islanding**. Figure 4 below displays the situation of the two Lérins’ islands.

---

[11] Source: http://www.bespokeyachtcharter.com/luxury-yacht-charter/iles-de-lerins/

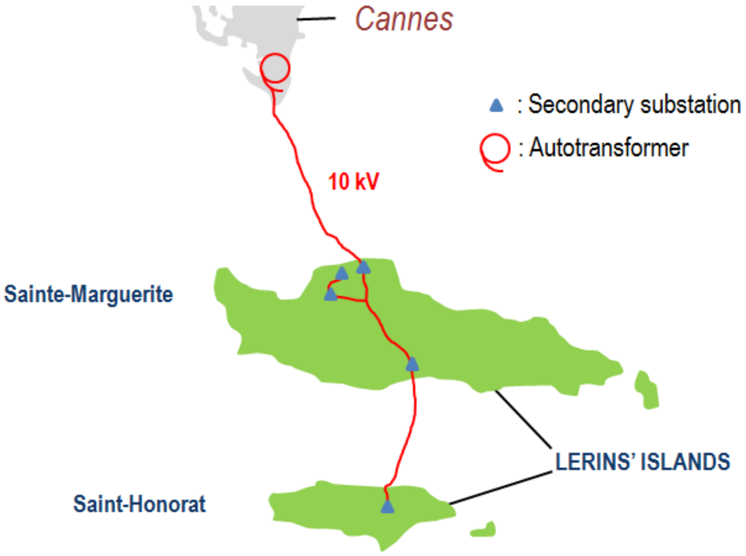


Figure 4. Grid situation on Lérins' islands

Next section describes the **expected equipments** that mostly depend on the ERDF applications from EDF and ENGIE.

2.2.1.3 Equipments expected on Lérins' islands

EDF and ENGIE applied to a European fund to set up self consumption systems on the *Lérins*' islands. These equipments may be useful for islanding as it will give some flexibility to the islands and could help the **islanding to last longer**.

a) Sainte-Marguerite (EDF)

If EDF's application is accepted, 2x500 m^2 of **photovoltaic panels** on "*Sainte-Marguerite*" will be installed. 500 m^2 of PV are planned to be connected to a very close substation and the other will be connected to another substation through around 300m of cable.

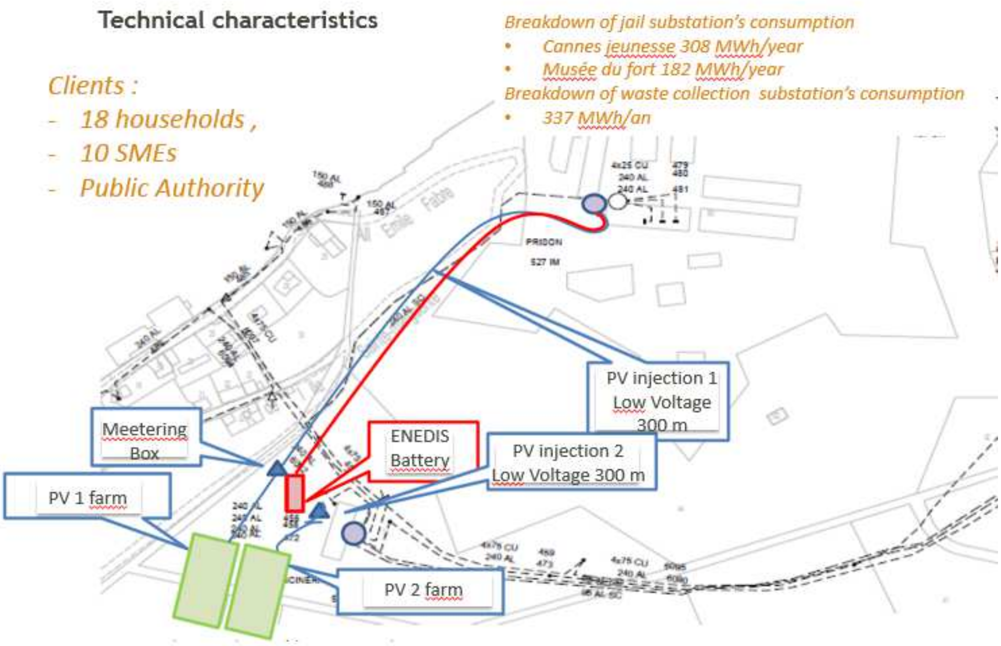


Figure 5. EDF proposed installation on « Sainte-Marguerite »

Enedis plans to install a **250 kW/620 kWh storage system** from *Nice Grid* (a previous smart grid project).

b) Saint-Honorat (ENGIE)

This section of the deliverable (ENGIE) is confidential. The following abstract is provided:

ENGIE plans to install **local PV production**, a **static storage** and remote monitoring and controlling devices in order to pilot flexible electric load. Then ENGIE plans to organize power exchanges between the 4 clients of *Saint-Honorat* Island. The objective is to minimize cost of electricity for the clients and to maximize self-consumption on the island which is connected to the main grid by a submarine cable.

ENGIE will rely on all these flexibilities and generation capacities to deliver an islanding service to the Abbey, and to **provide support services to the local grid islanding managed by Enedis.**

2.2.2 Alternative areas

"*Plaine du Var*" lies to the west of Nice. It includes western districts of Nice, a part of Saint Laurent du Var and towns all along the Var River as Carros, Le Broc and Gilette. It is an area involved in economic and ecological development through the *Eco Vallée* project.

"*Plaine du Var*" is an area where there is a **high rate of photovoltaic generation installed which is required for islanding purpose**. Investigations have been concentrated on the Lingostière and Saint-Isidore districts of Nice, and on the city of Carros, in which the project *Nice Grid* had been realized.

If islanding is performed on the *“Plaine du Var”* area, it will be done at **an LV level which means at a secondary substation level.**

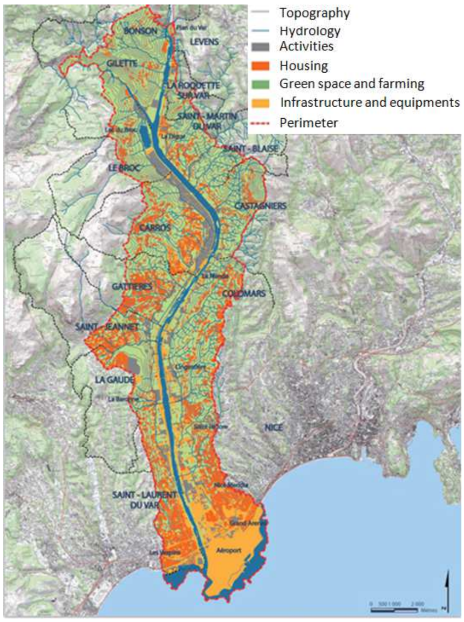


Figure 6. Map of the « Plaine du Var » area[12]

In order to select the LV districts where the islanding could be realized, **research of the existing photovoltaic generation** has been done on the different secondary substations of the considered areas. The following table shows the substation with the highest rate of generation compared to the substation’s power in the areas.

Table 5. Potential secondary substation for islanding in Carros

	Secondary substation's name	Pesquier	Docks Trachel	Colombie	Caille-tiers	Plaine 1	Rose-marines	Salles
Transformer	Transformer's rating power (kVA)	630	400	630	400	250	630	250
Customers	# of clients type “Pro” (≤ 36 kVA)	7	7	24	8	4	2	1
	# of clients type “Private individual” (≤ 36 kVA)	99	2	155	102	94	44	0
	# of clients (> 36 kVA)	2	3	1	0	0	0	1
Production	Type	PV	PV	PV	PV	PV	PV	PV
	# of producers	10	3	10	12	9	13	1
	Total production (kWc)	52	423	32	53	63	56	180

---

[12] http://www.ecovallee-plaineduvar.fr/sites/default/files/wysiwyg/territoire_vivant.jpg

Regarding the previous table, the substation with the highest PV generation / consumption rate is “Docks Trachel” which was the islanding substation of *Nice Grid*.

2.3 Islanding specifications

This section describes the **islanding specifications** in *Nice Smart Valley*. It includes the **two technical solutions** studied by the project, the different type of islanding, the different services that would be delivered and the specifications of every islanding device (*from the storage system to the disconnecting point)*.

2.3.1 Technical solution to island

The next section describes the technical solution to island the two *Lérins*’ islands.

2.3.1.1 Islanding at the MV level

The islanding solution **at the MV level** would consist in **opening the MV side of the first secondary substation** of *Sainte-Marguerite*.

This solution requires some **new equipment on the grid**. First, the **MV breaker** (*called islanding breaker*) which will secure the islanding does not exist at this location on Enedis’ distribution grids. Moreover, as soon as the islanding breaker will trip, the MV grid behind will not be connected to the primary substation. Indeed the islandable grid would not be able to use the grounding at the MV level of the primary substation which is fundamental for the power protection scheme of Enedis. The islandable network would then be in an isolated grounding which is unused by Enedis. The power protection scheme of Enedis would not be efficient anymore to detect the single-phase fault on the MV grids. To overcome this situation, **some reflections are in progress on using a zero-sequence generator which would replace the grounding of the primary substation to return to the traditional protection plan at Enedis**.

The main advantage of this solution is that islanding is generalized on the islands. There would be an only one islanding to supervise in the project. The main drawback is that it requires **some new equipment that Enedis does not often use**.

2.3.1.2 Islanding at the LV level

This islanding possibility would consist in islanding the LV side of the secondary substations. This solution would be similar to the one that had been tested in *Nice Grid*. This solution presents the advantage that it does not require an adaptation of the power protection scheme as the islanding of the MV level would but it would multiply the number of islanding that would be observed. Moreover, as it was written in the previous sections, the *Lérins*’ islands are natural protected areas which mean that it is not possible to install equipment everywhere on it. For this reason, **it would not be possible to island every client on the islands.**

2.3.2 Different types of islanding that will be tested

The following table presents the different islanding types have been examined:

Table 6. Description of the type of islanding studied

Type of islanding	Short description	Advantage	Drawback
Automatic with short blackout	As soon as a blackout is detected, the islanding breaker is switched off to let the islands ready to be islanded by the GFU.	- Clients can still be supplied even if there is a blackout upstream. - Short blackout duration.	- Blackout exists as in Enedis' traditional N-1 configuration. - Levers cannot be anticipated by the aggregators.
Required by the DSO	Regional control room of the DSO can remotely start an islanding.	- Short blackout duration. - DSO's lever needs can be anticipated by the aggregators.	Blackout exists as in Enedis' traditional N-1 configuration.

In the project, different types of services will be studied:

- **Services provided by the aggregators to help the DSO** maintaining the quality of service during islanding. This is the one tested in *Nice Smart Valley*.
- **Services provided by the DSO for specific customers with critic processes** to make them having a shorter blackout than the DSO's requirements. The islanding would be started at the scale of several clients pooling the islanding resources. The main issue of this solution is that it is highly unlikely to have a part of the grid only with customers with critic processes or customers that would pay for a service increasing their power supply duration. If this solution was implemented it would require leaving some customers in blackout while some others would benefit from it as they would pay for islanding. This situation is impossible for Enedis as it would lead to a two-tier situation which is contrary to Enedis' mission.

2.3.3 Specification of the disconnection point

It will depend on the chosen area for islanding and **will be defined later in the project.**

2.3.4 Specification of the interface at control room

It will depend on the chosen area for islanding and **will be defined later in the project.**

Different parameters will be displayed on a **graphical interface**. The electrical parameters will be the following:

- the frequency measurement in the islanding grid,
- the voltage at the GFU's,
- the state of charge of the GFU,
- the temperature in the container,
- etc.

It will also include an interface that allow for **remotely start, schedule or stop an islanding.** The interface will be available through an Enedis' IT. In other words, it means that every authorized employee of Enedis will be able to see the information. For safety reasons, the access to the start/stop islanding page will **be limited to the Regional Grid Supervisory employees.**

2.3.5 Storage solution

2.3.5.1 Storage asset

It is decided due to site installation and implementation constraints to **use a single storage asset** for the GFU. There are advantages to this:

- Separation of the conversion and storage (storage asset) components for optimal integration in regard to available space.
- Use of a standard shipping container from Saft integrating all the auxiliaries necessary to run the lithium-ion batteries.

Figure 7. GFU storage asset container

The Saft *Intensium Max E* 20-foot shipping container is used to store up to 620 kWh of energy and is supplied by a voltage of 800 V_{DC}.

2.3.5.2 Power Converter System (PCS)

The latest in a long line of products (UPSs, PV inverters), SOCOMEC's SUNSYS PCS² is a bidirectional power converter based on a modular architecture consisting of on-load replaceable 33-kVA power modules:

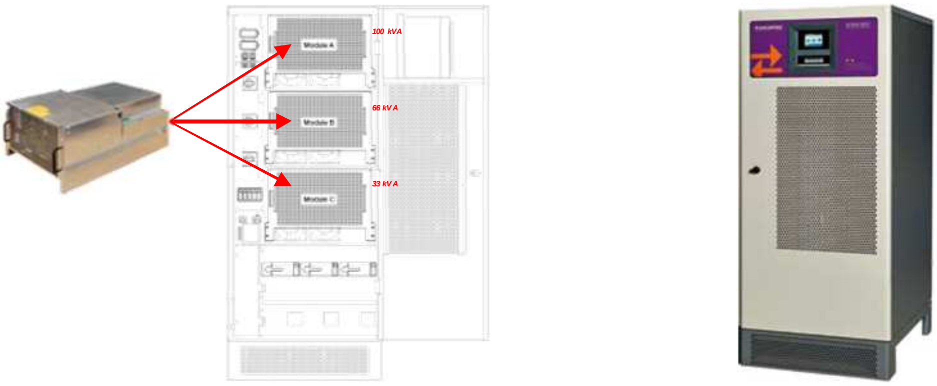


Figure 8. SUNSYS PCS² modular architecture[13]

---

[13] Source: SOCOMEC.

A modular architecture consisting of four 66-kVA SUNSYS PCS² is selected. This set-up offered several advantages:

- Ease of handling and integration.
- Increased availability. In the event of preventive or corrective maintenance, the entire system does not go down. Only the affected 33-kVA module or converter unit is stopped.
- Possible increased service life by running just the right number of converters needed and finding the best operating point for maximum efficiency.

Like PV inverters, most of the power converters for energy storage systems operate in **current source mode**. An ideal current source delivers a constant current irrespective of the load on the circuit (infinite internal resistance). The output current is controlled and the voltage depends on the load. In France, such inverters and converters must not function without a reference voltage and frequency supplied by the main distribution grid. As a result, and to avoid this situation, Enedis usually requires an algorithm into the inverters that is able to detect an unintentional islanding (*see section 2.4.3 for more details*).

Because islanding by definition involves disconnecting from the main distribution grid, it requires **bidirectional power converters operating in voltage source mode**. An ideal voltage source maintains a fixed voltage drop across its two terminals irrespective of load (zero internal resistance). The output voltage is controlled and the current depends on the load.

In on-grid mode, the main distribution grid provides the reference voltage and frequency. The energy storage system controls active and reactive power by charging or discharging the storage asset according to the commands received from the grid manager in response to energy flow management and voltage/frequency control needs.

During islanding sequences, the energy storage system provides the reference values and controls the voltage and frequency of the islanded grid. It switches seamlessly between charge and discharge modes depending on the balance of energy generation/consumption.

2.3.5.3 Islanding Control System

Islanding Control System is the central nervous system of the entire project. It basically consists of a programmable logic controller (PLC), a user interface (UI), and a synchronization/connection/control/protection circuit board.

It provides all of the following functions:

1. **Supervision** of the storage asset and management of its operating limits;
2. **Measurement and analysis** of electrical parameters on the main grid and islanded grid;
3. **Load distribution** to the different converter units depending on their capacity;
4. **Load transfer** during scheduled islanding sequences (to achieve P=0 at connection point between the main grid and the islanded grid);
5. **Coordination of the Black Start** function during automatic islanding;
6. **Regulation of PV generation and the GSU** (Function P(f)) when the system reaches operating limits;
7. *Optional: Synchronization and automatic connection of the islanded grid to the main grid when islanding ends;*
8. **Circuit breaker control** of the storage circuit breaker for the GFU;
9. **Additional isolation protection** (also built into the SUNSYS PCS² converters).

2.4 Involvement of customers for islanding support

2.4.1 Support of additional storage

Two solutions are under investigation in the project. They both use **the frequency as a vector of communication through the grid**. The main difference relies in GSU's behavior as in solution one it would behave as a current generator whereas in solution 2, it would behave as a voltage generator. **The final choice will be made after some simulations to be performed to assess the stability of the islanding in both solutions**.

Next sections describe the two solutions.

2.4.1.1 Solution 1

The GSU will have the capacity to help the GFU (250 kW / 620 kWh) to maintain the frequency stability of the islanding. The GFU will have the capacity to modulate the injected voltage frequency in function of its state of charge. This function will be called f(SoC).

Using the frequency as a vector of communication presents a main advantage as is does not imply a new telecommunication channel. As almost every power converter connected to the network is regulated with a frequency measurement, a modification of GFU's regulation seems sufficient to send the information of GFU's state of charge through the network. Another advantage is that everyone on the islanded network will receive the information as the frequency naturally propagates through the entire islanded area.

The target frequency of the islanding will be defined by the SoC(f) displayed in Figure 9 below.

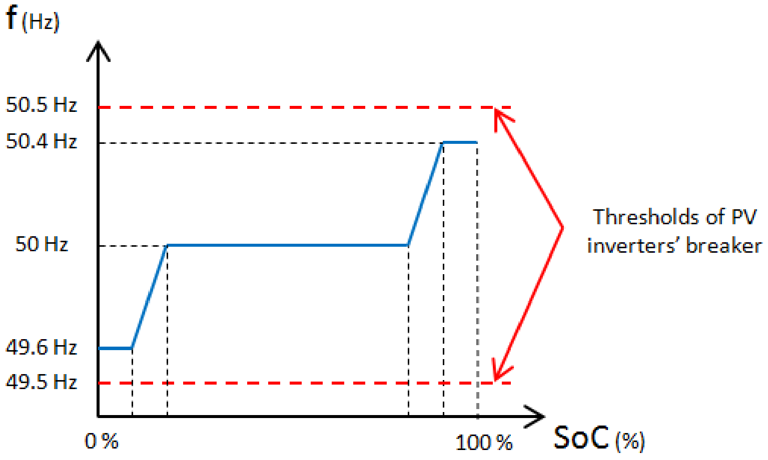


Figure 9. f(SoC) regulation of the GFU

The thresholds of the P(f) function are not defined yet but it would be implemented in the same way as the transmission grid:

- In case of overgeneration on the islanding area, the GFU will increase the frequency over 50 Hz.
- In case of overconsumption on the islanding area, the GFU will decrease the frequency under 50 Hz.

The GSU will reply to this frequency measure with the P(f) regulation showed in Figure 10.

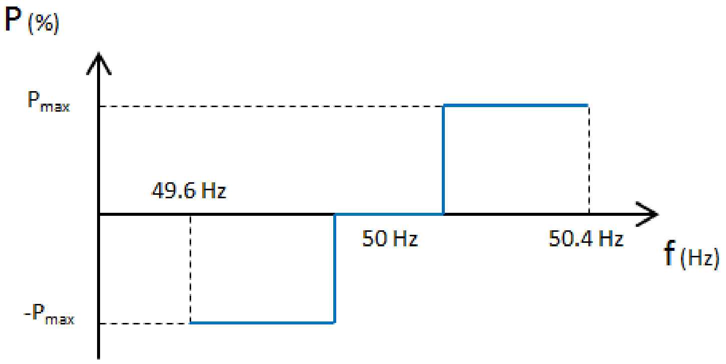


Figure 10. P(f) regulation of the GSU

A frequency pattern can be used to let the GFU know that the islanding is occurring. In the same way, another frequency pattern can be used to let the GSU know that islanding is going to stop. *These patterns are not defined yet in Nice Smart Valley.*

2.4.1.2 Solution 2

The first analysis of the network at HV and LV level has identified a risk of stability due to the impedances coming from the distances between the devices, their localizations and mainly due to the sub-marine cable (which could be capacitive). Due to the impedances of the grid, generators oscillations might occur and make the grid unstable.

The present control is designed to operate in optimal condition in an inductive network. Therefore a more precise grid simulation is requested in order to master this risk.

Due to the installation configuration on the two islands, the solution proposed by Socomec will be the operating the two BESS as a Grid Forming Unit (voltage generators distributed into the grid without any communication).

The BESS located on the island Ste Marguerite will be the “Master BESS” and the BESS located on the island St Honorat will be the “slave BESS”

In order to fulfill all the requirements a new algorithm has to be developed which gives the possibility to share the power level among the converters in off-grid mode. In this way, the “Master BESS” (Enedis) can control the contribution of the “Slave BESS” (ENGIE) to the grid.

The same algorithm will be used by each converter to protect itself autonomously against operating conditions out of the limits (e.g. high level of SoC).

This new and innovative functional mode will request to re-design the control architecture of both converter, the “Master BESS” and the “Slave BESS”.

A deeper feasibility analysis will confirm that it will work in all conditions and will keep the grid stability.

The critical design issue will be to master all the energy exchanges between the entire converters involved in storage and PV, in all directions, at the expected level and keeping the frequency plus the grid stable and compliant with the standards.

The feasibility has also to take into account the architectures and settings of the several loops involved in the control (current, voltage, etc…) at the right response time.

Due to the complexity of the installation, the distances between the devices all the innovations have to be qualified by simulations and by real field tests.

The study we will also consider some particular operating modes like:

- Black start with the consumption above the power capability of the "Master BESS". Partial downgrade of the consumption has to be managed in order to launch the black start.
- Black start in similar condition as above except that thanks to the "Slave BESS" the consumption is compatible with the two BESS.
- With several "Slave BESS" located somewhere in the low voltage distribution.

Beside the functionalities described above, a fast and reliable communication line is requested between the islanding switch at high voltage (located in Guerite) and the "Master BESS" (located in Prison). The best technology for this line would be an optical fiber. The aim is for the re-synchronization to the grid and for islanding without black-out.

2.4.2 Support of prosumers

Aggregators will be able to deliver to Enedis the required flexibility in order to keep a part of the grid powered during the maximum duration. The flexibility will have to be activated in real-time depending on local measurements into the islanding area.

The details of the technical activation of the prosumers are not defined yet in *Nice Smart Valley*.

The flexibilities of ENGIE assets on Saint-Honorat (PV, storage asset, DSM) will permit to support an islanding situation if required by Enedis. The DSM capacities involved are made of heat pumps, water heaters within hot water tanks, electrical heaters.
As Enedis would directly manage ENGIE assets during islanding, an operational constraints frame must be designed. This will be done accordingly to the services contract which should be designed in the coming weeks.

2.4.3 Support of local generation

2.4.3.1 P(f) regulation

Distributed energy resources will be able to help the islanding to last longer as it decreases the net consumption of the islanding area.

There is one case where the local generation can be a problem for islanding. It concerns the case when the islands might be in overgeneration. If this happens and if the state of charge of the GFU is close to 100% the GFU will not be able to maintain the stability of the islanding.

To overcome this potential issue, the PV inverters will have a P(f) function that will decrease the generation when the GFU commands an overfrequency. The thresholds of the regulation are not defined yet because they will depend on the chosen area. This solution will also be relatively cheap as recent inverters have a similar native P(f) function required by the European grid codes.

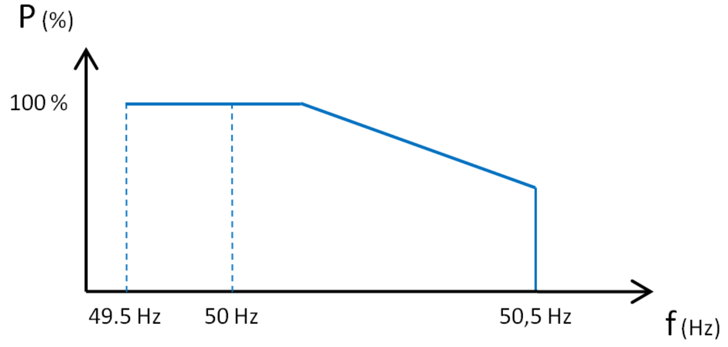


Figure 11. P(f) regulation of the photovoltaic generation

2.4.3.2 Replacement of the anti-islanding function in LV generators

In France most of the DER connected to the LV grid has an anti-islanding function supposed to stop an unintentional islanding. The shape of the algorithm depends on the PV inverter's manufacturer and can be a threat for intentional islanding as it trips the coupling breaker of the PV inverter. In *Nice Smart Valley*, to overcome this potential problem, it has been decided to implement a coupling breaker (called B.1 in France) that does not include this algorithm. The range of the thresholds of this protection are closer to nominal values (50 Hz ± 0.5 Hz and 400 V ± 60 V) than the range of other protections (47.5 Hz < f < 50.6 Hz and 320 V < U < 460 V) but it should not be a problem as the GFU will have the capacity to control the frequency and the voltage magnitude quite well.

2.5 Smart Grid Architecture Model (SGAM)

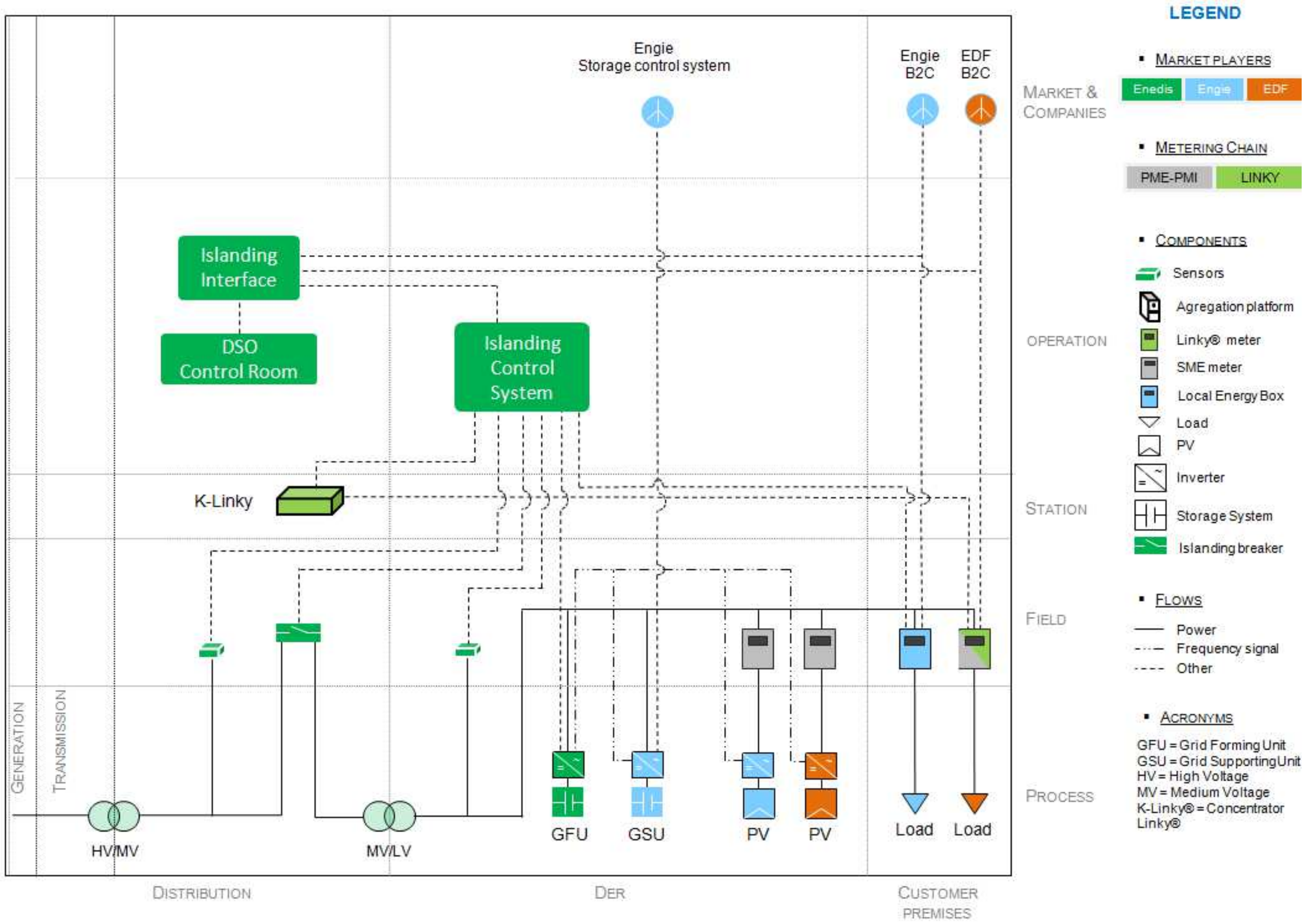


Figure 12. SGAM Model for Use Case 1

2.6 Next steps

This section summarizes the next step of the project and the planning.

2.6.1 Practical level

Regarding the experimentations on the field and the technical aspects, the next steps are already in process or will be carried out in the coming months:

- **Choice of the islanding area**, depending on the result of the ERDF call for tender in *Lérins*;
- **Administrative processes** to prepare the installations of PV and storage systems in the Lérins islands;
- **Islanding support service design for the DSO;**
- Finalization of the **specifications for the communication and regulation of the two storage systems**;
- Specification of the **interface deployed at the Enedis control room** to monitor and activate islanding remotely;
- Specification of the **regulation for customers supporting the islanding**;
- **Installation of the storage systems and PV generation** on site;
- **Recruitment of customers;**
- **Islanding tests.**

2.6.2 Theoretical level

On the theoretical level, the project will run in parallel some analyses that will be detailed in the deliverables in 2019:

- Findings on the **business models**
- **Contractual approaches** between DSO and aggregators

2.6.3 Planning

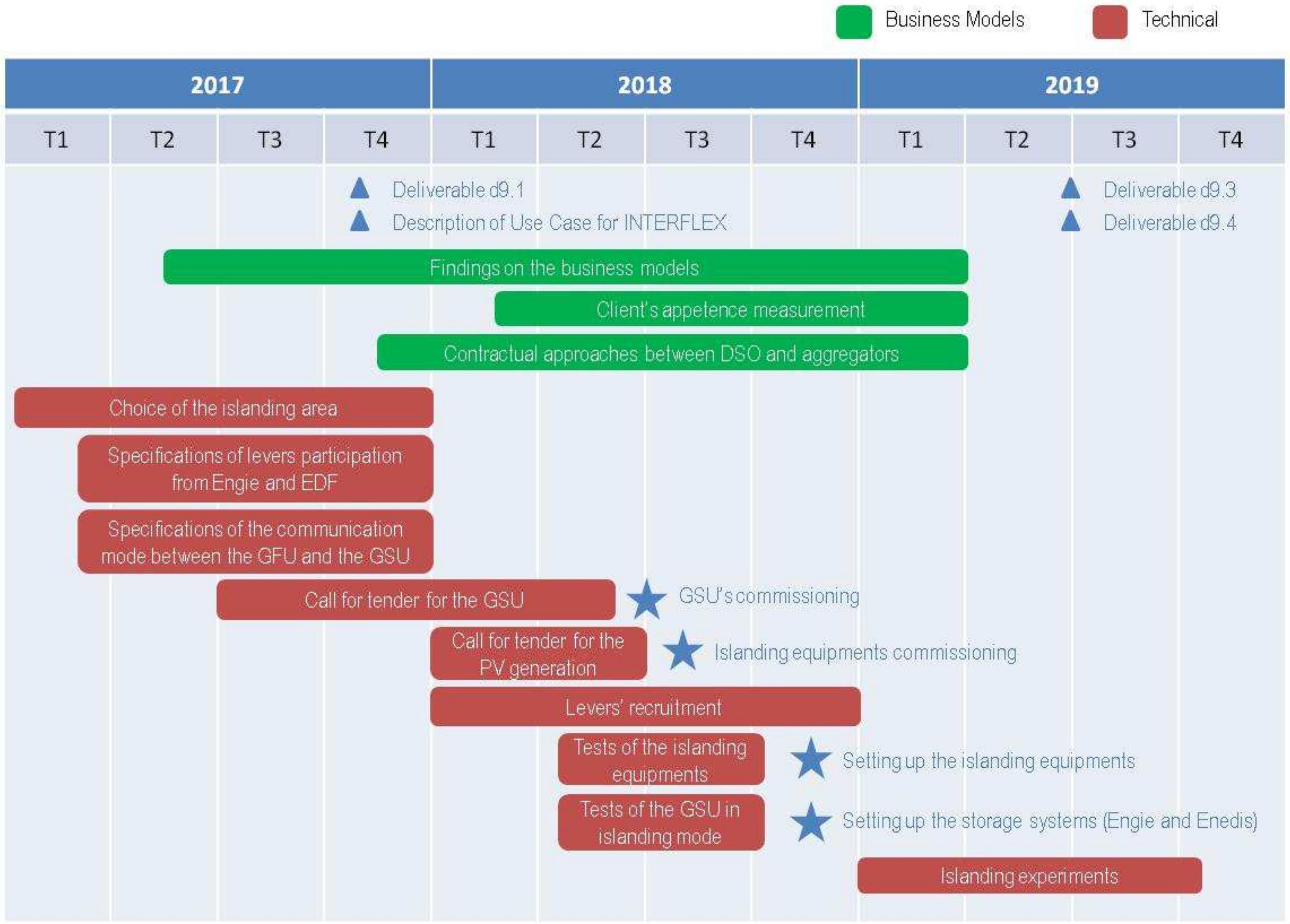


Figure 13. Planning for the use case

3. USE CASE 2 – MULTISERVICE APPROACH FOR GRID-CONNECTED STORAGE SYSTEMS

This use case is dedicated to the multiservice approach for grid-connected storage systems. It will be studied in two approaches:

- **Testing on the field**

The experiments, forecasted for the beginning of 2019, will allow for dispatching storage systems delivering the following services:

- "Cloud storage": using community energy storage assets to increase self consumption for customers
- Ancillary services and services on the national level (e.g. capacity and reserve mechanisms)
- Simulating grid constraints for the distribution grid on the MV level
- Islanding
- Optimization of power sourcing for end customer, including load report from peak to offpeak period and reduction of subscribed power

- **Simulation, business models and market design approach**

On the other hand, this theoretical approach should:

- Evaluate business models for the storage systems
- Process simulations in a context of 50% renewable energy
- Analyze grid fees scenarios for storage systems in a context of 50% renewable
- Assess regulatory issues

3.1 Definitions

Operational stakeholder	Role
DSO	The entity responsible for the monitoring and the operation (the maintenance of the grid) of the grid, the control of grid system such as transformers, the planning and the construction and, finally the connection of the renewable energies and clients at the LV and MV grid. In France, this operator is responsible for both the medium (20 kV) and low voltage (400 V), and regulates the voltage so that the final user is supplied according to the European standard EN50160. The DSO controls the MV grid from a regional control room, from which the flexibility could be activated to manage local distribution grid constraints.
Aggregator	An entity that combines the flexibility capacities from multiple loads and/or generators and/or storage systems. It first prospects for the flexibility potentials in a given area, contracts these flexibilities and installs the necessary equipment. It then operates the flexibility through an aggregation platform in order to either sell on national markets/mechanisms or to solve local grid constraints.

Storage Operator	Entity which is in charge to ensure storage availability and to execute charges and discharges according to the orders received from its stakeholders. There can be several Storage Operator on a grid down a MV/LV transformer as there may be several storage asset down a MV/LV transformer. There is only one Storage Operator per storage asset

3.2 Cloud storage principle

3.2.1 Collective self-consumption

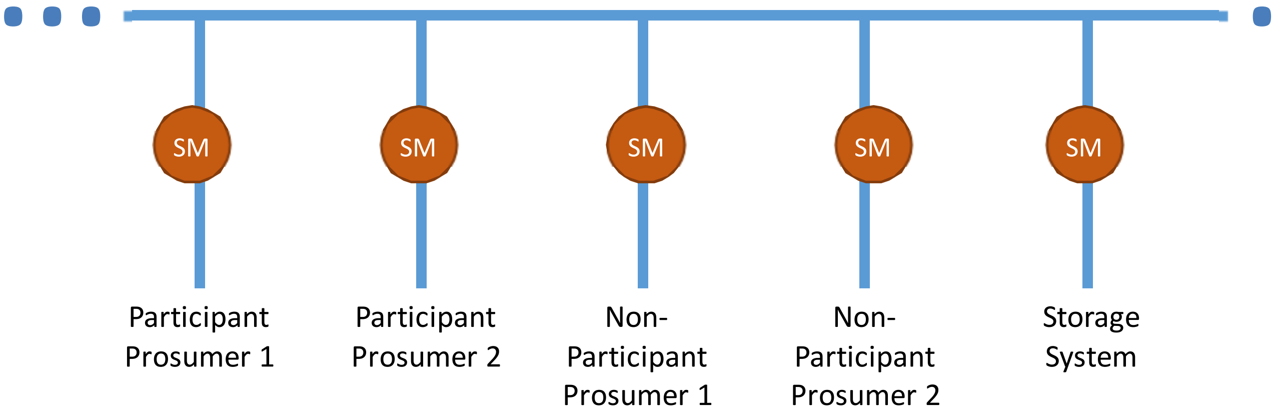
In France, the framework for collective self-consumption lays on two pieces of legislation:

- The “Self-consumption ordinance” (“Ordonnance autoconsommation” in French) defined “self-consumption” and “collective self-consumption” for the first time in French law. It imposes a legal person that oversees all collective self-consumption operations and which is also responsible for calculating the coefficients that will indicate how production will be allotted to the consumers. It also mandated the French Energy Regulation Agency (CRE, in its French acronym) to set a special grid tariff for self-consumption.
- The “Self-consumption decree” (“Décret autoconsommation” in French) detailed the application of the ordinance. It established that the load curves would be recorded every 30 minutes. It clarified the role of storage systems in self-consumption systems. It extended the right to a special network tariff to any producers in self-consumption with a maximum of 100 kW of production, even if, globally, the self-consumption systems has a higher production capacity.

3.2.2 Cloud storage

The “cloud storage” solution proposed by this document will encompass several prosumers that are connected to the distribution grid. In this Use Case, some prosumers could have PV panels even before recruitment takes place, and the target area for the demonstrator will be chosen among the areas with the highest numbers of PV producers already installed. In addition, Enedis expects that some, if not most, of them already have smart meters measuring both the energy produced and consumed.

The storage system is thus a layer to be added to an already existing and functioning system, and it must also take into consideration that not all consumers connected to the same feeder will agree to participate. A possible structure is shown below, where the storage system is integrated into an existent feeder. Each prosumer, as well as the storage system, is equipped with a smart meter, marked “SM” in the diagram.



We measure the interest of cloud storage by comparing it to the current solution relying on distributed storage installed down each prosumer' head meter with no exchanges between prosumers. The created value comes from: installation and maintenance costs pooling, sizing optimization and land use optimization.

It is necessary to determine the rules guiding the power exchanges between the prosumers, the DSO and the storage system. An important limit is the maximum storage capacity of the storage asset, since the storage system cannot indefinitely receive the energy produced by the prosumers.

3.2.3 Proposed solution for power flow reconciliation

Enedis proposed a preindustrial solution to reconciliate power flows, which could be used for the project, but needs to be dicussed with ENGIE.

The solution must respect the following principles:

- The power flows reconciliation is performed by a third party entity which neither a customer, neither a supplier, neither the entity in charge of the energy flows management;
- The solution must be accurate.

Enedis would collect the load curve of the participants and the charging curve of the shared storage. At the end of every month, Enedis would:

- Calculate the production and consumption for each participant and the share of the PV energy injected into the public distribution network
- Calculate the charging curve for the storage system
- Make these data public to all relevant stakeholders (energy supplier of each participant, balancing responsible party, legal person in charge of the operation

These data would be used to

- Calculate energy transport and distribution bills
- Calculate the remaining bills to be paid to the energy supplier

- Calculate taxes and fees
- Monitor the network balance

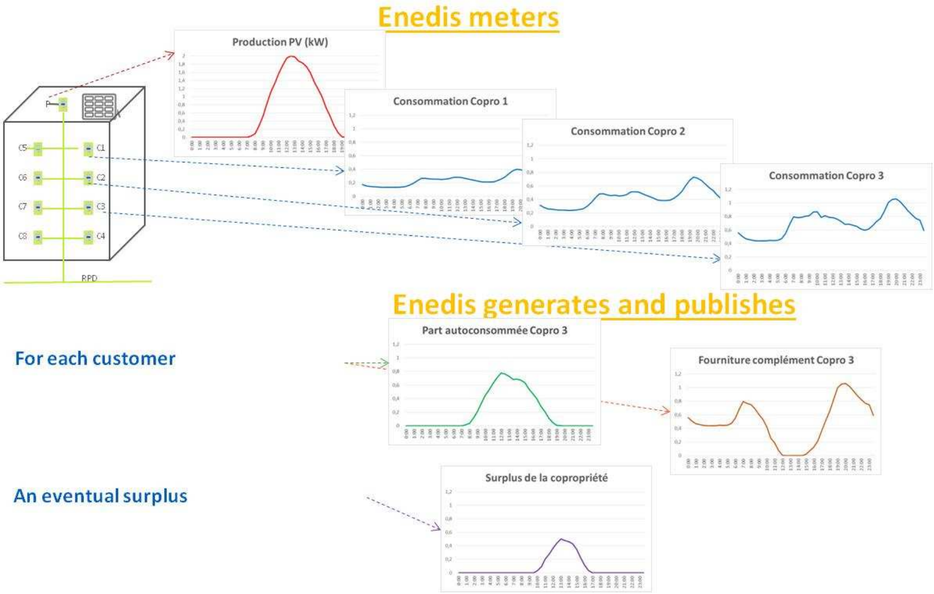


Figure 14 – Proposition of power flow reconciliation for collective self consumption

3.5 Location of tests

The choice of the location of the tests was based on the area covered by each secondary substation, according to the rules imposed by the regulatory changes mentioned in the introduction. Enedis' own database provides some information on each substation, such as the transformer's rating, the quantities of each type of consumer connected to the substation, the total energy generation capacity and the number of clients reporting problems. The final selection was ultimately dependent on three criteria: the number of PV producers connected to the substation, whether the substation experienced constraints and the number of clients reporting problems.

3.5.1 *Plaine du Var* area

The table on the next page gives an overview of the areas chosen to participate in the project.

The table on the next page gives an overview of the areas chosen to participate in the project.

Transformer	**Secondary substation's name**	**Selves**	**Pesquier**	**Docks Trachel**	**Colombie**	**Cailletiers**	**Lou Souleou**	**Plaine 1**	**Rosemarines**	**Salles**
	Transformer's rating (kVA)	160	400 or 630	400	630	400	400	250	630	250
	Constraints	134%	No	No	No	No	No	No	No	No
Clients	# of clients reporting problems	No	20	No	No	No	No	No	No	1
	# of clients type C5-Pro[14]	2	7	7	24	8	3	4	2	1
	# of clients type C5-Part[15]	75	99	2	155	102	87	94	44	0
	# of clients type C4[16]	0	2	3	1	0	0	0	0	1
Production	Generation	PV	PV	PV	PV	PV	PV	PV	PV	PV
	# of producers	4	10	3	10	12	5	9	13	1
	Total production (kWc)	6	52	423	32	53	18	63	56	180

		Lingostière - St Isidore		**Plaine du Var**		
Transformer	Secondary substation's name	Saquier 305	Villa de Flore	Carros Ecarts	Ginestière	Lei Ribo
	Transformer's rating (kVA)	160	250	400	160	100
	Constraints	120%	120%	No	No	103%
Clients	# of clients reporting problems	28	No	8	7	No
	# of clients type C5-Pro**Erreur ! Signet non défini.**	2	25	4	2	4
	# of clients type C5-Part**Erreur ! Signet non défini.**	50	85	101	42	34
	# of clients type C4**Erreur ! Signet non défini.**	0	0	0	0	0
Production	Generation	?	PV	PV	PV	PV
	# of producers	2	1	3	2	3
	Total production (kWc)	18	18	8	21	8

---

[14] Clients connected to the low voltage and under 36 kVA

[15] Clients connected to the low voltage grid and under 36 kVA

[16] Clients connected to the low voltage grid and over 36 kVA

3.5.2 Lérins islands

Lérins' islands are described in section 2.2.

3.6 ENGIE's storage services and feasibility of the cloud storage

This section of the deliverable (ENGIE) is confidential.

3.7 Next steps

3.7.1 Practical level

Regarding the experimentations on the field and the technical aspects, the next steps are already in process or will be carried out in the coming months:

- Choice of the location for the storage systems
- Specifications of the storage systems
- Specifications of the cloud storage solution
- Specification of the grid constraints on the LV level
- Installations and commissioning of storage systems
- Trials

3.7.2 Theoretical level

On the theoretical level, the project will run in parallel some analysis that will be detailed in the deliverables in 2019:

- Definition of grid fees scenarios
- Regulatory analysis
- Business model analysis

4. USE CASE 3: LOCAL FLEXIBILITY SYSTEM OPERATED BY THE DISTRIBUTION SYSTEM OPERATOR

This use case is dedicated to the use of flexibility managed by aggregators for the need of the DSO, using a local flexibility system. It will be studied in two approaches:

- **Testing on the field**

The experiments, forecasted for **mid 2018**, will allow for:

- Develop and test local **forecasting methods** for the aggregators: the idea is to predict the flexibility resource at the relevant local scale
- Test the process of local optimization, aggregation and dispatch of flexibilities by the aggregators
- Test **client behavior and responsiveness** for aggregators
- Test the **reliability of the use of flexibilities** by the distribution system operator
- Test the **entire chain of flexibility activation**, from Enedis to the flexibilities (customers or storage assets)
- Test the **forecasting method** (predictions and constraint simulations) at an **operational level** (e.g. control room) for Enedis
- Understand the **addition or cannibalization between two flexibility uses** for the distribution grid and other services in competition (e.g. ancillary services)
- Test the ability to **take advantage of the gas grid to make electrical flexibility available**, through innovative gas appliances (gas/electrical flexibility)
- Test other types of flexibility for the use of the distribution grid: EV, storage…

- **Simulation, business models and market design approach**

On the other hand, this theoretical approach should:

- Evaluate **need for flexibilities** in a context of 50% of renewable energy generation and penetration of EVs
- Estimate the **value of the aggregators' flexibilities** on the distribution level
- Converge on a **market design** for flexibilities, in term of contracting and compensation
- Estimate a potential "**missing money**" (difference between current value and cost of the flexibility) within the flexibility business model, in order to pave the way for flexibility in the future, when they will be needed for the grid operation

- **Note:**

The constraints on the distribution grid can occur on the MV or LV grid, and can be related to current power or voltage issues. In this deliverable, **the constraints on the MV grid, which have been extensively computed, are described in the different areas of the demonstrator.** The document describes also the system to involve flexibilities to solve these MV constraints. **Flexibilities connected to the MV and LV grid can take part to mitigate MV constraints.**

4.1 Description of the use case

This first section describes the main components, the involved stakeholders and the scenario of the use case.

4.1.1 Definitions

Flexibility represents any active means of load, storage or production management, able to temporarily modulate their load curves to deliver services to the electrical system. *Nice Smart Valley* will study the flexibilities connected either to the LV or to the MV grid, in order to manage distribution grid constraints.

The **local flexibility system** is a set of information systems allowing for the DSO to anticipate grid constraints and to activate flexibilities managed by aggregators. It is composed of two main tools, the **forecast management tool** and the **aggregator portal**.

The forecast management tool is a continuous process of real-time grid planning. It consists of a set of information systems, electrical grid sensors, procedures and organizations that help grid control and operation to manage the changing uses of the grid

It improves grid observability for the DSO. It also serves as a support to the interfaces between Enedis and the transmission system operator and energy generators.

An **aggregation platform** is an information system including sensor and remote control devices that the aggregators use in order to manage their flexibilities assets (e.g. demand side management at customer premises, storage and local generation). It allows for operating the flexibilities in order to monetize them for example to solve local grid constraints. This platform includes mainly the following functionalities: flexibility forecasting, aggregating and dispatching

The **aggregator portal** is an interfacing tool that the DSO and the Aggregators use to exchange data. It is an information system that provides all the necessary features that both parties need in order to create valid flexibility offers, examine and chose those offers.

4.1.2 Role of the operational stakeholders

Operational stakeholder	Role
DSO	The entity responsible for the control (the coordination of the power flows on the grid), the operation (the maintenance of the grid), the planning and the construction and, finally the connection of the renewable energies and clients at the LV and MV grid. In France, this operator is responsible for both the medium (20 kV) and low voltage (400 V), and regulates the voltage so that the final user is supplied according to the European standard EN50160. The DSO controls the MV grid from a regional control room, from which the flexibility can be activated to manage local distribution grid constraints.
Aggregator	An entity that combines the flexibility offers from multiple loads and/or generators and/or storage systems. It first prospects for the flexibility potentials in a given area, contracts these flexibilities and installs the necessary equipment. It then operates the flexibility through an aggregation platform in order to either sell on national markets/mechanisms or to solve local grid constraints.
GRDF	GRDF is the gas distribution operator and is in charge in this project of deploying innovative gas appliances able to provide flexibility to the distribution grid. GRDF is deploying a control and communication infrastructure, connected to a gas/electrical supervision platform. This plat form is connected to the two aggregators of the project which can offer flexibility to the DSO.

Customers	Here, an entity that consumes electricity through a supplier and who agrees to participate in the flexibility program, i.e. modulating temporarily its consumption, contracting with an aggregator.

4.1.3 Scope and objectives

- **Overall process between DSO and aggregators**

This use case aims at defining the way the **DSO can use the flexibilities for its needs**, the role of its actors and the technical details/the process of how they implement the flexibility. The anticipated constraints that appear on the MV grid are predicted based on the information provided by the **forecast management**. The **aggregator portal** is an interface between the control room of the DSO and the **aggregation platforms of the aggregators**.

- **Gas/electrical flexibilities**

GRDF is in charge of deploying the **gas/electrical flexibilities** and building the **control architecture**. GRDF is connecting its platform to the aggregation platforms of aggregator 1 and 2 (*each flexibility is connected to a unique aggregation platform*). The aggregators are then aggregating this flexibility then are offering it to the DSO, and sending control orders to the GRDF control platform.

4.1.4 KPIs

ID	Name	Description
WP2.2_KPI_3	Flexibility	The available power flexibility in a defined period (e.g. per day) that can be allocated by the DSO at a specific grid segment. Measured in MW. This in relation with the total amount of power in the specific grid segment in the same period.
WP2.2_KPI_5	Active participation of all kinds of flexibility	The DEMOs aspire to make use of flexibility from different technologies. If and how different types of technologies can actually be accessed and utilized during the DEMO phase depends on the number of different technologies that are available in the region of the DEMO as well as on the general capabilities of the DEMO. DEMOs have declared a number and types of technologies they are targeting during DEMO phase and will be measured against their initial aspirations.

4.1.5 Step by step analysis of use case

Two scenarios will be tested in the *Nice Smart Valley* project: a **day-ahead** *(preventive)* and an **intraday** *(emergency)* **scenario**. Before offering flexibilities to the DSO, the aggregators must **register** themselves and their **portfolio** to the **aggregator portal**, step which is described below.

4.1.5.1 Preliminary step: registration

The aggregator has to fill in its **administrative information** when connecting to the portal for the first time, or when adding new flexibility assets to its portfolio.

4.1.5.2 Day ahead scenario

The first scenario is a day ahead scenario, i.e. a **preventive activation of flexibility** to anticipate works on the grid or a predictable constraint or incident on the distribution grid. Within this approach, the flexibilities can be offered the **day before**.

4.1.5.3 Intraday Scenario

The **intraday scenario**, in case of unforeseen incident on the grid, will be different of the preventive scenario described above, because **the flexibility has to be involved in the very short term, near real time. This scenario is still under discussion between aggregators and the DSO**. The last steps of the preventive scenario **should remain unchanged** for the emergency scenario. The first step need to take into account the **emergency of the situation**, the **processing time at the regional control room**, and the **communication time between DSO and aggregators**.

4.2 The flexibility use for Enedis on MV grids

This section's main objective is to present the "Broc Carros", "Isola" and "Guillaumes" zones identified by the DSO for the flexibilities and the interest gained from implementing them. This section will detail the constraints that appear on the MV grid located in these zones and the results obtained from the grid calculations, to conclude then the need to use the flexibilities to resolve those constraints. The end of this section will tackle the approach used on the LV grid.

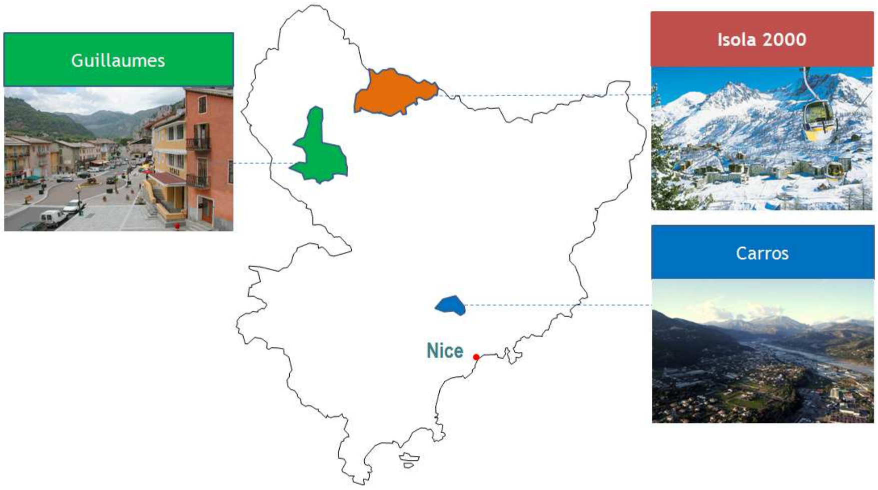


Figure 15. Perimeter of Nice Smart Valley in Alpes-Maritimes region

In this section, primary substations' names are written in capitals whereas towns' names are conventionally written. The description of the different areas is available in APPENDIX 2.

4.2.1 Presentation of the grid configuration in the three MV areas

4.2.1.1 Carros

Figure 16 provides an overview of the electrical grid under normal conditions and under N-1 conditions at the transformer level.

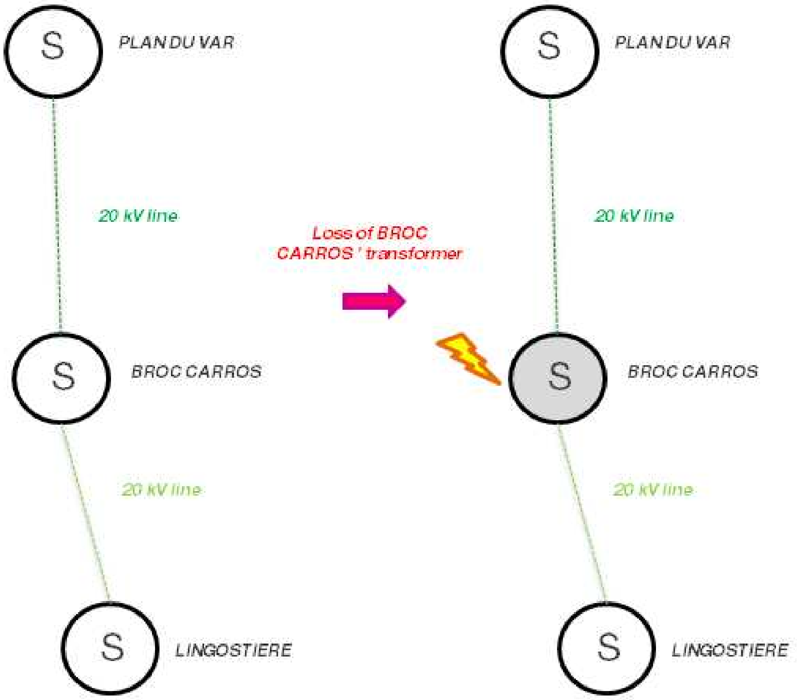


Figure 16. Overview of the electrical grid in the area under normal conditions and in the event of a loss at the transformer

Under normal conditions, the BROC CARROS primary substation is supplied from several high-voltage lines. A single incident requiring high-voltage equipment reliability can therefore not lead to a loss of supply at the high- and medium-voltage substation.[17] Nevertheless, this primary substation only has one transformer, which means that if the latter is tripped, the medium-voltage line will no longer be supplied. In the remainder of this document, we analyze flexibility requirements in the event of a loss affecting this transformer.

4.2.1.2 Isola

Figure 17 provides an overview of the electrical grid under normal conditions. Under normal conditions, the ISOLA 2000 primary substation is supplied from a high-voltage line between the portal structure and the ISOLA 2000 primary substation. But this very cable line is also one of the possible places for high-voltage line losses. When this happens, the ISOLA 2000 primary substation can no longer be supplied from the high-voltage line, which entails a need for reconfiguration in order to restore service to customers. Figure 17 shows the high-

---

[17] Scenarios under N-2 conditions were not tested because they are extremely rare.

voltage scenario under N-1 conditions involved in the line loss mentioned above. The two main reconfiguration operations are:

- the closing of the high-voltage normally open terminal between the portal structure and ISOLA VILLAGE;
- The closing of the medium-voltage normally open terminal between ISOLA VILLAGE and ISOLA 2000.

The ISOLA 2000 loads are then supplied via the medium-voltage line coming from the transformation of 63 kV into 20 kV at the ISOLA VILLAGE substation.

As the features of medium-voltage lines are not the same as those of high-voltage lines, it turns out that there may be load levels that can result in grid constraints. This point is discussed in section **2.2** below.

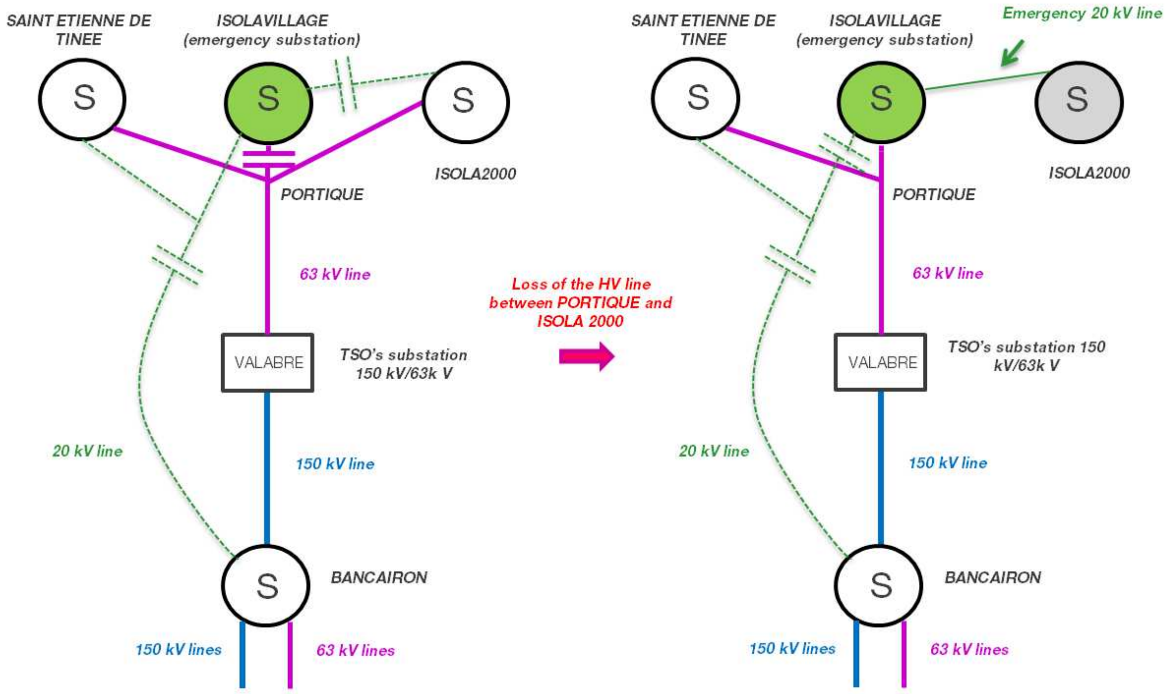


Figure 17. Overview of the electrical grid in the area under normal conditions (left) and under high-voltage N-1 emergency configuration (right)

Figure 18 provides an overview of the electrical grid under normal conditions and under N-1 conditions. Under normal conditions, the GUILLAUMES primary substation is supplied from a 63 kV high-voltage line. In the event of a loss on this line and/or at the level of the 63 kV/20 kV transformer, supply can no longer be received directly from the ENTREVAUX primary substation.

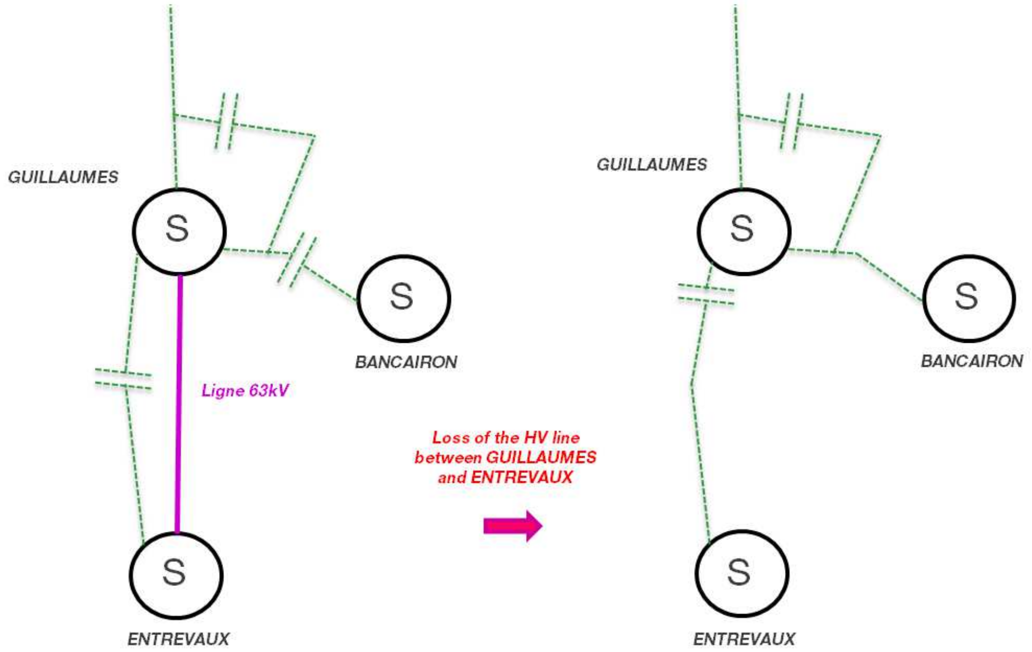


Figure 18. Overview of the electrical grid in the area under normal conditions and under N-1 conditions

4.2.2 Results of grid computations in the three MV areas

The detailed grid computations hypothesis and results are provided in APPENDIX 3. Table 7 presents the different results obtained with simulations, assuming an N-1 configuration all over a two-year period. It is recalled that only N-1 configuration leads to flexibility interest at MV level for the DSO.

The three areas of *Nice Smart Valley* have been selected according to a pre-study that showed the possible constraints in N-1 emergency configurations. Today, considering the current load level and the topological nature of the grid, study results for the three selected areas in *Nice Smart Valley* offer very low rates of occurrence for the potential activation of flexibility.

The potential DSO’s flexibility interest for other cases as avoiding constraints caused by a future building project was not assessed. Climatic hazards could be assessed. Moreover, the flexibility may have a higher likelihood of activation in the future as the distributed energy resources will be developed and new uses as electric vehicle will increase. To assess the potential of the flexibility, Enedis will perform some new simulations with different scenarios of increase of DERs and uses to assess the interest of the flexibility for the DSO. The definition of the scenarios is currently in progress, and the results of those simulations will be detailed in the final deliverable of the project.

Table 7. Summary of the opportunity of flexibilities in Nice Smart Valley, assuming an N-1 configuration all over a two-year period

	Isola	Carros	Guillaumes feeder 1	Guillaumes feeder 2
Maximum volume of useful flexibility	2.5 MW	0.45 MW	0.5 MW	0.66 MW
Number of constraint of 10 minutes duration	30	7	1	8
Number of constraint between 10 minutes and 40 minutes	25	2	1	3
Number of constraint higher than 40 min	25	0	3	2
Main months in constraint (≥ 80% of flexibilities opportunity)	December January	July	December January	December January
Hours of constraint[18]	10pm to 6am	11am to 2:30pm	11pm to 2am	10:30 pm to 2am
Power cut every[19] **…**	64±6 years	390±60 years	320±40 years	104±20 years
A long power cut (≥ 40 min) every[20]	146±15 years	(None)	570±130 years	340±50 years

4.2.3 Flexibility use on LV level

4.2.3.1 *Finding areas with flexibility interest for the DSO*

Enedis is looking for LV grids where there are generation and/or constraints into the grids. The idea is to test flexibility on-grid to assess whether it would be possible to use it to mitigate constraints.

The studied area was focused on the “Plaine du Var” which lies to the west of Nice.

a) Research of high PV-generation MV/LV transformer

The Table 8 shows the MV/LV transformers with the highest ratio: total production / transformer’s rating power of the studied area.

---

[18] According to the two-year simulations in N-1 configuration.

[19] Assessed with a Poisson process using the previous computation results and the normative rate of failure of HV and MV equipments.

[20] Assessed with a Poisson process using the previous computation results and the normative rate of failure of HV and MV equipments.

Table 8. Secondary substations with PV generation in the studied area

Carros						
Transformer	Secondary substation's name	Docks Trachel	Colombie	Cailletiers	Plaine 1	Rosemarines
	Transformer's rating power (kVA)	400	630	400	250	630
Clients	# of clients type "Pro" (≤ 36 kVA)	7	24	8	4	2
	# of clients type "Private individual" (≤ 36 kVA)	2	155	102	94	44
	# of clients (> 36 kVA)	3	1	0	0	0
Production	Type	PV	PV	PV	PV	PV
	# of producers	3	10	12	9	13
	Total production (kWc)	423	32	53	63	56

We can see that for most of the studied area, the ratios are not very high. Docks Trachel has the only one ratio over 30% but includes a very small number of clients to test flexibility in consumption.

Next part will show the different MV/LV substations and LV grids which could be subject to have constraints.

b) Results of the computations

A department of Enedis specialized on LV grids has studied the MV/LV transformers and LV grids where it would be interesting for the DSO to have some flexibility. It is important to note that this section only includes computation results as Enedis had almost no measure from the LV grid.

In France, most of the constraints appear at very high consumption moments which are mostly in winter (uses of heater) or summer (uses of air conditioning) seasons. The voltage constraints mainly appear at the end of the LV feeder where the voltage drop is usually high[21]. The current constraints can appear everywhere into the grid as it mainly depends on the cross-section and the type of the installed cable.

The Table 9 shows the results of the study. It shows the main characteristics of the MV/LV grid, the number of customers, the level of installed generation and the number of computed constraints[22].

---

[21] If there is almost no generation.

[22] Here the number of constraints is the number of customers that might have a voltage over or below the norms.

Table 9. Secondary substations in constraints according to computations

		Carros			Lingostière - St Isidore		Plaine du Var		
Transformer	Secondary substation's name	Sel-ves	Pes-quier	Sal-les	Saquier 305	Villa de Flore	Carros Ecarts	Ginest-ière	Lei Ribo
	Transformer's rating power (kVA)	160	630	250	160	250	400	160	100
Constraints	Transformer's load potential constraint	134%	0	0	120%	120%	0	0	103%
	# of clients in potential constraint	0	20	1	28	0	8	7	0
Clients	# of clients type "Pro" (≤ 36 kVA)	2	7	1	2	25	4	2	4
	# of clients type "Private individual" (≤ 36 kVA)	75	99	0	50	85	101	42	34
	# of clients (> 36 kVA)	0	2	1	0	0	0	0	0
Production	Type	PV	PV	PV	PV	PV	PV	PV	PV
	# of producers	4	10	1	2	1	3	2	3
	Total production (kWc)	6	52	180	18	18	8	21	8

In the studied area, there are:

- Four potential current constraints at the transformer level;
- Five potential voltage constraints into the grid.

We can also note that according to computation, an only one transformer have both current and voltage constraints.

These results show on which MV/LV transformer the constraints may appear on the grid. To assess whether constraints happen on-grid, Enedis has installed some recorders for short periods. These recorders are able to calculate other parameters that are under standards as harmonics.

c) Measurements campaign

Enedis has chosen to set up a measurement campaign on 7 of the 8 identified secondary substations displayed in Table 9. This campaign has been performed in May, 2017.

- **Set up**

The measurement campaign consisted in setting up a local recorder at the LV side of the MV/LV transformer that had been identified using simulations tools (see previous section for details). Two Fluke-type recorders have been used for a 1-week campaign of measurements for each MV/LV transformer. They were programmed to record the voltage, current, flicker, voltage unbalance and harmonics for an entire week. Both recorders were connected to two recording stations recording every parameters with a step of 30 s.

- **Results**

The results of this campaign did not show any voltage or current constraints at the MV/LV transformer. This result is not surprising for two reasons:

- The current constraint at the transformer should appear at very high consumption rate which was not the case during the measurement campaign.
- The recorders were installed at the LV side of the MV/LV transformers which lead to miss potential constraints downstream.

As a single measure is not sufficient to estimate the voltage and current everywhere on the grid, Enedis is studying the possibility to install a state estimator using the smart meters' sensors. It could give some information on what happens into the grid at the very high consumption moments and could be useful to activate the flexibility to mitigate constraints.

4.2.3.2 Approach on LV constraints mitigation

This approach is subject to feasibility studies and discussion among project partners.

a) Load forecast on LV grid

Resolving LV constraint is a challenge as it is very difficult to predict their appearances. Indeed, forecasting the LV consumption is a topic studied by laboratories for some years. Today, there is no method[1] able to evaluate - with near certainty - the consumption of a single or a few LV customers. As a consequence, trying to predict an LV constraint is utopian as it could be a false-positive of a missed constraint depending on the behavior of a few customers. For this reason, the solution cannot be 100% based on prediction tools and using sensors will be fundamental.

Different equipment will be installed by Enedis on the field. They could be useful to detect and mitigate the potential LV constraints.

b) LV grid automation

Enedis started to deploy its advanced metering infrastructure in December 2015. As a priority, Enedis will deploy its smart meters Linky (and the associated concentrator) on the selected areas. The Linky infrastructure brings the following inputs for the grid observability:

- When the load increases or decreases, the voltage on the distribution network is fluctuating. We speak about voltage excursion on a node of the low voltage network when the voltage is under 207 V or over 253 V (230 V +/-10%). The meter communicates the voltage value when it exceeds a certain configurable threshold for each meter. These measurements are useful for the detection of grid constraints.
- The Linky smart meters deployed in the areas can be used to detect and localize faults occurring on the grid
- The concentrator can be used as a gateway with the supervision of Enedis

---

[1] Including deep learning algorithm.

The smart meter communicates with the concentrator located in the secondary substation via power line carrier (G3-PLC). The concentrators communicate via GPRS with Enedis supervision center.

Furthermore, the meters can be used to send flexibility activation order, as they can be used as gateway and are deployed in each customer premises.

Enedis will install a new generation of secondary substations with currents and voltages measurements at both LV and MV level. It consist of a box installed the substation with electric sensors, as well as temperature and water level sensor. These “smart secondary substation” would not be deployed on all the secondary substations, but only on the substation where LV constraints will be studied. They are part of the “socle smart grid” deployed by Enedis in priority within the region.

Next section describes the type of constraints that could be mitigated in the project.

c) Type of constraints

Figure 19 introduces the two type of constraints that could be mitigated in *Nice Smart Valley* in the specific case of no generation is connected.

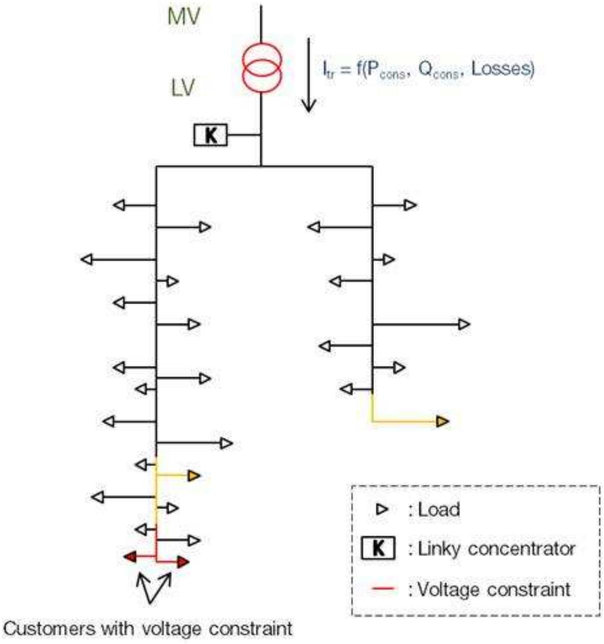


Figure 19. Example of LV constraints that could be mitigated (no generation considered)

The two types of constraints correspond to:

- Current at the MV/LV transformer;
- Voltage into the grid (over- and under-voltage).

At this moment of the project, the choice of the solution to activate the flexibility is not fixed. There are three possibilities to activate the flexibility:

- Using an automatic local enslavement;
- Using a remote control by a flexibility platform;
- Using a mix of an automatic local enslavement and a remote control by a flexibility platform.

d) <u>Potential solution to mitigate a current constraint at the MV/LV transformer</u>

In *Nice Smart Valley*, the current constraint to be mitigated could be located at the transformer level. A technical solution a part of local enslavement of flexibility could be relevant**. These issues have to be discussed between the project partners and are subject to feasibility**

4.3 Description of the flexibility portfolios

Aggregators are in charge of managing flexibilities: this section describes the flexibility portfolios for the two aggregators EDF and ENGIE. A focus on the gas/electrical flexibilities is provided also at the end of the section. The different technologies and products are presented.

4.3.1 EDF's flexibility portfolio

EDF is one aggregator of the project, managing flexibilities on the business and residential side.

4.3.1.1 Flexibility technologies

Several solutions can be implemented by EDF to allow flexibility:

Table 10. Solutions that can be implemented by EDF to allow flexibility

Type	Description
Generation flexibility	Installation of equipment without integrated algorithm of load shedding. The load shedding function will be ensured by the activation of dry contacts allowing switching off the electrical starters remotely at the desired time.
Flexibility on gas/electrical processes	The gas/electrical processes are: 2 micro-cogenerations and two hybrid rooftops: the rooftop is controlled by an I/O card and the 3 other processes are controlled by Modbus TCP interface, all operated by GRDF (*cf.4.3.3 and 4.4.3*). The technological solution consists in interfacing the GRDF server with the EDF servers. The interface between both servers needs to be designed.
Sites already equipped with equipment to control the consumption	The load shedding function will be ensured by the activation of dry contacts allowing switching off electrical starters at a distance and at the desired time.
Sites equipped with a Building Management System operated by an EDF partner	These are usually large buildings. The technological solution that is most compatible of the systems already in place is to interface this Building Management System with the EDF servers, according to modalities of exchange to be built. With the support of the client and EDF's partner, it will be necessary to modify the Building Management System to implement the desired load shedding strategies.

Flexibility on industrial refrigeration	Solution envisaged for 2019
Flexibility controlled by Linky smart meter	control of domestic hot water thanks to dry contact for increasing consumption flexibilities

4.3.1.2 *Flexibility products*

The following table synthesizes the types of offers, the targets and activation delays from an EDF perspective.

Table 11. List of offers' types from an EDF perspective

Type of offer	Target	Delay of activation
Energy Efficiency	Businesses	D-1 to intraday
Demand response	Large scale business customers	D-1
Self-consumption	Residential Businesses	D-1 to intraday
Behavioral	Residential clients Cities Businesses	D-1
Valorization of bi-energy	Businesses	D-1 to intraday
Electrical Vehicle	Residential clients	D-1

4.3.1.3 *Flexibility valuation*

Given the initial information provided by Enedis on the occurrence of requests for incident management or grid management and the value of the flexibilities, EDF should not define a specific offers corresponding to the needs of the distribution grid. The idea is to look for a possible additional value for our customers in order to make our offers more attractive. The aim is to identify existing offers that would allow us to offer this flexibility at zero marginal cost. EDF goal is to "customize" existing offers for the needs of a local flexibility market.

It should be noted that the attractiveness of the offers is related to the value of the flexibilities for the distribution grid and therefore on the purchase price of this flexibility by the local flexibility market. If the value of this flexibility is minimal, customer recruitment will be low and it will be difficult to reach the goal in terms of volume of customers.

Nice Smart Valle's ambition is to enable companies and local authorities to participate actively in the electrical system in an innovative way.

Through their participation in flexibility, the *Nice Smart Valley* participants will contribute with their opinions and comments to improve the energy efficiency of their territory.

- **Principle of experimentation**

B2B participants will be asked to **provide electrical flexibility** to the distribution grid operated by Enedis.

This could be aimed at reducing the consumption peaks in winter, from December to the end of February, with notice given the day before the demand response (D-1). In this case, the duration of the demand response will be a few hours.

Flexibility will also be able to manage the incidents on the grid. The management of incidents (such as fires impacting the grid) requires short notices (from 1 to 3 hours) for a duration of 2 to 3 hours. It would also be possible to envisage D-1 notice in anticipation of an excessive load carry-over in case of N-1 high voltage grid on D-day (case of Isola 2000). The solicitation period is in this case annual.

Finally, flexibility can also delay grid investments (a priori not studied in *Nice Smart Valley*).

- **Targets**

Focus on residential customers:

Nice Smart Valley's ambition is to test a behavioral offer and a controlled offer.

Behavioral offers:

The customer will be encouraged to reduce its consumption by messages sent the day before a peak period determined by Enedis.

Controlled Offers:

Thanks to the *Linky* meter dry contact, EDF will control the electric vehicle charging station.

4.3.2 ENGIE's flexibility portfolio

This section of the deliverable (ENGIE) is confidential. The following abstract is provided:

ENGIE as an aggregator will **control several kinds of electric flexibilities** coming from B2B clients and **gas/electrical flexibilities** coming from B2C clients.

ENGIE currently does not know yet the expected local products characteristics as they depend on the electric process involved.

ENGIE aims at **monetizing its flexibility on all available value pockets** (TSO, SPOT markets, local energy markets and DSO) and at **cumulating the value when it is possible**.

4.3.3 Focus on the gas/electrical flexibility portfolio deployed by GRDF

4.3.3.2 Synergy between electricity and gas network

The French natural gas network, which is nearly 200,000 kilometers long and covers more than 9,500 cities, contributes to the reduction of the seasonal demand on the power grid especially during winter, limiting CO_2 emissions and preventing important investments in the power sector. Besides, it is becoming greener thanks to the injection of a mixture of gas from unconventional sources, like hydrogen produced from renewable electricity and like methane produced from biomass (renewable gas must account for 30% of gas consumption by 2030 (near 70 TWh), according to the last study carried by French Energy Agency in 2017). **The gas network is established in two areas of the *Nice Smart Valley* demonstrator, namely the plains of the Var River and the airport of Nice**.

Today, the emergence of smart technologies using the natural gas network, referred to as **“Gas/Electrical flexibilities”**, represents an opportunity for the global energy system to benefit from a larger and more diversified volume of local flexibilities. GRDF’s contribution to *Nice Smart Valley* is to implement these flexibilities through **high efficiency gas products installed in residential and non-residential buildings**, which will give a smooth flexibility to the power grid without any impact on end user comfort. GRDF will give its support in **finding the test sites** and **managing agreements between the consortium and end users**. **Dedicated connection system** between gas devices and aggregators’ platforms will also be developed for the purpose of the experiment.

The final objective is to:

- Provide **significant flexibility to the local electricity network** thanks to intrinsic characteristics of gas technologies like local power generation, hybridization, coupling with local renewable energies, etc. This will allow to increase simultaneously the global efficiency of the mix, and the integration of local renewable energies, enhanced by the use of biomethane.
- **Evaluate the gas network capacity** to deliver in case of generalization of smart gas technologies, in order to identify if infrastructure evolution is needed or not.

4.3.3.3 Flexibility technologies

The flexibility portfolio that will be tested includes two families of products: the **hybrid heating solution**s and the **cogeneration**. These two types of flexibility are described below.

a) Cogeneration

The installation of **local heat and power production devices** running with natural gas or biomethane contributes to significantly reduce basic energy demand in collective dwelling or tertiary buildings. These technologies usually run during heat demand period. On aggregator demand, they could **start or stop their power production** with good reactivity (one minute if the system is warm enough).

In *Nice Smart Valley*, two CHP units with the Internal Combustion Engine (ICE) technology will be installed in non-residential buildings, typically offices or healthcare buildings, new or existing. The units will **range from 16 to 50 kW_e power production** each and will be sized according to the heat needs of the test sites.

ICE CHP modules are **really mature and widely developed in Europe** (50,000 installed, around 100 in France). Really suited for exemplary buildings regarding energy efficiency (NZEB), ICE modules produce power by the mean of a classic gas engine connected to a rotating power generator. Heat is recovered directly in the engine or at the exhaust, and is used directly in the building. Usually this technology is installed in a dedicated room with a condensing boiler and a heat tank. Power efficiency is between 30 to 35%, with a primary energy efficiency around 145%.

Flexibility may be triggered by **starting or stopping electricity production** of CHP modules, heat being stored in the heat tank or directly used in the building. Cogengreen is the manufacturer that will supply the systems.

It has to be noticed that fuel cells, initially integrated in the project, has been removed from it. Despite interesting characteristics of these products to provide flexibility, with great amount of power production, manufacturers are not mature enough to make the system remotely controllable for flexibility purposes.

b) Hybrid heating solutions

Hybrid heating solutions, **running on both gas and electricity**, increase global efficiency of heat production by using the more efficient energy source at any time. Usually running on the most efficient system locally or on lowest energy prices, hybrid technologies could switch from one energy source to another on aggregator’s demand, with a few seconds reactivity.

The goal is to provide the aggregators **with 50 to 100 kW$_e$ of gas/electrical flexibility** installed on several buildings:

- **In individual houses**, installation of 10 hybrid gas boilers (electrical power is up to 5 kW$_e$, heat power is up to 30 kW$_{th}$). Vaillant, with its brand Saunier Duval, has been chosen as the manufacturer for this product.
- **In non-residential buildings**, installation of two hybrid rooftop units (electrical power ranging from 7 to 42 kW$_e$). The selected manufacturer is ETT.

Hybrid gas technologies are a **combination of an electrical heat pump and a gas equipment**, typically a condensing gas boiler. They provide heat (for heating and domestic hot water) and cooling for some models.

Integrated in one or two casings, local smart regulation select the best system for operation, mainly depending on the outside temperature (when temperature is low, heat pumps are less efficient, thus priority is given to the gas boilers) or energy prices.

These devices can easily provide flexibility by **switching temporarily and almost immediately from one equipment to another**, typically from the electrical heat pump to the condensing gas boiler during peak demand. Thus, it contributes to energy demand reduction during peak hours while maintaining the thermal comfort of end users.

The targeted sites and technologies to be tested are summarized in the figure below.

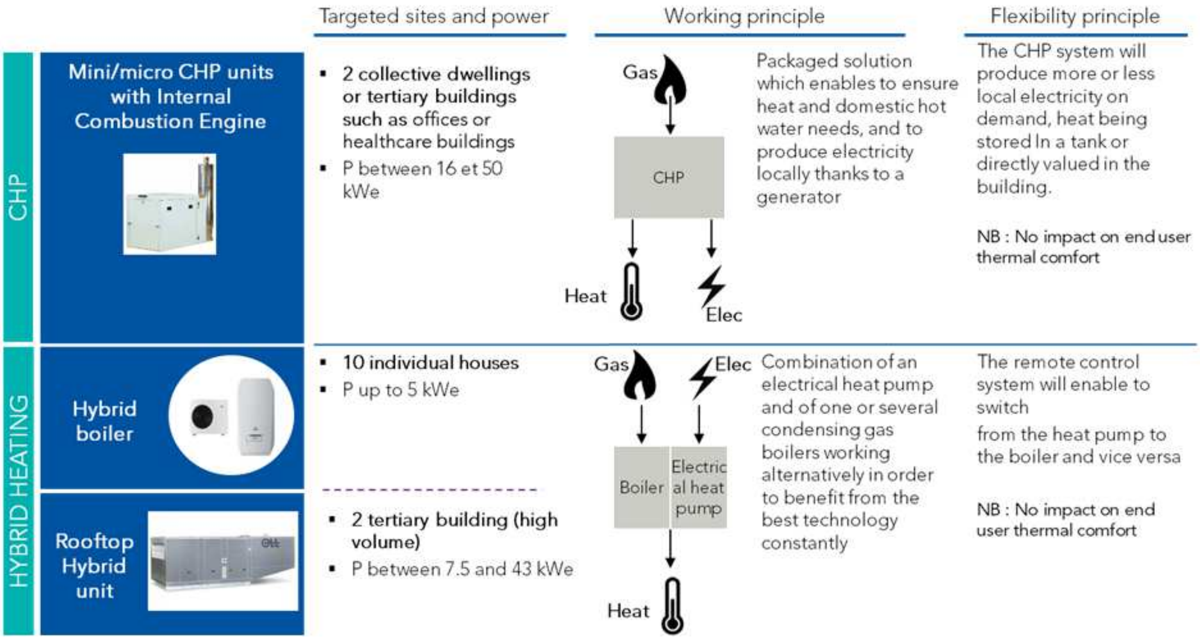


Figure 20. Customer recruitment objectives by type of equipment

4.4 Description of the aggregation platforms

An **aggregation platform** is an information system including sensor and remote control devices that the aggregators use in order to manage their flexibilities assets (e.g. demand side management at customer premises, storage and local generation). It allows for operating the flexibilities in order to monetize them for example to solve local grid constraints. This platform includes mainly the following functionalities: flexibility forecasting, aggregating and dispatching

In this section, the **aggregation platforms of the two aggregators, EDF and ENGIE**, are described. The **supervision system for the gas/electrical flexibility** provided by GRDF is also presented.

4.4.1 EDF's aggregation platform

In order to respond to the demands of Enedis, EDF will implement an aggregation platform, within the framework of *Nice Smart Valley,* to optimize the responses of its customers.

4.4.1.2 General principle

The objectives of this platform are:

1) The aggregation platform **generates offers of flexibilities** to meet the demand of Enedis. The characteristics of these requests (volume, durations, periods, delays ...) remain to be specified in the technical working group dedicated to IT architecture.
2) The platform will **receive demands of flexibilities** from the Enedis Information System and will **propose offers of aggregated flexibilities**.

3) The platform **indirectly controls the flexibilities** of EDF customers by interfacing with external IS via some webservices (APIs):
    - GRDF IS to pilot the gas/electrical flexibilities
    - Linky IS for controlling residential equipment within the smart meter (e.g. the control of the hot water tank via the dry contact of the smart meter)
    - Other IS
4) The platform can **request the residential customers and the businesses for manual control of their equipment or processes**. These requests are sent by email and/or SMS.

4.4.1.3 Data collection

The processed data are:

- The **load curves** of residential and business customers in the 30-minute time step from the Linky's meters and SME meters. These curves will be transmitted by the Enedis IS in a secure way. Customers will have previously given their consent to use these data through the signing of an experimental agreement with EDF).
- **Flexibility requests from Enedis** (notice, volume, duration, etc ...) transmitted according to the XMPP protocol
- **Flexibilities offers from EDF** (shifting volume, flexibility's price) transmitted according to the XMPP protocol

4.4.1.4 Aggregation, optimization and activation

The pool of flexibility is estimated customers by customers and then aggregated to obtain the volume requested by Enedis.

The activation of the flexibility will be done by:

- **Transmission of “mobile peak demand”** by Linky via Enedis IS
- **Load shifting orders** transmitted over internet to energies box or building management system installed at customers’ premises.
- **Sending SMS and email** to activate behavioral flexibility offers in order that customers perform manual shifting.

4.4.2 ENGIE’s aggregation platform

This section of the deliverable (ENGIE) is confidential. The following abstract is provided:

A **flexibility activation program** is designed each day by ENGIE accordingly to the forecast flexible capacity, the markets opportunities and the commitments toward TSO and DSO. This program is then **modified in real time** accordingly to on the one hand market evolution and on the other hand DSO and TSO activations.

The flexibility is **controlled from ENGIE central instance** which will take into account the **flexibility portfolio location** and **dispatch the flexibility orders** to the flexible capacities which are required to fulfill the aggregator commitments.

4.4.3 GRDF's aggregation platform

4.4.3.1 Principle

In this project, GRDF is responsible for **designing the entire architecture of the communication chain** that will connect the gas/electrical flexibilities to the aggregation platforms. For this purpose, GRDF will develop a **SCADA** (*Supervisory Control and Data Acquisition*) through a partnership. The SCADA will consist of three different parts:

- The **acquisition of data flow** which comes from the aggregators
- A **supervision system**
- **Automatic management and control systems** located in the different demonstration sites

The technical architecture of the global solution will be centralized and the SCADA will be the main component of it. Before describing the different parts, it is necessary to highlight two points:

- The material overlay which will command the gas devices for the purpose of this project will not be intrusive in the devices' intrinsic control system
- The notion of user comfort is really important. For private individuals, the temperature in the housing will never exceed 2°C above the set point temperature.

4.4.3.2 Data collection

GRDF and the aggregators will define together the solution for flow acquisition (e.g. *web services, FTPS, etc.*). The exchanged data and the detailed specifications will also be agreed upon. All the requests from aggregators will be saved in the database with two different elements:

- The **type of request**, for example: "switch off heat pump in site number 2", "turn on site number 3 (mCHP)"
- The **time of request**, for example: "switch off during 2 hours"

The goal is to answer all requests, thus to obtain the best treatment rate (number of treated requests versus number of requests).

4.4.3.3 The supervision system

The second part constitutes the **intelligence of the communication chain**, which will be in charge of processing the requests. To play this role, GRDF has selected recognized SCADA software on the market (TOPKAPI by Areal). This software has a lot of references in management energy systems and, most importantly for this project, can communicate with more than hundred different protocols.

The main functions of the supervision system are:

- Centralize all demands from aggregators (part 1)
- Monitor the automates
- Generate answer shortly after receiving the demand. The answer will be made by integrating all the parameters of the site at a given moment, in order to provide the best answer.
- Map visualization of all the sites and their parameters in real time
- Generate alerts that may be sent to different people through email or SMS
- Estimate the available flexibility
- Display the consumption and production curves

- Check external accesses by the means of logins and passwords with five different levels of accreditation
- Generate indicators at different time scales: day, week, month and year. These indicators will be necessary at the beginning and throughout the project to follow its progress and to perform post-analysis.

4.4.3.4 Automatic management and control systems

The last part is dedicated to monitoring the gas devices. The goal is to install a local treatment unit as an overlay on each gas system, knowing that this architecture will not be intrusive in the devices' intrinsic control system.

The main functions are:

- Monitor gas devices through different communication protocols
- Collect the consumption data from the different meters and sensors (gas, electricity, temperature…) and upload them to the SCADA
- Save the data during 30 days
- Generate alerts in case of any detected issue

To conclude, GRDF has selected a partner to develop the communication chain. Suez, a French utility company, won the contract on May the 29th of 2017 in co-contracting with WIT, a company specialized in automation of remote management, and in partnership with AREAL, a company editing SCADA software.

4.5 Specification of the local flexibility system

This section presents the information systems used by Enedis and the aggregators in order to **enable the flexibility operation**.

4.5.1 Forecast management

This section presents the first approach for the information systems used by Enedis and the aggregators in order to **enable the flexibility operation**.

4.5.1.1 Concept and use cases

Forecast management is a continuous process of **real-time grid planning**. It consists of a set of information systems, procedures and organizations that help grid control and operation manage the changing uses of the grid. For instance, it allows Enedis to ensure the grid functions well even if there are unanticipated changes or works on the grid. It improves grid observability and also assists the balance between production and consumption. Finally, it serves as a support to the interfaces between Enedis and the transmission system operator and energy generators.

Forecast management has 4 possible use cases:

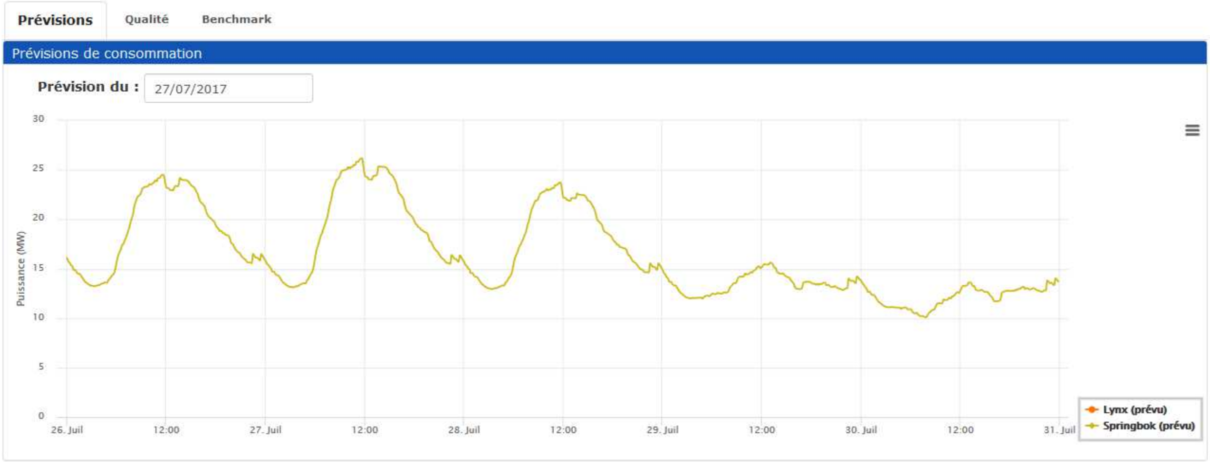
1. Long term grid planning
2. Medium term planning of work on the grids
3. Grid optimization on D-1
4. Real time grid optimization

These use cases may involve using flexibilities. For instance, these short-term optimizations may show that, in order to avoid any constraints on the grid, certain flexibilities need to be activated at specific moments and places.

4.5.1.2 Focus on Enedis forecasting tools

Enedis' forecast management includes two information systems of particular relevance to the *Nice Smart Valley* demonstrator: **STC** and **SYPEL**, which mean "*Remote Operation Simulator*" and "*Electrical Energy Prevision System*" in their French acronyms. STC is a **grid simulation tool** used to predict grid constraints in real time, by calculating the state of the grid at every moment. Enedis uses it to validate works on the grid, by determining if these works are feasible and will not engender any constraints. STC will be used to **validate the use of flexibility** through grid simulations.

SYPEL is a tool to **predict consumption and production levels**. It offers both short term deterministic predictions based on the weather forecast and medium term predictions based on statistical patterns. The short term predictions are calculated up to D+4. They serve to optimize grid use and are also sent to the national-level STC. The medium term predictions are helping grid planning and the coordination of works on the grid. The forecast are done at primary substation level for the load and generator level for generation capacities connected to the MV grid



Prévision du : 27/07/2017

Figure 21 - Screenshot of a SYPEL simulation at a primary substation level

4.5.1.3 Focus on GE forecasting tool

This section describes the functional specifications of the forecasting module, which is provided by GE in the context of *Nice Smart Valley*.

Please note that this "Forecasting tools" scope for GE is not the initial/current GE scope as per the initial/current Interflex Grant Agreement ; this scope would be the result of a scope change as requested by ENEDIS and GE and submitted to INEA on July 7th, 2017. At the date of submission of the present deliverable it is still pending final bilateral agreement between ENEDIS and GE on operational details, as well as approval by the European Commission.

a) Forecasting in the project context

The Forecasting Module will be designed to provide information about load and PV production on the Demo distribution grid that shall be used to relieve potential future network constraints by activation of flexibilities

As the generation of forecast time series will initiate the sequence workflows for the various UC, the function of Forecasting Module is critical for a reliable operation of the Demonstration on the experimentation period. The Forecasting Module shall satisfy the requirements in terms of reliability, availability and robustness.

b) Forecasting Module

- **Forecasting outputs**

- The forecasting system shall compute PV Generation forecast time series for *PV Sites* on the demonstration network.
- The forecasting system shall compute Load forecast time series for *aggregated Entities* on the demonstration network.
  - Load
  - The level of aggregation is not defined yet, and will depend on the specification of the Use Cases. The ***Base Case*** is limited to the production of Load forecast at the level of the **primary substation** only (Medium Voltage scenario).

New scenarios (possibly, Low Voltage scenario) could be implemented following the progress of the specification of the UC, which would be supported by the extension of the Forecasting scope to other aggregation levels, depending on the provision of corresponding data and measures, amongst the levels supported by the native Forecasting Module: transformer, feeder, distribution substation.

Unless otherwise agreed, the content of output files shall be limited to the **active power forecast** time series (load, PV). No export of quantiles, quality index, statistic metrics is planned.

- **Temporal Parameters**

In the ***Base Case***, the characteristics of the forecasting time series shall be the following, supporting day-ahead scenarios:

- Resolution: hourly;
- Horizon: 1 day;
- Forecast frequency: 24 hours.
- Export frequency: 24 hours.

The temporal characteristics shall be adapted to the extensions during the project, particularly for the needs of intraday scenarios: multiple updates, resolution from 10 min to 1 hour, horizon up to several days. The Forecasting Module shall automatically export the results of the forecast process in files, at the configured time of day.

Inputs

The forecasting set of algorithms uses several sources for input data consumed as exogenous variables:

- NWP weather forecast data[23] (sources[24] and data flow services, yet to be specified), including:
    - Ambient temperature;
    - Global solar irradiance;
    - Relative Humidity (optional);
    - Wind speed, wind direction (optional).
- Weather historical data[25] (optional, depending on the weather data flow service).
- Metering data of PV installations[26]
- Power metering at the substation level (power metering data exports from SCADA historian, or from dedicated meter)
- Additional load power metering (not needed for the ***Base Case***, needed to support any extension to new scenarios).

For all the metering data, they will be aggregated and anonymised if supplied by Enedis.

Additional data from Enedis may be needed, to deal with the part of the distribution network grid outside of the Demonstration area, e.g. downstream the feeders (from the eligible substation(s) of the Base Case) that are feeding other districts. Depending on the chosen approach, data may consist in aggregated load profiles, additional metering data from SCADA Historian or meters, generation schedules (in case of relatively important levels of dispatchable generation). This issue still needs some concertation within the Working Groups of the project.

- **Static Data**

Import of static data is used to set the model of the network entities and of the installations eligible for the generation of forecasting time series. Optional characteristics are parameters that are used only within some forecasting algorithms – if data cannot be provided, such methods will not be used in the context of the Demonstration tests. Forecasting information listed below is needed:

For PV Forecasting[27]:

- *Identifier of the PV installation;*
- *PV Nominal Power;*
- *Geographical coordinates;*
- *Upstream substation*
- Upstream feeder (*optional*)
- Upstream distribution substation (*optional*)
- Installation description (*optional*)
    - PV module technology
    - PV module orientation
        - Tracking systems: o/n, tracking type;
        - Array azimuth angle and tilt angle
    - Number of inverter(s), efficiency.

---

[23] Data to be provided by GE

[24] Two sources to be used for redundancy purpose.

[25] Data to be provided by GE

[27] Enedis has the data but it requires a specific agreement between GE and Enedis, and potentially from generator

For Substation Load Forecasting:

  - Identifier of the Substation;
  - Geographical coordinates
  - Identifiers of child entities (if additional data to be provided, e.g. diverse generation installations).

For extensions of the forecasting to other network entities, a more complete description of the network model will be required. It may be provided as an export CIM file (or equivalent) or as a simple hierarchical model of the topology (in the normal network configuration): substation, transformer, feeder, distribution substation, LV feeder, sites.

- **Data Formats**

The Forecasting Module shall support the data conversion from different sources in the absence of well-established international standards. It shall include the data converters for:

- NWP weather forecast inputs: files in GRIB format and/or NetCDF format;
- PV power metering data: files in custom formats (ideally XML or JSON based)
  - Format for metering data of small PV installations (from Linky meters)
  - Format for metering data of large PV installations > 36 kVA (from SME meters)
- Load power metering exports (from SCADA Historian): files in custom format (ideally XML or JSON based)
- Additional load power metering data: files in custom format (to be specified)

A data importer shall be developed for the Static Data files as well. A CIM oriented format is preferred.

To facilitate the integration with the DSO's Operation and Planning applications, and to facilitate a later performance analysis with comparison with the DSO's own forecasting tools, the format of the output files of the Forecasting Module shall also be converted in DSO's custom format.

- **Forecasting Engine**

The modularity of the forecasting system shall be used to apply several forecasting methods in parallel selected from the collection of available methods. For the extension to the new scenarios, a selection of new set of methods shall be decided accordingly.

- **Performance metrics**

The performance metrics calculated within the Forecasting Module shall be for internal purpose only and not be exported. Any study about performance analysis in the context of the project shall be done based on the forecasting export files.

4.5.2 Issues under discussion between Enedis and the agregators

The following section gives a selection of the issues under discussion for the local flexibility system between Enedis and the aggregators for the process involved for flexibility activation on the distribution grid:

- Which procedures to **declare flexibility** for the aggregators?
- Should aggregators submit their flexibility offers first or are they requested by the DSO?

- Which rules for the **merit order**?
- How the **rebound effect** could be taken into account?
- What happens in case of **not enough offers** or **too expensive offers**?
- Which **timing periods** for flexibility processes?
- Which rules for the **market settlement**?
- Which rules for the **billing**?

4.6 Customers' recruitment: first steps

The flexibilities described above require the **empowerment of customers.** This section describes the **recruitment first steps**. First, the descriptions of the **communication tools** as well as the **general ideas to foster the recruitment** are developed. Then, the two aggregators as well as GRDF present their **targets and goals for recruitment**, and the **methodologies involved reaching these targets**. The actual status of flexibility offers and prospects is also provided.

4.6.1 Communication strategy and tools for recruitment of clients

The main target in a communicational perspective is to make *Nice Smart Valley* a **reference demonstrator, a technological showcase, with a global visibility, and a clear readability towards the general public as well as the smart grid "community"**. In this sense, the communication of *Nice Smart Valley* is an **essential component to increase understanding of the demonstrator** and **support recruitment** of local business and residential clients. *Nice Smart Valley* employs **pedagogical communication tools** and highlights all its **societal and environmental benefits** to attract new potentials clients. The **idea of community**, the **link to the local anchorage** as well as the **smart city issues** are relevant in order to empower the customers of the project.

4.6.1.1 Communication around the local French demonstrator

a) A name for "DEMO1"

The French demonstrator of the European InterFlex project was officially named "*Nice Smart Valley*." to **underline its local anchoring**. In fact, *Nice Smart Valley* will take place on several geographical areas of the Alpes-Maritimes, and on a part of the Metropolis Nice Côte d'Azur territory. *Nice Smart Valley* aims to position itself on **an innovative territory ready to accommodate new Smart Grids experimentations.** The term "valley" refers also to the "*Plaine du Var Ecovalley*", an operation of regional interest at the heart of the perimeter of *Nice Smart Valley*.

The name of *Nice Smart Valley* has become officially public on 26th April 2017, in the presence of Christian ESTROSI, Mayor of Nice.

b) Creation of a graphic identity

NICE SMART VALLEY

The symbol, which looks like an elongated 8, was invented by mathematician John Wallis in 1655. It represents **the permanence and continuity of service,** the notion of infinite energy. It is often associated with the notion of alliance, a **strong union between different entities**. The graphic symbol changes from blue (wisdom, serenity, truth...) to green (conciliation, hope, transparency, nature, etc.).

4.6.1.2 Strategic recommendations for recruitment

An extensive work was done by the consortium to **imagine innovative solutions to foster recruitment of customers**, especially through two collaborative events**.**

A "Creative Evening" organized by the local smart grid cluster enabled external stakeholders (startups and SME) to enrich the recruitment strategy of EDF, ENGIE and GRDF with original ideas. In this context, the consortium of NICE SMART VALLEY mobilized the participants around the subject of client recruitment with the following question: which tools, solutions or ideas to engage the participation of individuals and companies in the experimentation of intelligent energy systems? The exchanges made it possible to create a real synergy between all participants and to outline interesting suggestions of recruitment strategy.
A communication seminar brought together communication managers from partner companies. The thematic afternoon workshops included an interactive working session on the recruitment strategy of *Nice Smart Valley*. Azzura Lights, a startup in Nice, specialized in pedagogical actions on energy led a workshop dedicated to recruitment of clients.

Figure 22. Communication workshops

A broad range of ideas and recommendations that could be followed were discussed during these two events, among others:

- **Creation of a community Twitter account:** The idea to promote *Nice Smart Valley* and to solicit participation, especially by the animation of a specific Twitter account for the community of prosumers. Through this account, the *Nice Smart Valley* community could regularly get information about the demonstrator, share publications and interact with the *Nice Smart Valley* team. A twitter account is an appropriated communication canal to create a sense of belonging to the followers.

- **Website:** *Nice Smart Valley* has an official website[28] to present the tomorrow's smart grids demonstrator in an innovative format. It will regularly share publications of the recruitment process and showcase customer testimonials in order to attract new clients. On the website tab "participate", internet users can fill in a form to get more information on the participation and ask pointed questions.
- **Annual information meetings:** A kick-off meeting and three annual information meetings could be organized by aggregators. The aim of these annual meetings could be to provide an update on the progress of *Nice Smart Valley* to clients. Thematic discussion sessions could be launched in order to share experiences and give advices.
- **Information brochure:** An information brochure intended for the general public would present main facts of *Nice Smart Valley* and outline the three different experimentations as well as the geographical area of the Smart Grid demonstrator. This promotion tool would provide all important information on *Nice Smart Valley* at a glance to visitors of the showroom and potential clients.
- **Street Marketing** (*Communication with flyers and stand in a strategic location*).
- **Better identification of clients** thanks to INSEE databases.
- Involving academics (e.g. IMREDD) in the development a recruitment strategy.
- Creation of pedagogical communication tools like comic strip, graphical tutorials and motion-design videos.
- Dissemination of energy vocabulary with **serious games.**
- **Mailing via the local authorities** (Metropolis Nice Côte d'Azur) to customers of concerned zones.
- Presence on **local events** like the Fair of Nice to promote *Nice Smart Valley*.
- **Press coverage in the local and national press**, to increase awareness of the *Nice Smart Valley* demonstrator.
- Creation of a **storytelling** including explanations of specific vocabulary to the energy sector with simple words (self-consumption, societal and environmental benefits).
- Organization of **open house days in the show room** from January 2018 onwards.

4.6.1.3 The showroom: an innovative space to explain the demonstrator

Located in a building on the *Promenade des Anglais* in Nice, the showroom of *Nice Smart Valley* will be a **space to explain the project and to promote it**, including at international level. The main idea is to use **innovative pedagogical tools**: the visitor is able to understand better **by doing instead of only listening and reading**. By employing the latest virtual reality and augmented reality technologies, the visitors can immerse themselves in the demonstrator's operation, discover the latest technologies and visualize the data platforms at the heart of the smart city. The visitor **could play the role of grid manager, aggregator and prosumers**. This new immersion site fostering pedagogy through action and immersion will welcome among others the prospects from 2018 onwards. In this sense, the showroom aims to facilitate customer recruitment for **EDF, ENGIE** and **GRDF**. The official inauguration ceremony will take place on the 20th of December 2017.

---

[28] www.nice-smartvalley.com.

Figure 23. First pictures of the show room

4.6.1.4 Participation to local events

a) <u>Conference *Innovative City Convention 2017*</u>

In the occasion of *Innovative City* on 5th and 6th last July in Nice, the French smart grid demonstrator *Nice Smart Valley* was present on the stand of Metropolis Nice Côte d'Azur via a motion design video explaining the function of the experiment.

Nice Smart Valley made the audience discover the smart electric system of tomorrow through a panel discussion on 5th in the presence of Christian Tordo, *Deputy mayor* of *Nice, metropolitan advisor and vice-president of EPA* and the strategic directors of each industrial partner.

Figure 24. Panel discussion at Innovative City Convention

b) <u>Forum *Industria*</u>

The next *Forum Industria*, a business to business matchmaking event is being held in *Cagnes-sur-Mer* on 22th and 23th November. *Nice Smart Valley* exhibits during these two days in order to exchange about the project and find potential business partners. Organized by the Smart Grids Club of the Chamber of Commerce and Industry Nice Côte d'Azur, *Nice Smart Valley* participates in a round table discussion around the energy efficiency and the recruitment of clients.

4.6.2 Customers' recruitment on EDF side

This section details the recruitment targets, methodology and first step of the aggregator EDF.

4.6.2.1 Introduction

EDF's objective will be to test:

- the **recruitment rate** for the proposed offers
- **customer motivations** to be part of the experimentation
- the rate and reasons for any refusal of the proposed offers
- the **real customers response** to the shifting solicitations

The risk is not to find enough motivated customers to be part of this experiment because of the low-wage offers (because the flexibility value is currently not very high for the distributor) and the flexibility requests from Enedis at random times of the day (depending on the incidents on the network that cannot be foreseen in advance).

4.6.2.2 Targets for the recruitment

EDF, as a flexibility aggregator, is in charge of recruiting **350 residential** and **20 business customers** out of the 5 specific target areas defined by Enedis: *Carros, St Isidore, Lingostière, Airport of Nice, Guillaumes, Isola 2000 of the Alpes Maritime*s.

4.6.2.3 Methodology for the recruitment

a) Methodology used for the recruitment of tertiary customers, industries and local authorities

0. EDF has examined the **list of the most important companies** in the territories concerned by the project. After targeting (according to the offers envisaged), EDF has drawn up a list of companies to contact for a first appointment.
1. EDF makes a **first visit to present the experiment**, checks and collects information on the willingness of the company to participate, and checks whether it has demand response potentials.
2. If necessary, EDF shall re-negotiate with the sponsoring partner or its subsidiary in charge of the offer to adapt the offer regarding to the needs of the Project and the choices of the participant.
3. Each project participant signs with EDF an **experimentation agreement** for the duration of the project. This agreement describes precisely the modalities of cooperation.
4. If the customer subscribes (or has subscribed) to an EDF (or his partner's/subsidiary's) offer and signs the EDF experimentation agreement, EDF, or its partner/subsidiary, installs and commissions equipment:
    - Interfacing between the process hardware to control the load and the load itself (software and/or hardware) with installation of a manager
    - Installation of a command box
    - Installation of additional equipment if necessary (instrumentation ...)

    - Commissioning and qualification
5. In 2018 and 2019, the experiment will run with the participant having the option to refuse the demand of load shedding or shifting.
6. At the end of each solicitation, the results are measured and analyzed and regularly transmitted to each participant. In the case of measured flexibility lower than the commitments, the consortium reserves the right to apply penalties to the participant concerned. (*Choice to be confirmed*)
7. Following this experiment, in 2019, a synthesis of the evaluation work on the experiment will be carried out.
8. Throughout each stage, the contact is kept with the participant, who is kept informed of the progress of the experimentation, and this by telephone, emails, visits or meetings of all the participants.

In addition, EDF is setting up an internal dashboard to monitor the planning of participants' visits, signing of agreements and, where appropriate, installing the equipment.

- **Schedule**

Figure 25. Recruitment schedule for EDF

b) <u>Methodology used to recruit residential clients</u>

Recruitment will take place in successive stages:

1. Communication Campaign

In two times :

• a global presentation campaign of the project by Enedis, to be relayed by EDF to its customers;

• A recruitment campaign carried out by EDF with all the inhabitants of the *Nice Smart Valley* area presenting the EDF offer(s).

<u>Identification of prospects</u>

For legal reasons, EDF information systems cannot be used to recruit participants for the *Nice Smart Valley* project. A first step may thus consist in constituting this customer file. This file will consist of the postal, mail or telephone contact details of the prospects.

↓

2. Eligibility

- The success of the first phase brings the inhabitants to contact EDF through various channels that will be defined later.
- EDF will then verify the eligibility of customers.

↓

3. Signature

- For eligible households, depending on the EDF offer, one or more convention(s) of experimentation will have to be signed.

The customer file will be forwarded to the C.I.L. (EDF Informatics and Freedom Correspondent) who will take care of the declaration of this file in accordance with the so-called data protection law.

4.6.2.4 First recruitment results

a) Offers status

Piloting and shifting offers for Small, Medium and Major Business are already available and enriched with the characteristics of flexibility being specified by Enedis.
Piloting and shifting Offers with GRDF are in the progress of precision.

Residential behavioral offers are being finalized.
Small, Medium and Major Business behavioral offers are undergoing reflection.

b) Recruitment status

Prospects have not been contacted yet. In expectation to enrich EDF's already existing and ongoing offers to have the right language elements to recruit customers.

4.6.3 Customers' recruitment on ENGIE side

This section of the deliverable (ENGIE) is confidential. The following abstract is provided:

ENGIE will manage its **local flexibility portfolio** in order to deliver **services to the DSO.** The portfolio should entail **storage, curtailable and flexible capacities**.

Hence, ENGIE has to develop a **local flexibility portfolio relying** on flexible customer in order to test **how a local portfolio can contribute to those use cases**.

ENGIE is looking for **2 MW flexibility capacities** and is targeting **B2B customers** on this project except for gas/electrical appliances for which ENGIE may monetize flexibility **from residential customers.**

4.6.4 Customers' recruitment on GRDF side

GRDF's role in the *Nice Smart Valley* project includes the **identification and selection of demonstration sites**, both residential and non-residential, in which gas/electrical flexibilities will be implemented.

4.6.4.1 Introduction

To participate in the *Nice Smart Valley* experiment, the customer will have to **purchase and install** one of the gas heating/domestic hot water solutions tested in the project. To facilitate the recruitment, GRDF will provide a grant to reduce the purchase and installation costs and to cover the maintenance costs during the test period. Indeed, the investment cost of the gas heating/domestic hot water solutions tested in the project is higher than the reference solutions' one (e.g. a condensing boiler for the B2C segment), which makes it hardly acceptable for the customers despite lower operation costs due to an optimized energy consumption. To participate, the customer should also accept that his solution is instrumented and remote-controlled during the 18-month experimental period. The remote control system will be provided freely and removed after the end of the experiment.

4.6.4.2 Targets for the recruitment

Ten individual houses and four non-residential sites, like offices or public buildings, are targeted; which implies a large diversity of customers: private individuals, companies and public bodies. They should be located within the *Nice Smart Valley* perimeter, and more precisely in the plains of the Var River where the gas network is established.

A targeted 100 to 150 kW_e of flexibility (which represents around 10% of total flexibility targeted in the project) could be provided to the aggregators by gas technologies. The final amount will depend on customer recruitment opportunities.

4.6.4.3 Methodology for the recruitment

To identify the test sites, GRDF intends to rely mainly on local installers that have the knowledge of both the customers and the products. Selected installers will sign a convention with GRDF that includes the payment of the grant, which will then be deducted from the customer invoice. The customer will also sign a convention with the installer, including the grant against the commitment to participate in the project. Other recruitment channels include GRDF's internal teams and GRDF's partners such as manufacturers, after-sale services, aggregators and local authorities.

Apart from the financial incentive, commercial arguments to promote gas/electrical flexibilities will mainly be based on the intrinsic benefits of the gas solutions (energy efficiency, savings on energy bills, etc) and on the fact that gas/electrical flexibilities, contrary to classic demand-side management, preserve end-user thermal comfort.

GRDF is not a business aggregator and therefore will not have direct contractual relationship with the participants, except if a new gas connection is needed. The flexibility offers will be proposed by EDF and ENGIE, in a competitive way and with their own commercial arguments. However, it should be noticed that for the B2C segment, only ENGIE has shown interest in proposing a flexibility offer so far.

Recruiting customers is a crucial task of the project because the experiment's realization depends on its success and because of the difficulty of this task, regarding both the deadlines and the small perimeter. The cost of the gas heating solutions and the expected low value of the local flexibility may also be an obstacle. Thus, the level of financial support necessary to trigger customer appeal is a topic for discussion and will be tested in this project.

4.6.4.4 Recruitment status

Several actions from the action plans have been initiated so far. In particular, GRDF has participated in the "*Foire de Nice*" trade fair which took place in Nice in March 2017. The public was essentially private individuals, but a special event was also organized to present the project to local professionals. The result in terms of prospects' number was low but it has enabled to train the teams in charge of promoting these new gas appliances, to start communicating about *Nice Smart Valley* and to make some contacts with local installers and manufacturers. The difficulty to make the project intelligible to private individuals was also underlined.

Thereafter, two mailings were addressed to gas and near gas network clients within the Plains of the Var river area, targeting separately B2C and B2B clients. These mailings aimed at publicized the project and get people interested in installing one of the targeted gas solutions. They have resulted in several prospects so far, that are still under technical analysis.

At this point, the ongoing action for the B2C segment is local installers prospecting. As for the B2B segments, some meetings are conducted with local authorities and professionals. They have enabled to identify several sites that could have their heating systems renovated, but at this point no convention has been signed. Indeed, the decision-making process for B2B clients is much longer than the one of private individuals.

4.7 First elements related to the business model

This section describes the first elements related to flexibility business model. It encompasses the existing valuation possibilities, such as markets and balancing mechanism. It presents the potential valuation on the local level with the use of flexibility for the distribution grid. It lists the open questions linked with market design and contractual approaches between DSO and aggregators.

4.7.1 Flexibility value for the overall system

Flexibility is not a new phenomenon in France. Indeed, regulated tariffs promoting demand response have been implemented as early as the 1980s from diesel engines. They aim at incentiving the consumer to reduce its consumption by mean of a high price during a given number of fixed-duration peak periods notified in advance in exchange for an attractive price outside these periods. However, due to fuel price increase and ultra-peak electricity price decrease, these historical offers are being gradually withdrawn. The capacity went from 6 GW in 1998 to 3 GW in 2012. Hence, French government decided to open most flexibility mechanisms and even create new ones in order develop peak power capacities as there are important for France which has 2 GW/°C consumption gradient. Thanks to this action, suppliers have the ability to replace them by market offers and new peak capacities appeared from demand side management assets.

The French TSO has **put in place** mechanisms or **adapted** existing mechanisms to allow flexible consumers to **value their demand response capacities**:

- The **balancing mechanism** (BM), which has been in place for several years in order to ensure balance between supply and demand on the TSO grid. Since 2003, **demand response can be offered on this mechanism**
- Since 2011, the TSO has been contracting demand response for *fast and complementary reserves*. In 2016, they represent **40% of the total contractual volumes for these reserves.**
- The NEBEF ("Notification of Exchange of Demand Response Blocks") rules were introduced in 2013
- Since July 2014, industrial consumers can participate in **ancillary services (frequency reserves)** by proposing demand response blocks (1 MW minimum). These reserves, which can be automatically activated wthin a few seconds to a few minutes, are essential to the supply-demand balance. Previously, only production groups could contribute. In 2016, demand response can contribute up **to 10% of the primary reserve.**
- The **capacity mechanism** which entered into force in 2017

It is worth noticing that Demand Response can benefit from a support scheme (“Appel d’offres Effacement”) which is currently being notified to the European commission as a state aid scheme.

Balancing mechanism

The **balancing mechanism** is a tool that enables the TSO to mobilize generation or consumption in order to ensure a constant balance between injection and extraction on the electricity system. In the same way as producers who increase their production, it is possible to meet the needs of the network by reducing its consumption. This mechanism generally gives a higher remuneration than the markets but requires a greater reactivity and flexibility. The contracted volume for 2017 for demand response is **between 750 MW and 1450 MW** for the demand response and is **500 MW for the fast and complementary reserves**.

The last tender for the fast and complementary reserves display prices which decreased a lot in comparison with the previous year. For fast reserve the price evolved from 24 k€/MW in 2017 to 10 k€/MW in 2018. For complementary reserve it evolved from 16 to 5 k€/MW... It is mainly due to the flexibility offer increase while the demand remains stable and to the fact that offers included the capacity price from the capacity market which can be combined to this product.

NEBEF

In addition to the historical mechanism, another way of valorization was set up in 2013 under the name NEBEF rules. These rules enable the demand response operators to **directly sell**

their demand response blocks on the electricity markets, in particular the EPEX Spot market, in the same way as a producer. More and more players are contracting to participate in the mechanism: at the end of 2016, they are 24 (six more than in 2015). However, the volume of demand response on the NEBEF mechanism increases but remains quite low, reaching **11 GWh in 2016** mainly due to low spot market level. Hence, most aggregators keep monetizing the flexibility on the TSO mechanisms.

Capacity mechanism

The implementation of capacity market from 2017, provided for by the “NOME law”, aims to **secure the French electricity supply**, especially during periods of very high consumption. It involves creating a **new obligation** for electricity suppliers to contribute to power security based on their customers' peak energy consumption. The capacity mechanism also makes it possible to evaluate the availability of the offer through certificates of capacity. In 2016, **1,875 MW of demand response capacity** is certified on the capacity mechanism for the year 2017. This mechanism makes it possible to secure power supply by anticipating medium-term needs and by encouraging investments in means of production or demand response.

The current price level of the capacity certificates is around 10 k€/MW.

4.7.2 Flexibility value for the local system

The previous mechanisms can value the flexibility **independently of its location**. But flexibility can also have a **value linked to its localization**.

Flexibility can also be used to **relieve the grid locally**. The *Nice Smart Valley* project will investigate the potential ways to value flexibility for the operation on the distribution grid. It will propose a local flexibility market, operated by the DSO. It should be noted **some limitations to such markets:**

- Due to the limited number of players which are able to locally play on each market, such market may not be liquid.
- The value is **highly depending on the location**, and is derived from deep power computation, as this value depends on grid investment strategies and grid operation process.
- The **value can be also transitory**: as soon as the grid investment is done, the deployed flexibility loses its value for the distribution grid.

4.7.3 Flexibilities which could be used by the DSO

Local flexibilities may create value for the Distribution System Operator (DSO) either by **postponing grid investment, solving grid’s constraints or in case of works on the distribution grid**. In the first scenario, flexibilities may allow grid reinforcement measures **to be done at a later time**. The value created in this way can be estimated by a **net present value analysis** comparing investing right away and investing at a later moment (including the impact of these strategies on the quality of the electricity supply via the estimation of the energy not supplied) and subtracting the cost of the flexibility from it.

In this case, the DSO needs to **reserve the flexibilities well in advance**. Moreover, it must be noted that **the DSO has no “plan B” in this scenario**: the flexibilities must be available when required and they will likely be heavily penalized if they cannot meet their engagements. Indeed, if the DSO was to have a “plan B” (for instance reinforcing the network to cover for potential flexibility unavailability) then the flexibilities would lose their value. This raises the question of whether the DSO could make relatively long contracts (~ 3 years long or even longer) to secure aggregator investment.

In the second scenario, using flexibilities to re**solve grid constraints**, flexibilities may be used to keep the quality of the distributed energy even when incidents or last-minute works on the grid are necessary. In this case, the reservation of flexibilities would not be necessary. Indeed, their usage is not delaying an investment decision but aiming at improving the quality of supply or reducing the operating costs by using them instead of other real time solutions.

This may be considered an **opportunistic business model**, as in *Nice Smart Valley*, every moment that could lead to flexibility activation is based on an incident scenario. In other words, the grid must be in an “N-1” configuration to lead to flexibility interests. Incidents cannot be predicted with precision and there will not be much time between the signal the DSO sends to the aggregators and the activation of the flexibilities. Typical incidents include work on the grid and constraint management in “N” and “$N-1$” configurations. In the short term, Enedis believes that the incident scenario will be more frequent than the postponing of grid reinforcement measures[29] as before postponing an investment, Enedis needs to assess the behavior of flexibility and the reliability. This point is key for ENGIE for the development of the flexible services to the DSO. Indeed, the incident scenario products should not pay Aggregators with a fixed fee. Hence, as long as there is no opportunity for postponing reinforcement thanks to flexibility, there will be no visibility on the revenue and then no incentive for developing flexibility on a specific area.

Enedis is going to prioritize:

- Solving constraints by using storage, production or consumption flexibilities, connected to the medium and low voltages;
- Flexibilities that will likely be demanded to solve incidents.

Table 12. Scenarios of flexibility use for the DSO

Use	Grid planning	Grid control		
	Investment postponement?	Works on the grid	Incident	Normal grid state
Flexibility identification	Foreseeable/over the year	Several days or weeks	Short or anticipated for N-1 conditions	Short, but preliminary studies on vulnerable areas are possible
Flexibility reservation[30]	Yes	Yes	No	Yes Pre-reservation possible until D-4
Time to activate	H-1, day ahead, year ahead…	D-1	Immediately	Activation effective on D-1 and D

---

[29] Enedis has also suggested to preventively use flexibilities, even if this risks diluting the value of the flexibility.

[30] Contract with a fixed payment according to flexibility characteristics

Currently, on the *Nice Smart Valley* experiment zone, Enedis assessed that there is no need for flexibility except for ISOLA 2000 where flexibility may be useful. For this zone ENEDIS will assess the value which should be very small. For the other zones, there is no value. The project team will design what could be the future constraint on the grid in an energy transition scenario in order to assess more precisely those data.

4.7.4 Market design

The procurement of flexibilities by the DSO may be either oriented by **call for tender** or by **market offers** associated to a bidding process if there is enough offer volumes. The scope of the agreement could be limited to the availability and activation periods. Local flexibility could also be sold on to national markets when it is compliant with local commitments. The combination of the value pockets would increase the flexibility value and reduce the flexibility cost for the electric system.

These flexibilities could be remunerated on the **capacity and/or the energy**. Capacity remuneration is more adapted to cases in which the eventual activation of the flexibility is unsure. For example, some industrial clients may tend to prefer a higher level of fixed remuneration in order to guarantee some revenue, even if it means having a smaller or zero variable part.

For ENGIE, the market design should provide a local price signal in order to develop flexibility capacities at the place where it creates the maximum value. In order to invest, Aggregators needs visibility on the local value during several years. Without such information, aggregators may consider local value only as an upside for their business plan. In this case, flexibility can’t be developed to meet DSO needs. Only existing flexible capacities could be used for DSO support. They would get additional value from a local a punctual opportunity.

4.7.5 Offer structure

A flexibility offer could be characterized by:

1. The **commitment level**: a capacity can be guaranteed or not.
2. The **minimum duration** and the **maximum duration**.
3. The **notification delay**: minimum delay between the notification by the DSO and the activation.
4. The **maximum activation number per period** (year/month/day).
5. The **activation period**: period during which the flexibility can be activated by the DSO. This can be a continuous period of time, a kind of day, a time slot within a day).
6. The **flexible power**.
7. The **price**.

The **local value of the flexibility** will be determined and the project team will examine how fix and variable financial incentives could be used to remunerate flexibilities.

Flexibilities can be used on **national markets** or for local applications for the distribution grid. Depending on the technical requirements for each use, the uses can be “**cannibalized**” (i.e. the flexibility cannot be monetized on the two applications).

Finally, the project could assess what is the “**missing money**” (i.e. the difference between current local value of the flexibility is lower than the costs) and in which condition local **flexibility could be relevant for the system**. Indeed, currently there is no need for local flexibility on the *Nice Smart Valley* area. Therefore, there is no need to change the current process. However, ENGIE believes that in the future such local services could be relevant especially when the renewable capacities and the electric vehicles will be developed. Hence ENGIE believes that the local flexibility must be developed before there is a need for it in order to have operational processes when required.

4.7.6 Replicability and standardization

Even though the characteristics and requirements of the national and local markets are different, some elements already present in the national flexibility markets could inspire the way the local market could operate in *Nice Smart Valley*: the **contract models**, the **fixed/variable** shares, the **penalties** for flexibilities not correctly activated etc. In order to design its local flexibility market, *Nice Smart Valley* needs to determine how offers will be formatted in order to include the parameters listed above, taking into account that **standardized products** favor **competition**, but according to Enedis are not **tailored to fit the unpredictability of grid incidents**, causing some value to be lost[31]. For ENGIE, a standardized product **helps reducing flexibility costs** (acquisition cost and management cost) and can by combinations cover the different needs but **involve complexity on the DSO side** as it will have **to structure the standard products** in order to get the required product characteristic for a special event.

Moreover, **operational process linking DSO and aggregators** will be design and test in *Nice Smart Valley*. ENGIE underlines the need for process evolution on the grid investment requirement. Currently, as there is **no operational process enabling local DSO controllers** to use it, the flexible capacities are not taken into account in the grid investment analysis.

Furthermore, it should be noted that the zones chosen for the project **are not representative** of the entire country and that *Nice Smart Valley's* flexibility products may need to be adapted in order to be used elsewhere.

---

[31] Instead of creating a standardized product, Enedis suggests classifying them into different use cases (e.g. 2 hours per year).

4.8 SGAM Model

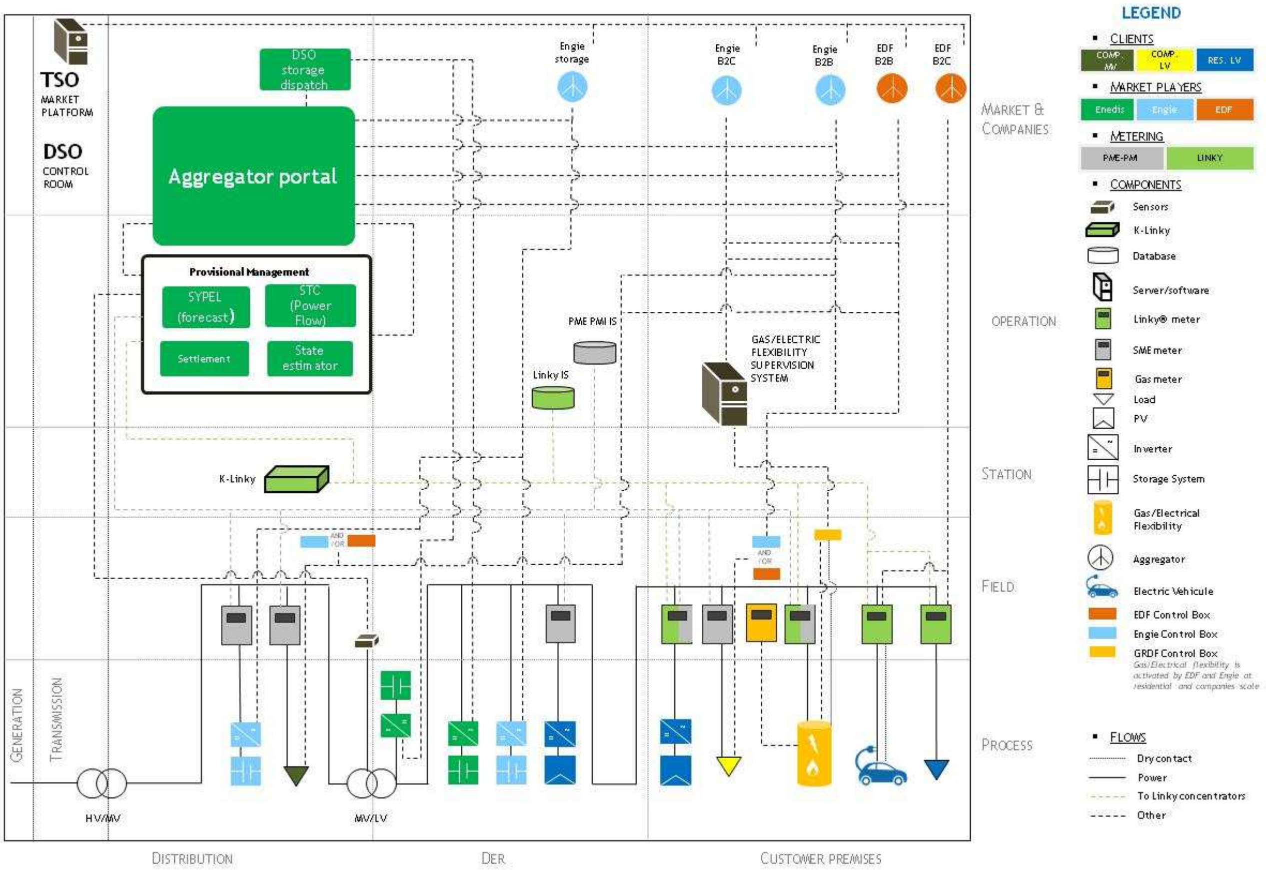


Figure 26. SGAM Model for Use Case 3

4.9 Next steps

4.9.1 Practical level

On the practical level, i.e. related to the experimentation on the field, the following steps are in process or will be started.

- Validation of the offer types for the aggregators;
- Description and validation of the process between aggregators and the DSO;
- Development of the aggregator portal;
- Recruitment of the customers;
- Implementation of the aggregator portal at the DSO control room;
- Test of communication chain between DSO and aggregators, and then between DSO and customers through the aggregation platforms;
- Description of the LV grid constraints and estimation of the flexibility needs for the DSO on this level.

4.9.2 Theoretical level

On the theoretical level, three areas of work are in progress and the resultants will be described in the deliverables D9.3 to D9.5 in 2019:

- <u>**Scenarios and simulations**</u>

The first step is to define the "50% renewable scenario": this scenario will take into account 50% of renewable generation, and the penetration of EV. It will be applied on the areas of the demonstrator. This work will be conducted in tandem with the project partners and the local municipality, Metropolis Nice Côte d'Azur.

The second step will be to process the same type of power flow computation described in this document, but applying this time a new load curve with the assumptions of the scenarios.

The third step will be to estimate the benefits associated to the mitigation of these constraints by deferring or avoiding grid reinforcement.

- <u>**Market design and contractual procedures**</u>

The first elements related to the market design, described in section 4.7, will be further analyzed to propose contractual procedures between DSO and aggregators.

- <u>**Business models computations**</u>

Based on the simulations, business models will be computed at the aggregator level.

4.9.3 Planning

The next figure indicates the planning considered until the start of the tests in July 2018.

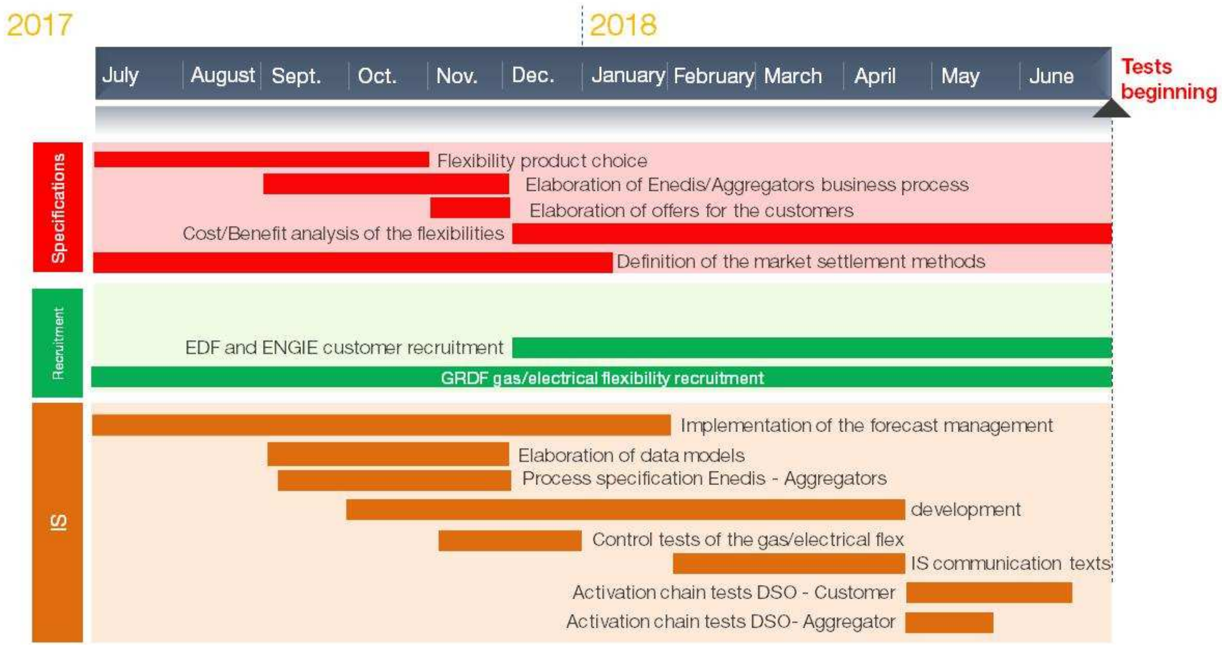


Figure 27. Planning for Use Case 3

APPENDIX 1 – METHODOLOGY TO ESTIMATE THE LEVEL OF USEFUL FLEXIBILITY

This appendix describes in detail the methodology applied to estimate the levels of flexibility that could be useful for the areas covered by the *Nice Smart Valley* demonstrator, namely those served by the ISOLA 2000, BROC CARROS and GUILLAUMES primary substations.

The portion of the *Nice Smart Valley* demonstrator's geographic scope suited to the activation of flexibility on the medium-voltage line corresponds to a selection of areas that could potentially be under constraint should there be a high load level following a loss of supply at a primary substation. The idea is to define the levels of flexibility required to prevent constraints from occurring and that would also be sufficient to enable all customers to maintain power.

Only high-voltage supply losses and/or single transformer losses (in the case of GUILLAUMES and BROC CARROS) are discussed in this document: simulations have shown that scenarios for medium-voltage systems satisfying the N-1 emergency configuration do not result in constraints in any of the *Nice Smart Valley* areas. For this reason, the list of systems under N-1 emergency configuration tested in connection with the *Nice Smart Valley* demonstrator is as follows:

- ISOLA 2000: primary substation connected to the transmission grid;
- GUILLAUMES: primary substation with a single transformer connected to a single line to the transmission grid;
- BROC CARROS: primary substation with a single transformer.

The hypotheses presented in this document relate uniquely to a smart grid demonstrator and do not take into account the current planning methods applied by Enedis. In addition, **the approaches used may not be directly extrapolated to cover all grids managed by Enedis**, because **the scenarios tested are specific to *Nice Smart Valley* and are not in any way representative of all Enedis grids. Economic aspects are not covered and will be studied at a later date.**

1. Load hypothesis

The first step in the method is to define the consumption levels for each of the *Nice Smart Valley* areas. This is achieved by first extracting two years of net demand curves for the substation to which load relief is provided.[32]

From these net demand curves we are able to derive two normalized six-month load duration curves for this substation, by dividing the data into two periods: summer[33] and winter plus

---

[32] Net demand corresponds to the active power passing through the primary substation, to which is added the power injected by the producers connected to this substation. This power thus corresponds to the total net consumption by the substation (consumption by customers + losses).

[33] Here considered as the period between June 1 and September 30.

the shoulder seasons[34]. The use of two normalized load duration curves is especially interesting because the maximum permissible current for the power cables differs depending on the temperature and therefore varies between these two periods. **It is therefore essential to evaluate opportunities for flexibility in each period of the year studied.**

In the simulations, only the normalized load duration curve for the substation receiving load relief is considered. Consequently, the curve for the substation providing load relief becomes that for the substation receiving relief. **The underlying hypothesis is that the load duration curves for primary substations in a given geographic area line up completely.**

The interest in working with normalized load duration curves lies in the fact that the results can be read rapidly. The load duration curve gives instantaneous information about the probability of occurrence for the load level being viewed, which cannot be viewed directly with the load curve. The identification of periods during the year when flexibility might be useful requires that we look at the curves.

2. Definition of useful flexibility

Here it is important to distinguish two cases. The first involves considering independent producers as not generating any power. The second considers that all independent producers are available. The first case, detailed below, will help define the level of flexibility necessary to resolve constraints in the absence of power generation. This is the maximum useful flexibility to restore service to all the customers in the area (excluding topological non-distributed energy).

In preparing the simulations to define levels of flexibility:

- **We examine, as mentioned above, scenarios involving a loss of high-voltage supply at primary substations and/or the single transformer (depending on the area) that may entail grid constraints** in the event of high load levels.
- We look for the best service restoration approach in order to maximize the restoration rate for customers. **We assume that the emergency configuration remains constant because the load levels entailing constraints are very high and close to the maximum.** It will thus remain unchanged for all simulations at the load levels studied.

2.1 Situation in the absence of power generation

The procedure described in this section will need to be used for both periods studied (summer as well as winter plus the shoulder seasons).

---

[34] Here considered as the period between October 1 and May 31.

The simulations involve the application of the same coefficient for all loads in the area, meaning that the **loads will undergo homothetic changes**. Our hypothesis is that the allocation of power between the loads always remains the same. In the current context, the tools and the large number of loads do not permit the simulation of varying load allocations over a limited time.

The idea is to simulate different load levels in order to determine the level from which the grid is under constraint. Figure 28 shows the load duration curve for the seasonal period studied.[35] The breakpoint $a_{\min}$ shown below corresponds to the load level from which the grid is under constraint (service restoration rate after intervention lower than 100%) in the simulated N-1 scenario.

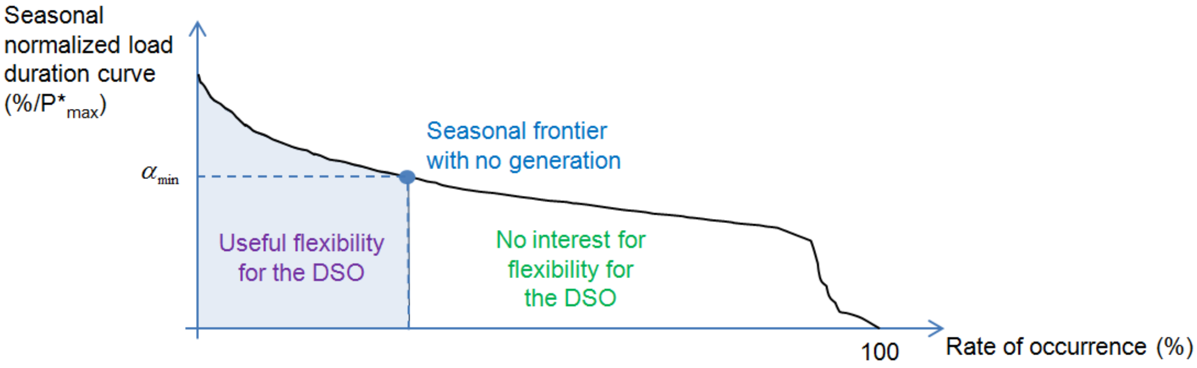


Figure 28. Determination via the load duration curve of the breakpoint for the seasonal period of the primary substation receiving load relief

Once the breakpoint has been determined, we run several load level simulations beyond this point. Given that the load level is chosen to be greater than the load threshold previously identified ($a > a_{\min}$), we expect to encounter one or more constraints.

Three types of constraints may appear:

- Transformer constraint: Exceeding 125% of the transformer's nominal capacity in a service restoration situation.
- Voltage constraint: Exceeding the threshold (8% for medium voltage) of the voltage differential in a service restoration situation[36] at the level of at least one node in the grid.
- Current constraint: Exceeding the *Intensité Maximale Admissible en Permanence* ("IMAP"), i.e. the continuous current-carrying capacity, or ampacity, at the level of at least one section of the grid.

We will now look more closely at each of these constraints. First, we will determine the flexibility required to alleviate the current (and/or transformer) constraint, then once the

---

[35] The normalized load duration curve is obtained by sorting in descending order the values for the power passing through the primary substations in a given period over two years. In this case, it is determined as a function of the rate of occurrence over these two years.

[36] In relation to normal voltage.

current constraint or constraints have been alleviated, we will determine the flexibility required to alleviate the voltage constraint(s).

2.1.1. Current and transformer constraints

For current or transformer constraints, the constraint(s) will be alleviated by reducing the downstream loads.

In practice, we multiply the downstream loads by a ß coefficient applied homothetically. The difference between the initial load (not using the ß coefficient) and the lowered load (using the ß coefficient) corresponds to the desired flexibility. Figure 29 shows the case of a current constraint at a feeder, where the desired flexibility corresponds to the difference between the consumption at the portion downstream from the constraint, before and after the constraint has been alleviated.

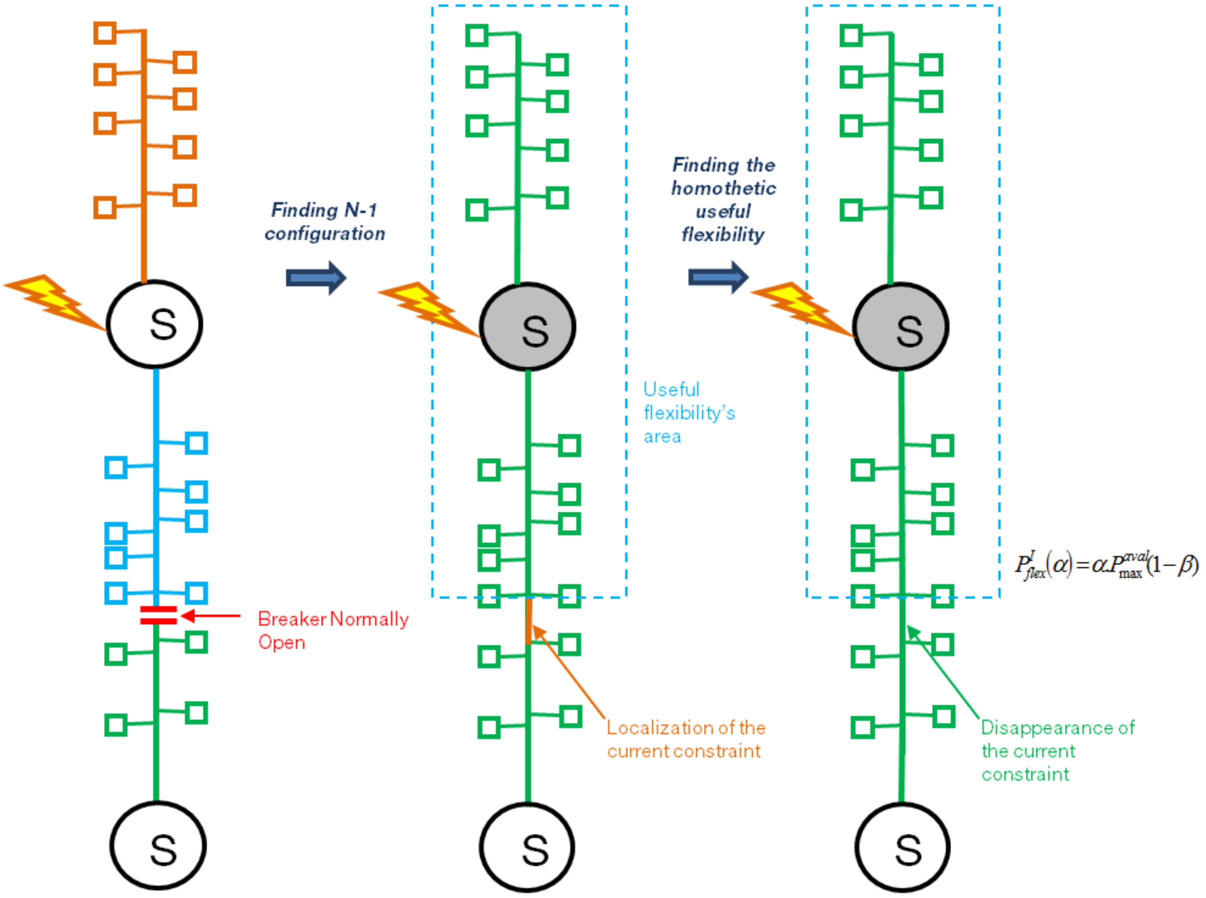


Figure 29. Functional diagram for the determination of useful flexibility in the event of a current constraint

We therefore have:

$$P^{I}_{flex}(\alpha)=\alpha\cdot P^{aval}_{\max}(1-\beta)$$

Where:

- P^{I}_{flex} is the useful level of flexibility.
- $P^{aval}_{\max}$ is the peak demand, downstream from the current constraint.
- *α* represents the load level studied via the normalized load duration curve, applied to all loads in the area.
- *β* is the maximum coefficient applied to the loads downstream from the current constraint.

Now that the current constraints have been alleviated, we will turn to the proposed method for alleviating the voltage constraints.

2.1.2. Voltage constraints

In this section, we will first describe, as for the current constraints, the method for determining the useful level of flexibility. Next, we will present a method for showing the impact of targeting a specific level of flexibility (out of the total useful flexibility) at certain positions.

2.1.2.1. Homothetic useful flexibility

If there are any voltage constraints within the grid, they will be alleviated by lowering the loads located geographically in the feeder portion of the N-1 high-voltage system shown in the diagram. This is because, in contrast to the current constraints, the loads at a feeder all have an impact on the voltage constraint (which may be small or large depending on the positions of the loads in relation to the area under constraint).

It is important to remember that the current constraint has already been removed. When the flexible load is in the area selected to alleviate the voltage constraint as well as the current constraint, the total flexibility will be equal to the sum of the flexibilities required to alleviate both constraints.

Figure 30 illustrates the approach to alleviation applied to the voltage constraints for each constrained feeder.

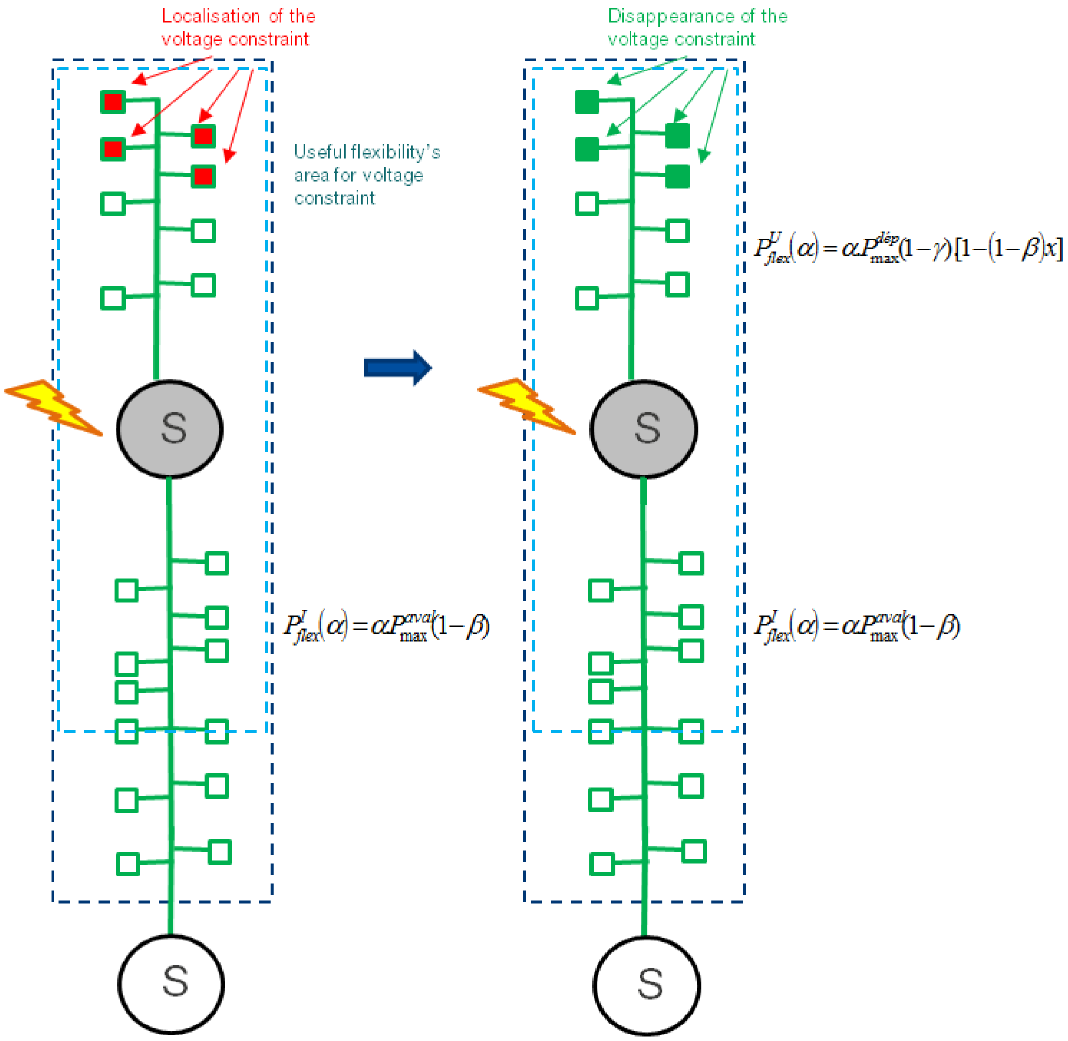


Figure 30. Approach to voltage constraint alleviation

From the calculation standpoint, if we apply a maximum γ-factor to the loads in the sub-area considered, the flexibility required to alleviate the voltage constraint (after having alleviated the current constraint) is represented by the following formula:

$$P_{flex}^{U}(\alpha)=\alpha P_{\max}^{zoneU}(1-\gamma)\cdot[1-(1-\beta)x]$$

Where:

- P_{flex}^{U} is the useful level of flexibility to remove the voltage constraint once the current constraint has been removed.
- $P_{\max}^{zoneU}$ is the maximum power consumed by the loads situated in the selected sub-area.
- x is the proportion of demand situated in the area targeted for flexibility to alleviate the possible current constraint as well as the voltage constraint (

  $xP_{\max}^{zoneU} = P_{\max}^{départ} \cap P_{\max}^{aval}$ with $x = 0$ in the absence of a current constraint or if the areas targeted for flexibility are distinct).

- *α* is the load level studied via the normalized load duration curve, applied to all the loads in the area.
- *β* is the maximum coefficient applied to the loads downstream from the possible current constraint that has already been removed.
- γ is the maximum factor applied to the loads in the selected sub-area to alleviate the constraint.

These simulations allow for the definition of useful levels of flexibility required to alleviate the constraints. In the case of multiple current and voltage constraints, the levels of flexibility will be indicated to alleviate the constraints individually (if the voltage constraint persists after the removal of the current constraint).

We will now evaluate the impact of targeted flexibility on the voltage constraint.

2.1.2.2. Impact of targeted flexibility on the voltage constraint

The aim of this section is to look more closely at how the targeting of flexibility affects the voltage constraint. The calculations presented herein will not be carried out in each and every case and will be run for a single load level, where $\alpha = \alpha_{\max}$.

We will now consider two fundamentally different approaches to estimating the flexibility required to alleviate these constraints depending on the size of the selected area. The first involves targeting extreme flexibility at the entire feeder in order to set a limit on flexibility depending on the maximum optimization or deoptimization of the targeted flexibility. The second relates to the targeting of flexibility by sub-areas.

With respect to these two approaches, the useful flexibility will be evaluated by following the same principle described in the preceding section.

We will now describe in detail the method used to evaluate extreme flexibility.

2.1.2.3. Evaluation of extreme flexibility

Within *Nice Smart Valley*, extreme flexibility corresponds to the minimum and maximum levels required to alleviate a constraint. In order to determine these levels, we must first rank the usefulness of load flexibility. **Within Nice Smart Valley, the criterion for the ranking of load utility to alleviate a voltage constraint relates to a voltage drop at the load connection points.**

Figure 31 shows the steps in the algorithm for evaluating extreme flexibility described below. First, a voltage profile is simulated at the feeder with the voltage constraint, then a choice is made depending on the extent of the voltage drop. Next, the load with the steepest voltage drop is lowered until another load has a greater voltage drop. If this happens, the new load is lowered until it is replaced by another. If the load reaches nil power, the algorithm lowers the load with the highest voltage drop in accordance with the voltage profile. The stopping criterion for this algorithm is the disappearance of the voltage constraint.

The level thus obtained is the minimum flexibility for which the loads shed are ideally distributed to remove the constraint. This same reasoning is applied to determine the maximum flexibility required to alleviate the constraint, this time sorting the loads in ascending voltage drop order (from the smallest to the largest). **The level thus obtained is the least efficiently distributed flexibility to alleviate the voltage constraint.**

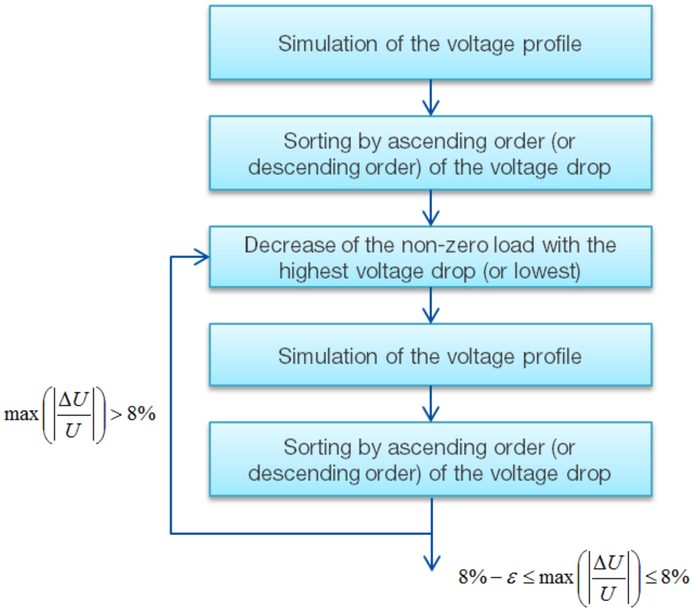


Figure 31. Extreme flexibility evaluation algorithm

This method thus enables the estimation of the useful flexibility at the feeder that will alleviate the voltage constraint.

2.1.2.4. Determination of flexible sub-areas

To avoid having to perform numerous time-consuming simulations to obtain a benchmark, it is preferable to think in terms of grouped rather than individual loads. The idea is to estimate, for sub-areas of different sizes (from the smallest local service point to the entire scope of the feeder), the useful flexibility to alleviate the voltage constraint.

Within Nice Smart Valley, we have opted, as in the preceding section, to sort the sub-areas according to the voltage drops for loads.

The method differs from that presented in paragraph 2.1.2.3 in relation to two specific points:

- **The calculation of the voltage profile is run one and only one time before any lowering of loads.** The sub-areas therefore remain unchanged for the first calculation of the voltage profile.[37]
- **All of the loads included in the sub-area vary homothetically** until the removal, if possible, of the constraint (there is no processing/optimization on a load-by-load basis).

Figure 32 shows the method for selecting the sub-areas to be tested. These sub-areas are defined in line with the sorting by voltage drop proposed in the previous section, and are enlarged as greater loads are permitted. In other words, **the load(s) with significant voltage drops will always appear in the sub-areas** (Sub-area 1 is included in Sub-area 2, and so on). Sub-area 1 is the smallest batch of loads allowing for the alleviation of the voltage constraint by applying a homothetic shedding.

---

[37] This is useful to limit not only the number of calculations, but also the creation of sub-areas that are not geometrically contiguous.

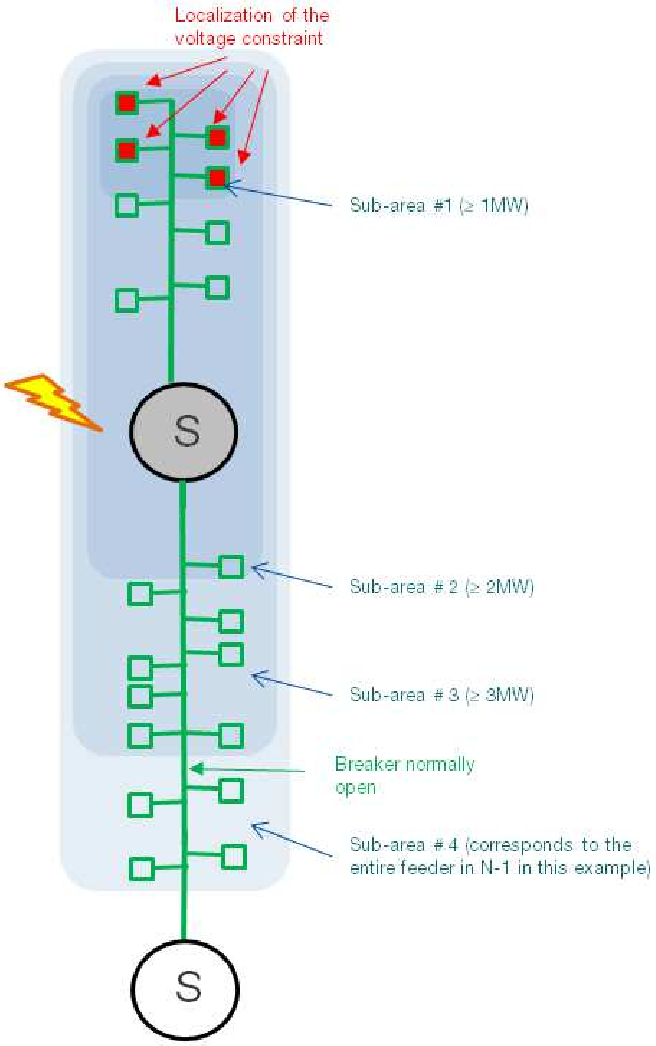


Figure 32. Illustration of the definition of potentially flexible sub-areas to alleviate the voltage constraint

Within *Nice Smart Valley*, sub-areas for flexibility were chosen including low- and medium-voltage substations as well as medium-voltage loads, with a step of about 1 MW[38].

Figure 33 shows the steps in the algorithm for evaluating flexibility by sub-area.

---

[38] If the useful flexibility is over 1 MW, the sub-area 1 will not be able sufficient to alleviate the voltage constraint.

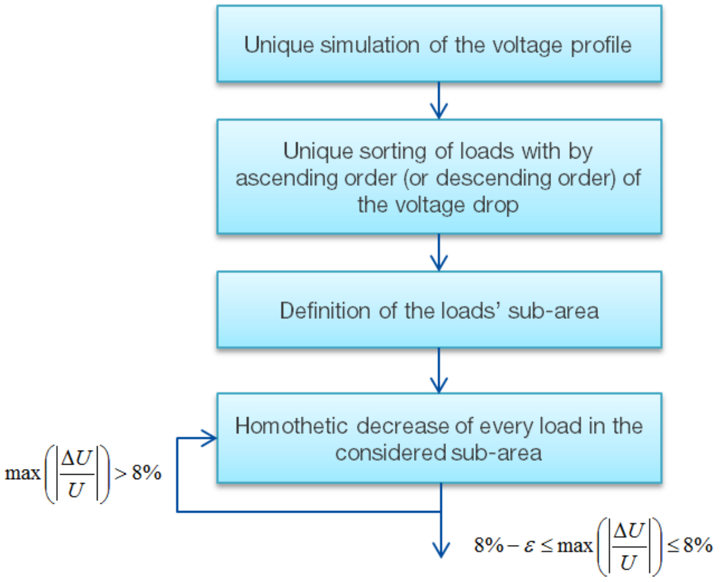


Figure 33. Sub-area flexibility evaluation algorithm

Simulations with different flexible sub-areas will allow us to take into account the impact that the localization of flexibility may have on its useful levels. **Within *Nice Smart Valley*, the choice was made to evaluate levels of flexibility in relation to areas having an impact on the constraint.**

The situation in the absence of generation by independent producers has already been discussed. We will now consider the situation with generation in the area under N-1 conditions.

2.2. Situation with generation by independent producers

In all the studies carried out, **only the useful, homothetic levels of flexibility were evaluated in all scenarios.**

Once the level of flexibility has been determined for the scenario in the absence of generation by independent producers, an analysis must be made taking into account local generation. **The impact of generation from the standpoint of protection is not considered. We therefore assume that the producer can remain connected to the grid in the scenarios studied.**

Producers may be positioned so as to allow generation without contributing to load restoration. This depends on the nature of the constraint, which must be taken into account:

- If it is a transformer load constraint, downstream generation will always affect the constraint, in cases where the grid management agency is able to restore the load up to the producer (even if the latter is situated at the end of the grid with heavy demand upstream).
- If it is a voltage constraint on the grid, the producer will have an impact on this constraint, depending on its distance from the primary substation. If the producer is

very close to the primary substation providing load relief, its impact will be minimal. Figure 34 shows the impact of the producer on voltage.

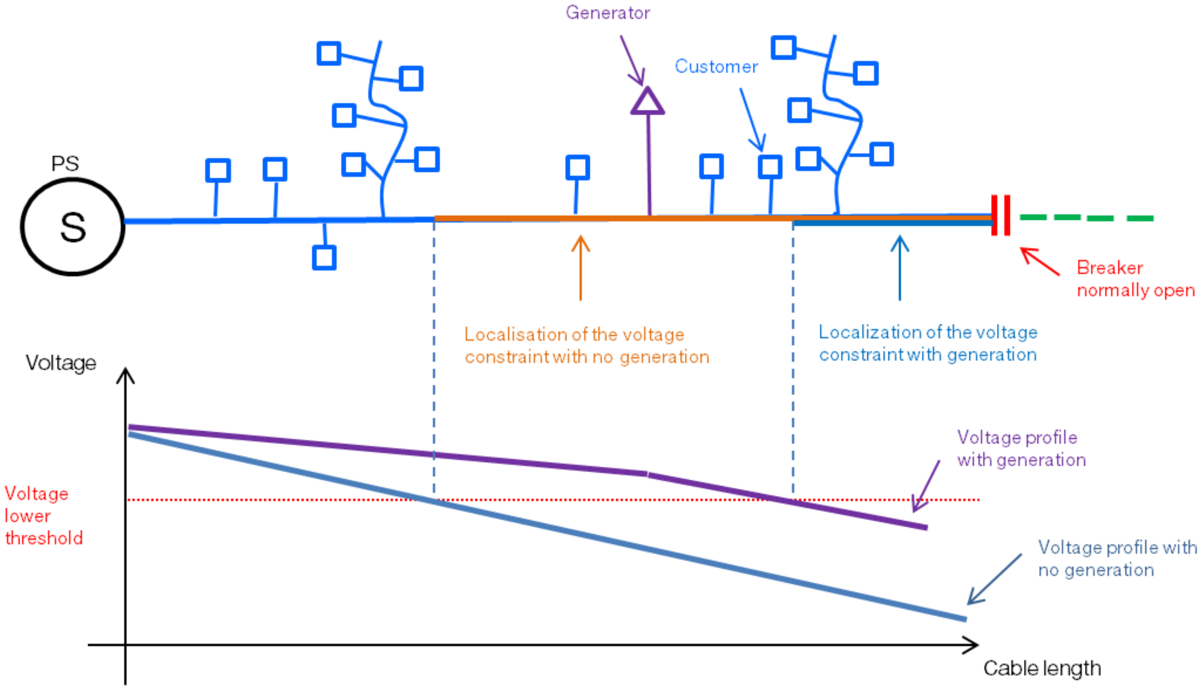


Figure 34. Impact of producer on voltage with power generated lower than power consumed downstream from the producer

- If a current constraint on the grid is involved, the producer's position will have a considerable impact on its ability to remove the constraint.
    - If the producer is connected downstream and powered on a continuous basis, it may help to restore the load.
    - If it is situated upstream, it will only have a limited impact on the constraint.[39] Figure 35 shows a scenario under N-1 conditions where load relief must be provided by primary substation PS1 to primary substation PS2. An independent producer is connected at PS2's feeder and a current constraint arises downstream from this feeder. The formula correlating the current downstream from the producer conforms to Kirchhoff's current law (we simplify the explanation by considering reactive power to be nil). I_2 depends uniquely on the voltage and the load level for the downstream customers, whereas the current upstream of the producer I_1 depends on I_{gen}. Applying Kirchhoff's current law, this gives $I_1 = I_2 - I_{gen}$, which means that the upstream current varies depending on the power supply by the producer. As the upstream current decreases, the voltage drop will be smaller, which will result

---

[39] The latter will reduce the current coming from the primary substation, which will in turn reduce the drop in voltage and thus raise the voltage profile compared to the scenario without producers. In the simulated models, as the loads consume stable levels of active and reactive power, at a higher voltage the current required will be lower.

in a very slight decrease in net current since the loads are at constant power.[40] The current may therefore drop very slightly owing to this phenomenon.

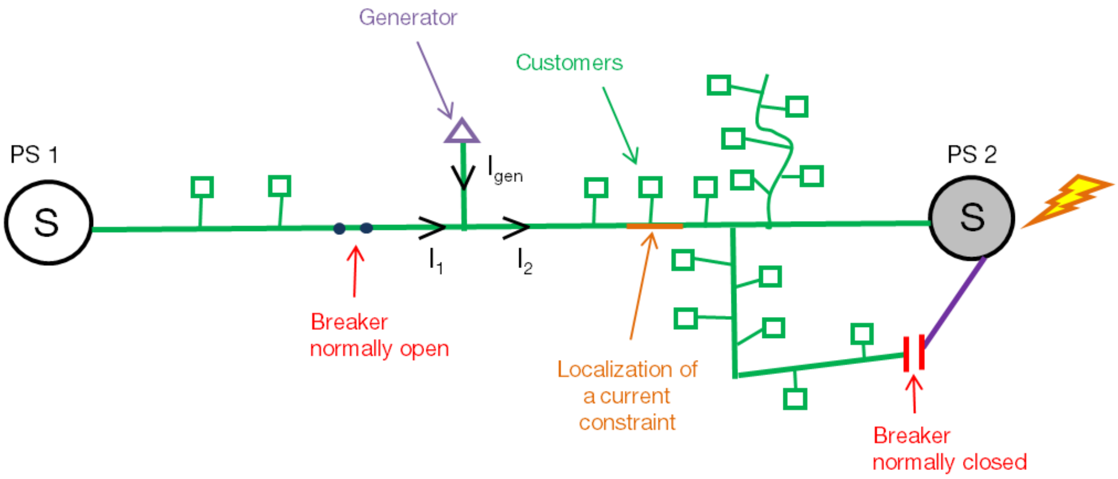


Figure 35. Example of the restoration of a substation in need of load relief with a producer on the cable line receiving relief

The choice made for the producers is to calculate a synchronous generation curve[41] by category for all the means of generation connected to the feeders providing and receiving load relief. **The hypothesis relating to this choice is that there is a correlation between the generation levels of the same category.**

The test procedure now involves reexamining all of the scenarios studied previously after activating generation at “probable” levels. To define these levels and maintain a form of realism, it is important to work with chronological curves rather than normalized load duration curves. By analyzing the times in the year when demand is high enough to potentially result in a constraint in N-1 configuration, we can evaluate the generation levels for each category. Within *Nice Smart Valley*, the choice was made to set minimum and maximum generation levels. **Overall minimum and maximum generation levels for each category are therefore evaluated at times where flexibility would be useful (procedure applied by power class $a > a_{min}$).** Figure 36 illustrates the evaluation method for these two points.

---

[40] They consume stable levels of power, irrespective of the voltage at their terminals.

[41] Sum of the generation curves for each producer by category.

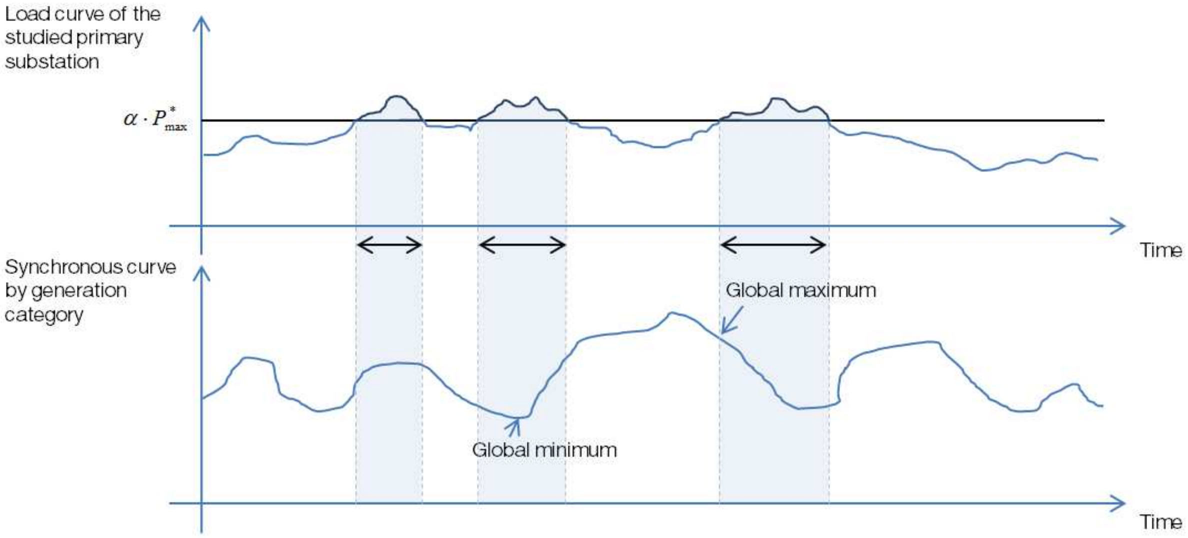


Figure 36. Evaluation of two generation levels by category of generation

Once the generation levels have been evaluated, the useful levels of flexibility can be evaluated, taking into account the power supplied by the producers. The aim is to follow this with the **simulation of synchronous minimum and maximum generation levels for all generation categories (no probabilistic calculation is applied)**. These simulations, in particular those relating to maximum and nil generation, will enable the identification of a specific range of homothetic levels of flexibility, depending on the rate of occurrence of the load level considered.

The second graph shown in Figure 37 is obtained by simulating the scenarios with generation described earlier. For each load level $a.P^*_{max}$, and for each type of constraint, two simulations are run for both generation levels described above. We therefore obtain two curves for each generation level considered and by type of constraint.[42] These curves, examined together with the curve in the absence of generation, will allow us to set the boundaries for flexibility. We thus delimit the range of useful flexibility to remove the selected constraint for each season, depending on the probability of occurrence.

N.B.: This testing procedure should be repeated for the second season if it involves constraints.

---

[42] There may be several non-contiguous constraints. In this case, there will be an exit graph for non-contiguous constraints.

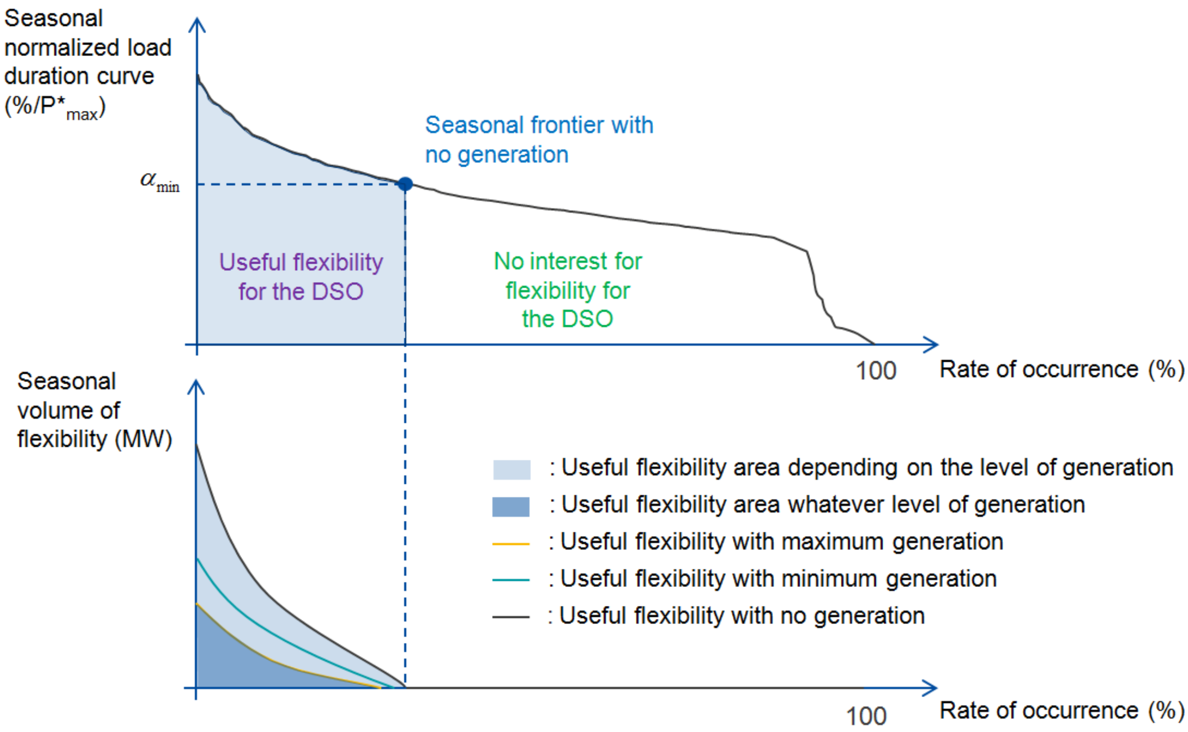


Figure 37. Range of useful flexibility depending on rates of occurrence

N.B.:

Figure 37 is provided only for guidance. It is important to bear in mind the following possibilities:

- *Scenarios in the absence of generation and with minimum generation may overlap, owing to the fact that the generation considered might be historically nil at times when flexibility would be useful.*
- *The shapes of curves for different generation levels may turn out to be different.*
- *The curves obtained may be discontinuous because one constraint might disappear before another.*

APPENDIX 2 – PRESENTATION OF THE THREE AREAS FOR MV CONSTRAINTS

1. Broc Carros

a) Localization of the primary substation

This primary substation is located in the “Plaine du Var”, in the heart of the “Eco Vallée”. Launched in 2008, the “Eco Vallée” is a strategic development project of the Nice Côte d’Azur metropolitan area. It serves as a research laboratory on sustainable development, aiming at bringing together world-class research, academic and service poles.

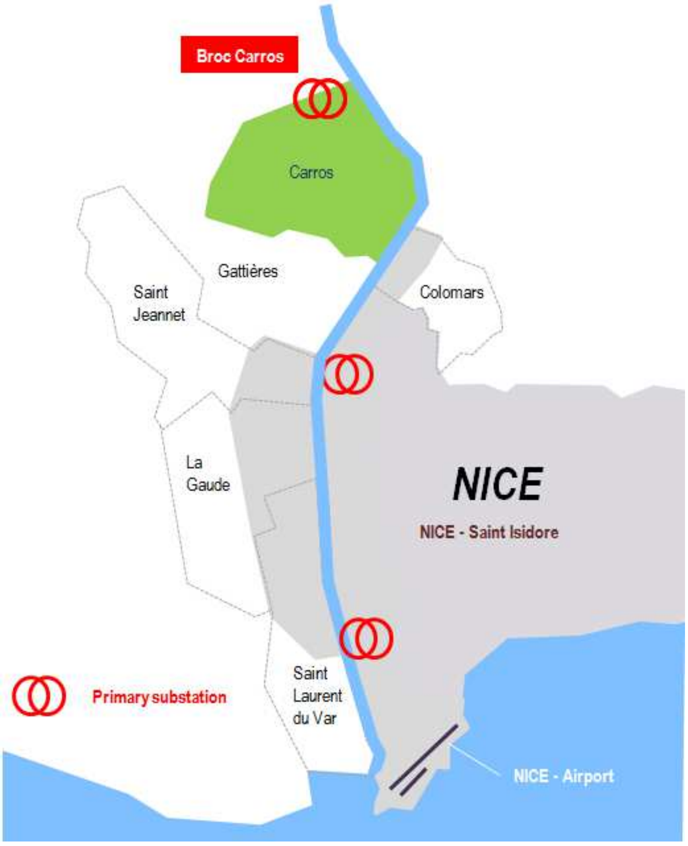


Figure 38. Localization of the “BROC CARROS” primary substation on the Nice area map

b) Characteristics of the area

The primary substation BROC CARROS mainly feeds the Carros commune and an adjacent commune (Le Broc). It serves as a backup for the LINGOSTIERE and PLAN DU VAR primary substations. It is a mostly urban grid.

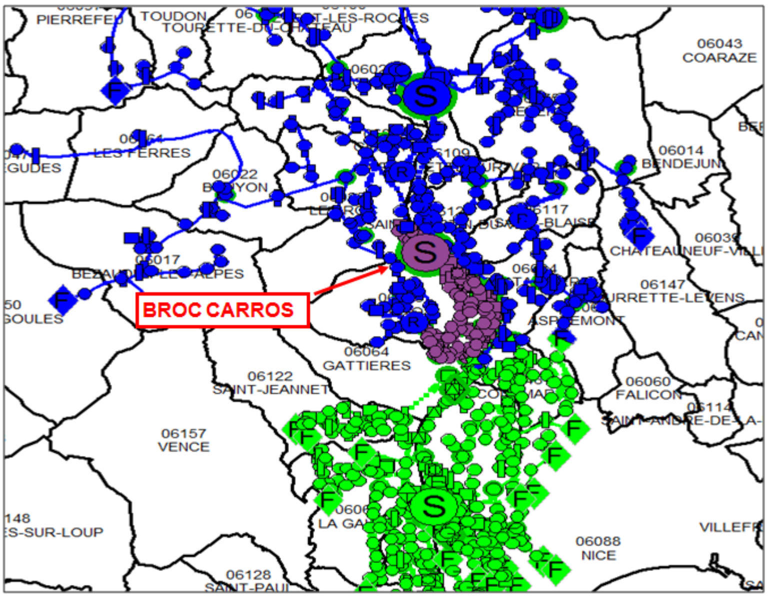


Figure 39. Distribution of the secondary substations in "Broc Carros" area.

Table 13. Number repartition of the LV/MV clients in "Carros" and "Le Broc" towns

Towns	# of LV Clients	# of MV Clients
Carros	5983	38
Le Broc	998	12

c) <u>HV supply of the area</u>

Several HV lines supply this primary substation (two 225 kV double circuit three-phase lines on the same electric pole and a 400 kV double circuit three-phase line). As it has two HV lines supplying it, this primary substation can continue to feed its load even when there is an incident on one of the HV lines that normally supply it.

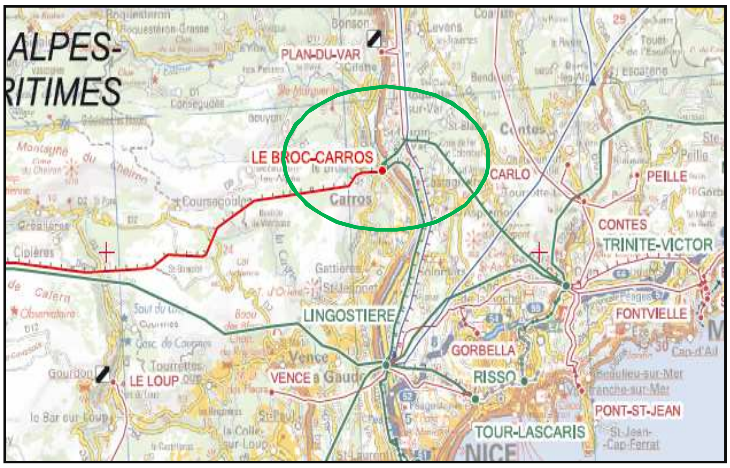


Figure 40 - Geographic distribution of the HV line supplying "BROC CARROS" primary substation

d) Primary substation single line diagram

BROC CARROS primary substation (HV/MV) has a single 40 MVA transformer, which feeds two half branches via a busbar.

e) MV feeders of the primary substation

The BROC CARROS primary substation feeds 10 MV feeders, 9 of which are entirely underground.

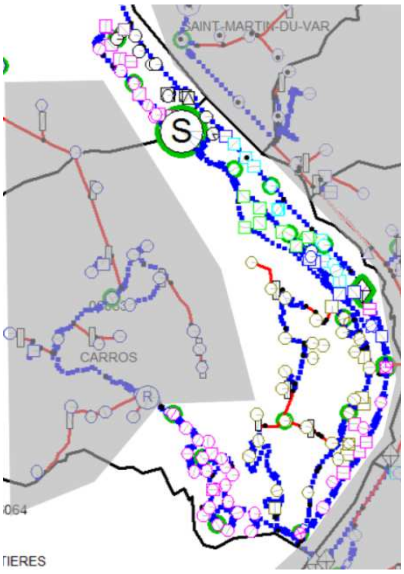


Figure 41. Distribution of the MV feeders powered by "BROC CARROS" primary substation

f) Choice of the area

This zone has been identified after noticing current constraints when BROS CARROS transformer had to be de-energized for works into the grid. Generators were used during the lock-outs in order to keep power quality in this section of the grid, which feeds several industrial clients.

2. Isola

A) *Localization of the primary substations "SAINT ETIENNE DE TINEE" and "ISOLA 2000"*

These two primary substations are located in the valley of the Tinée river. "SAINT ETIENNE DE TINEE" is adjacent to the Mercantour National Park, while "ISOLA 2000" is in the middle of the park. The Tinée River valley is located between two other valleys (Vésubie River valley and Cians river valley). The main winter sport stations of the Alpes-Maritimes department (Auron and Isola 2000) are located in the Tinée River valley.

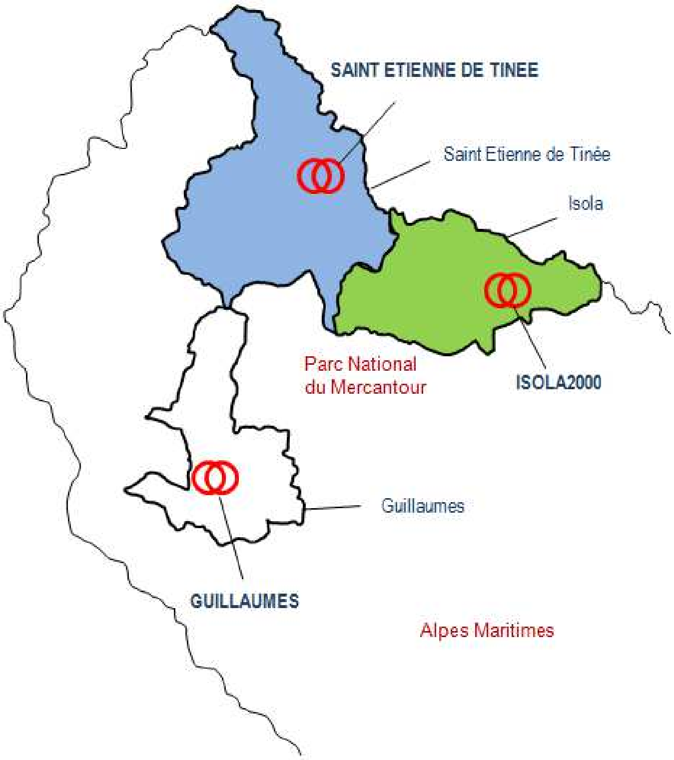


Figure 42. Localization of the "SAINT ETIENNE DE TINEE" and "ISOLA 2000" primary substations on the Nice area map

B) *Characteristics of the area*

"SAINT ETIENNE DE TINEE" Primary Substation: This primary substation mostly feeds the Saint Etienne de Tinée commune and two main adjacent communes (Isola and Saint Dalmas le Selvage). BANCAIRON and ISOLA VILLAGE serve as its back-up. The area under study is mostly rural.

"ISOLA 2000" Primary Substation: The "ISOLA 2000" primary substation only feeds the Isola 2000 ski station. "BANCAIRON" and "ISOLA VILLAGE" serve as its back-up. The area under study is mostly rural.

Table 14. Number repartition of the LV/MV clients between "Saint Etienne de Tinée", "Isola" and "Saint Dalmas le Selvage » towns

Towns	# of LV Clients	# of MV Clients
Saint Etienne de Tinée	4418	20
Isola	3101	28
Saint Dalmas Le Selvage	186	1

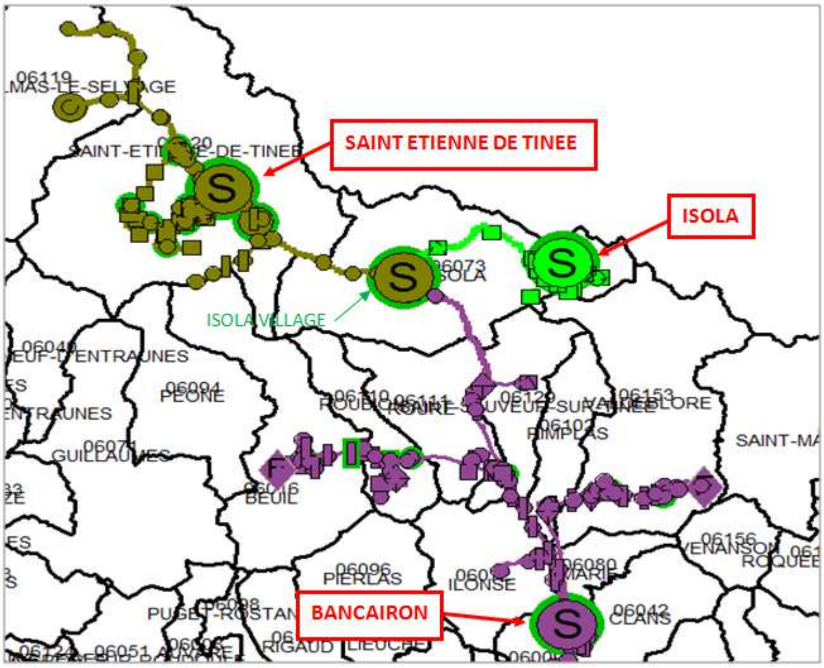


Figure 43. Distribution of the secondary substations in "Isola" area.

C) *HV supply of the area*

The primary substations "ISOLA 2000" and "SAINT ETIENNE DE TINEE" receive power from a HV feeder from "BANCAIRON". This feeder is on different voltages – on 115 kV up to the "VALABRES" substation, and on 63 kV after "VALABRES" (see diagram below).

The place where a potential incident happens or where maintenance is necessary is very important because it may lead to the loss of either one primary substation or two primary substations simultaneously. There are three possible scenarios:

1. Loss of “SAINT ETIENNE DE TINEE’s” primary substation (if the 63 kV link between “ISOLA PORTIQUE” and “SAINT ETIENNE DE TINEE” becomes unavailable)
2. Loss of “ISOLA 2000’s” primary substation (if the 63 kV link between “ISOLA PORTIQUE” and “ISOLA 2000” becomes unavailable)
3. Simultaneous loss of the two primary substations, which may happen if
   a) The 150 kV link between BANCAIRON and VALABRES becomes unavailable or
   b) The 150/63 kV transformer in VALABRES becomes unavailable or
   c) The 63 kV link between VALABRES/ISOLA PORTIQUE becomes unavailable.

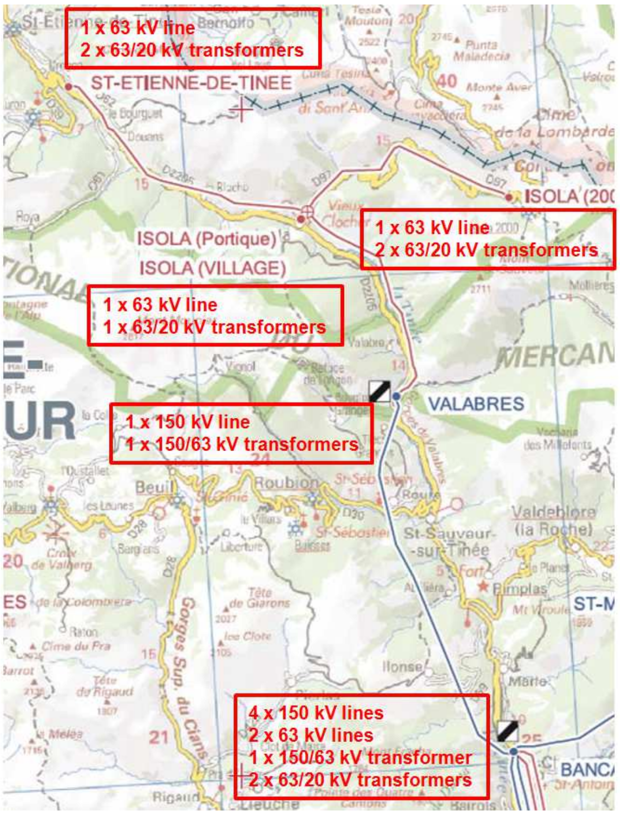


Figure 44. Geographic distribution of the HV line supplying ”SAINT ETIENNE DE TINEE” and “ISOLA 2000” primary substations

D) Primary substation single line diagram

“ISOLA 2000” and “SAINT ETIENNE DE TINEE” are both equipped with two transformers (2 x 20 MVA transformers for ISOLA 2000 and 20 + 10 MVA transformers for “SAINT ETIENNE DE TINEE”). “SAINT ETIENNE DE TINEE” primary substation is capable of operating normally with only the #1 transformer available and opening the #2.

E) MV feeders of the primary substations

“SAINT ETIENNE DE TINEE” primary substation supplies 8 mixed feeders (both aerial and underground).

"ISOLA 2000" primary substation supplies power to 8 MV feeders, 7 of which are completely underground.

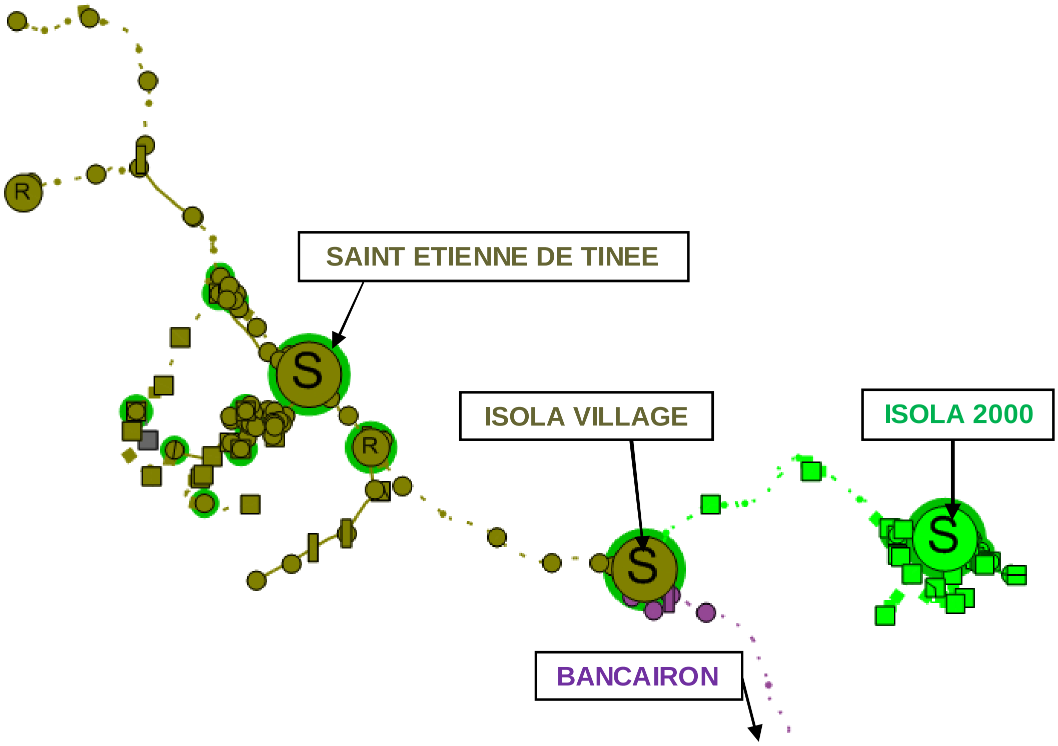


Figure 45. Distribution of the MV feeders powered by "ISOLA 2000" primary substation and "SAINT ETIENNE DE TINEE" primary substation

F) Choice of the area

This zone was selected after several HV incident leading to some constraints on the MV grids (current and voltage constraints).

Power restoration through the MV lines is limited by the long length of the cable and the lack of backup feeders (only one in MV). A backup primary substation cannot ensure power restoration at the "ISOLA" and "ST ETIENNE DE TINEE" substations on all the seasons of the year.

Several studies were conducted with the TSO in order to guarantee power supply to this area. Given its characteristics, no simple solution at a moderate cost could be found.

The MV grid supplying power to "ISOLA 2000" and "SAINT ETIENNE DE TINEE" substations is radial, with an increased power outage grid on a touristic area (a heavily frequented ski station).

Thus, using flexibility could represent a solution postponing reinforcement in order to mitigate potential power outages. The ***Nice Smart Valley*'s project decided to study only the case in which the "ISOLA2000" primary substation is lost** (loss of the 63 kV link between ISOLA PORTIQUE and ISOLA2000 primary substation).

3. Guillaumes

a) Localization of the GUILLAUMES primary substation

This primary substation is in the valley of the Var river and is adjacent to Mercantour's national park. Mercantour's national park is one of France's ten national parks. It is located between two French departments (Alpes-Maritimes and Alpes-de-Haute-Provence). It is known, in particular, as one of France's wildest parks and one of the most diverse in terms of landscape (being located between the sea and the mountains).

b) Characteristics of the area

"GUILLAUMES" primary substation mainly feeds the Guillaumes commune and three other adjacent communes (Péone, Saint-Martin-d'Entraunes and Daluis). It serves as a backup for two other primary substations: "SUBVAUX" and "BANCAIRON". The area under study is mostly rural.

Table 15. Number repartition of the LV/MV clients between Guillaumes, Péone, Saint-Martin-d'Entraunes and Daluis towns

Towns	**# of LV Clients**	# of MV Clients
Guillaumes	**975**	4
Péone	**2607**	5
St-Martin-d'entraunes	**243**	0
Daluis	**141**	0

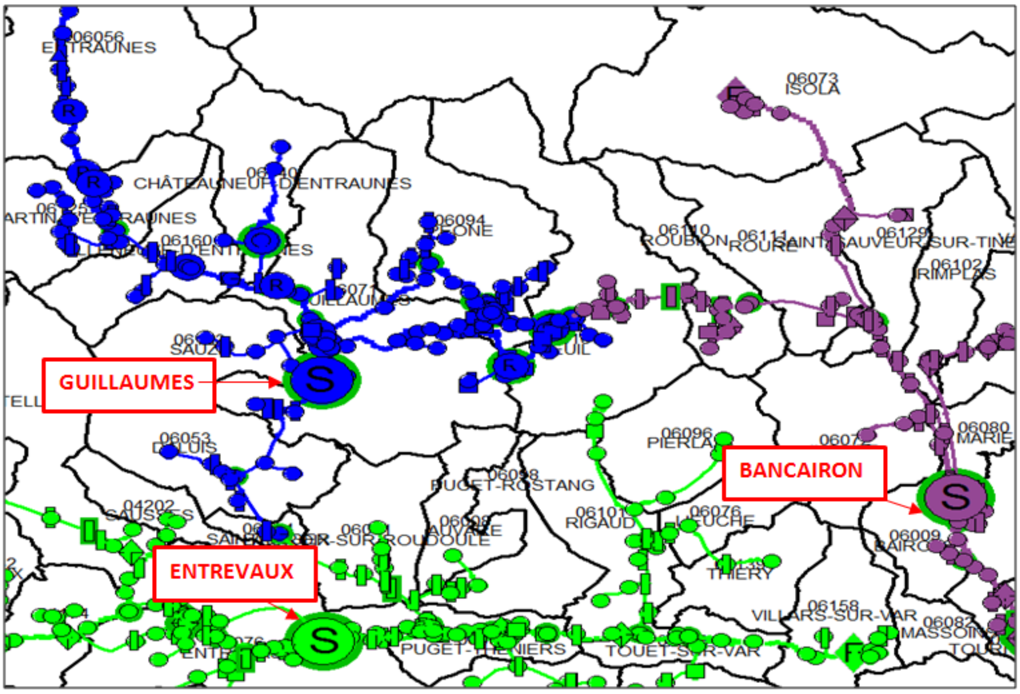


Figure 46. Distribution of the secondary substations in "GUILLAUMES" area.

c) HV supply of the area

GUILLAUMES is a 63/230 kV primary substation which receives power from a single 63 kV overhead line from ENTREVAUX. Since there are no redundant lines, this primary substation may not be able to restore power if there is an incident on the HV line that normally feeds it.

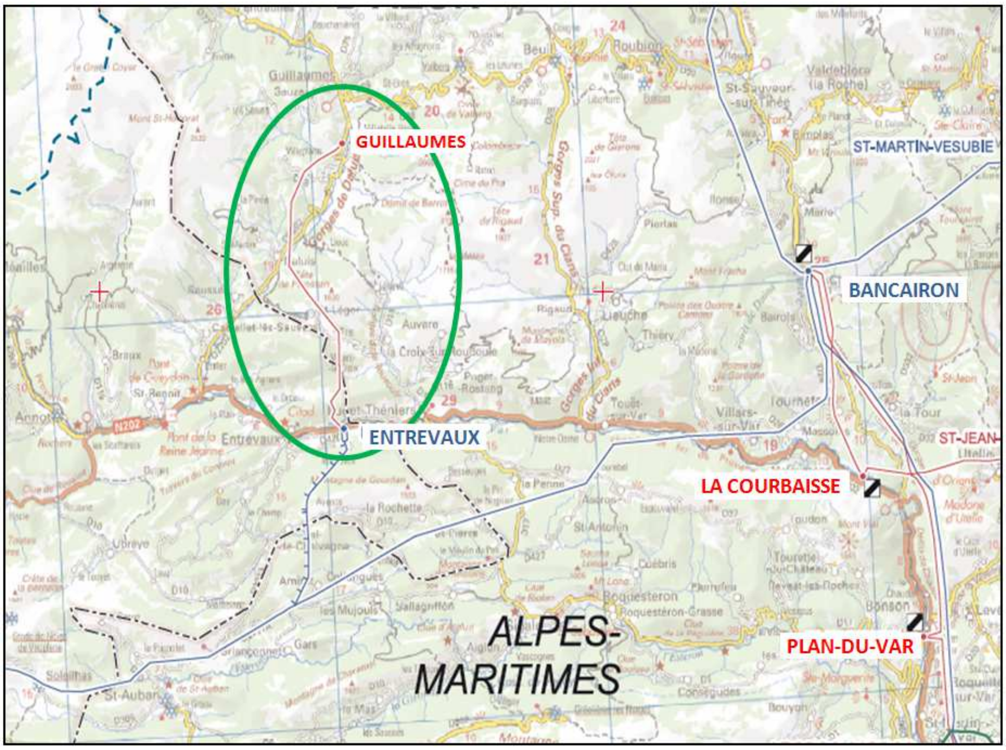


Figure 47. Geographic path of the HV line supplying "GUILLAUMES" primary substation

d) Primary substation single line diagram

The GUILLAUMES primary substation is currently equipped with a single 20 MV transformer, with a single half-branch.

e) MV feeders of the primary substation

"GUILLAUMES" primary substation supplies 3 mixed feeders (both aerial and underground).

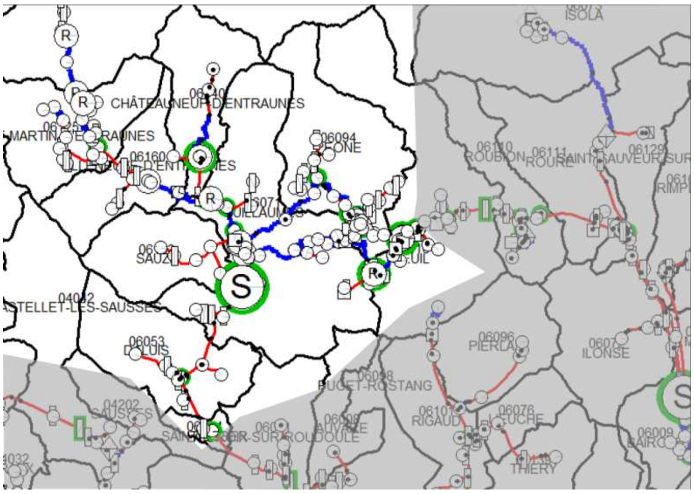


Figure 48. Distribution of the MV feeders powered by "GUILLAUMES" primary substation

f) Choice of the area

This area was identified after several power restorations resulting from works on the grid or grid incidents (MV, transformer, half-branch) indicated voltage drop problems. Power restoration from the MV side is limited by the long length of cables, small cross-sections and lack of backup feeders.

The possibility of reinforcing this primary substation was studied, showing the need of creating a new MV feeder from the ENTREVAUX primary substation. This feeder would pass through Daluis Falls to reach an AC3T (a remotely controlled 3 pole breaker) at the GUILLAUME substation, allowing departs A ("GUILLCA") or B ("GUILLCB") to have a backup other than the depart D ("BANCACD"), a significant improvement in the N-1 scenario.

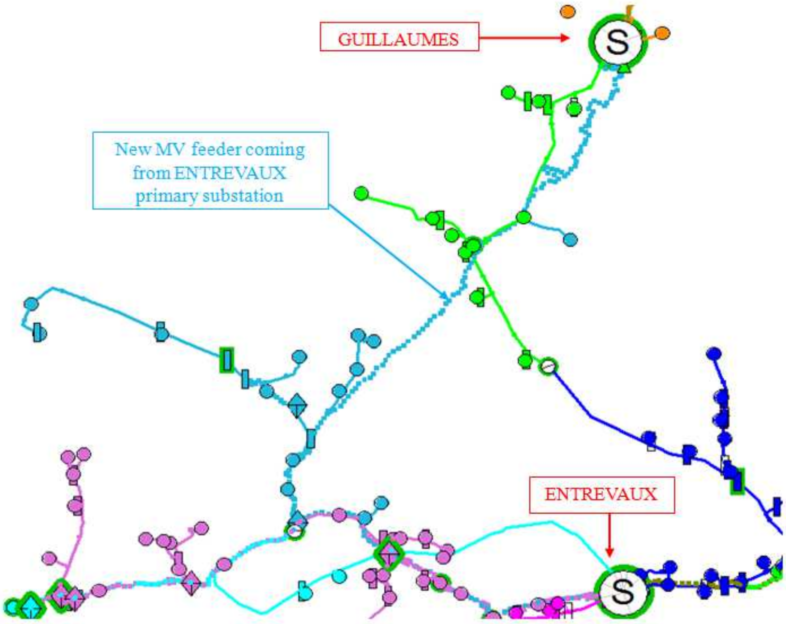


Figure 49. Distribution of the MV feeders powered by "ENTREVAUX" primary substation

After an incident on feeder E ("ENTRECE") in the beginning of October 2016, digging works have started in order to bury the feeder.

Enedis planning groups wished to study the connection between feeders E ("ENTRECE") and A ("GUILLCA"), knowing that 3 km of lines will be buried after last October's incident and that it could take advantage of digging works conducted by a French telecommunication company (France Télécom) on 1.4 km. This solution consists in connecting the two feeders, passing through Cians Falls.

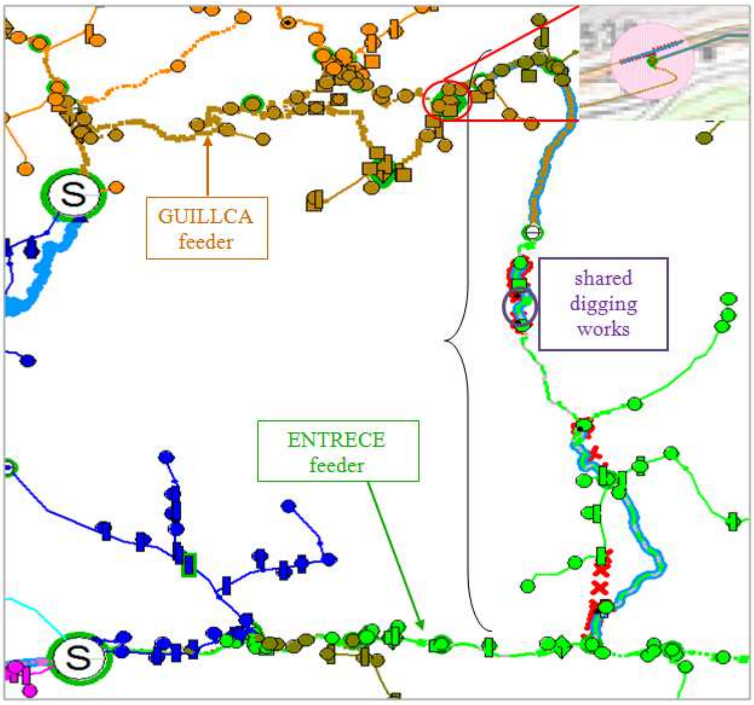


Figure 50. Possible new link between “ENTRECE” et “GUILLCA” feeders

The investment decision for this solution has been programmed recently. Enedis planning teams provides to spread works on 2018 and 2019. The new connection between the two feeders will not be commissioning until November 2019. As our field tests are before the commissioning, the demonstration will not be impacted.

APPENDIX 3 – GRID COMPUTATIONS TO ESTIMATE ENEDIS FLEXIBILITY NEEDS

This appendix' main objective is to present the "Broc Carros", "Isola" and "Guillaumes" zones identified by the DSO for the flexibilities and the interest gained from implementing them. This section will detail the constraints that appear on the MV grid located in these zones and the results obtained from the grid calculations, to conclude then the need to use the flexibilities to resolve those constraints. The end of this section will tackle the approach used on the LV grid.

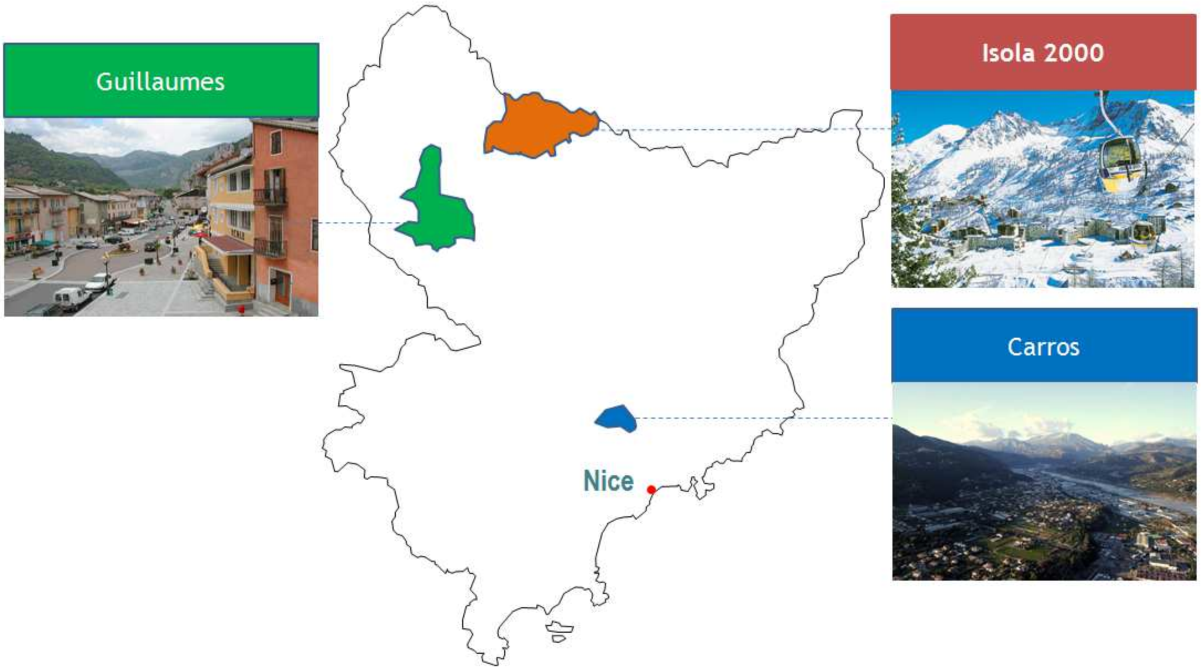


Figure 51. Perimeter of Nice Smart Valley in Alpes-Maritimes region

In this section, primary substations' names are written in capitals whereas towns' names are conventionally written.

1. Carros

The aim of this section is to present the various analyses carried out in the area served by the BROC CARROS primary substation.

In addition to a brief overview of the electrical grid in this area, the results of grid simulations, **all assuming operation under N-1 emergency configuration**, are presented.

Lastly, **the frequency of flexibility activation is evaluated by studying the results of the simulations in conjunction with the failure rates of Enedis equipment.**

1.1 Overview of the Broc Carros area

Figure 16 provides an overview of the electrical grid under normal conditions and under N-1 conditions at the transformer level.

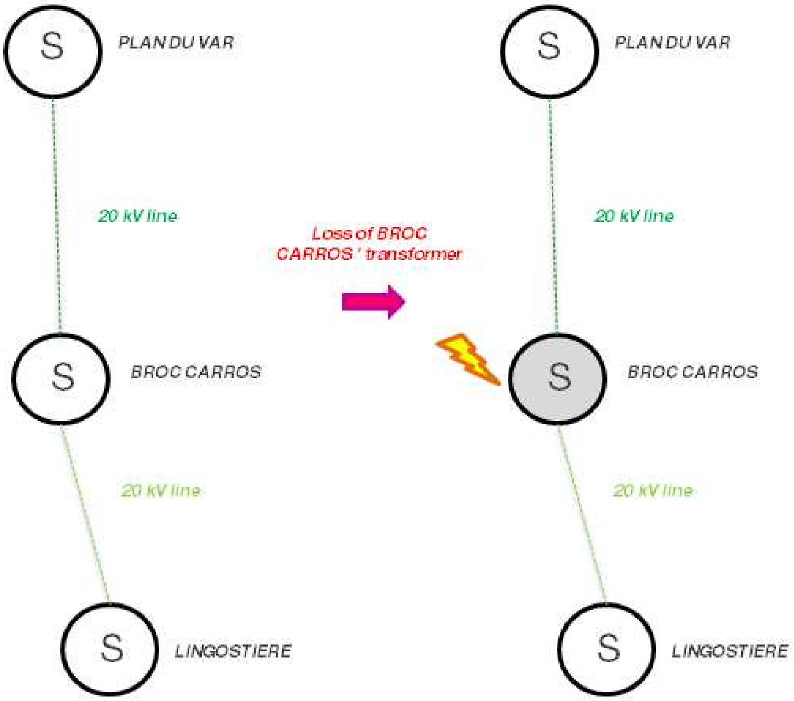


Figure 52. Overview of the electrical grid in the area under normal conditions and in the event of a loss at the transformer

Under normal conditions, the BROC CARROS primary substation is supplied from several high-voltage lines. A single incident requiring high-voltage equipment reliability can therefore not lead to a loss of supply at the high- and medium-voltage substation.[43] Nevertheless, this primary substation only has one transformer, which means that if the latter is tripped, the medium-voltage line will no longer be supplied. In the remainder of this document, we analyze flexibility requirements in the event of a loss affecting this transformer.

In N-1 configuration, there are: 1.67 MW of photovoltaic generation, 10.66 MW of hydraulic generation and 6.6 MW of thermal generation installed.

---

[43] Scenarios under N-2 conditions were not tested because they are extremely rare.

1.2 Research assumptions

Several assumptions were made before beginning to assess opportunities for flexibility in the Broc Carros area:

- The first assumption is that all current projects for the reinforcement of the grid will be carried out. The simulated grid is therefore in the state anticipated following the field experiments for *Nice Smart Valley*.
- The second assumption is that manual reconfiguration of the grid will not be used. The strategy of using manual reconfiguration was not studied because the results involve short durations for flexibility activation that would not always be possible for a technician to set manually.[44]
- The third assumption is that some independent producers would not be taken into consideration because, as can be seen from the generation curves, some of them have not been generating power for that long. We have therefore set them at nil generation even in cases where we consider generation to be active.

1.3 Grid simulations for the BROC CARROS primary substation

As mentioned above, the simulations presented in this section are based on the **hypothesis that the N-1 emergency configuration is set at the transformer level in all cases**. Consequently, the discussion in this section does not take into account the likelihood that an incident involving the equipment reliability and a sufficiently high level of demand to require flexibility occur at the same time.

The simulations show that, for the Broc Carros area, only the summer months offer opportunities for the DSO to make use of flexibility. For this reason, the results for the winter and shoulder-season months are not presented here.

Figure 53 shows the load duration curve for the BROC CARROS primary substation based on data for the summer months derived from two years of demand curves (2015 and 2016). The red portion of the load duration curve indicates the load levels that would entail the use of flexibility under N-1 conditions at the transformer level. The boundary between the red and blue portions of the load duration curve will be referred to as $a_{\min}$ in the remainder of this document.

---

[44] In addition, the use of manual intervention entails an absence of useful flexibility.

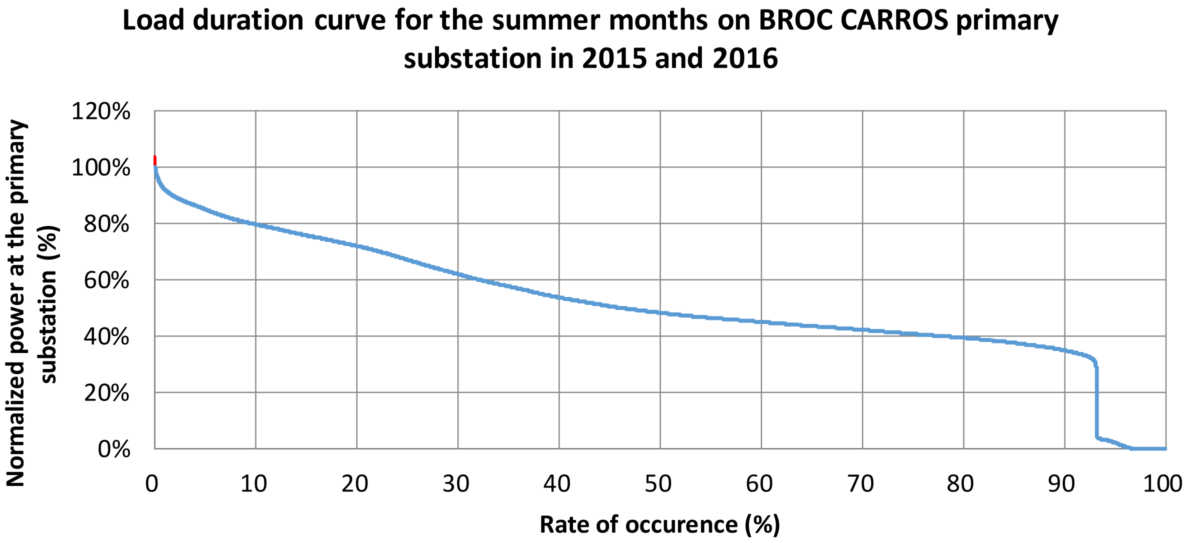


Figure 53. Load duration curve for the summer months in 2015 and 2016

Figure 54 shows the results for the simulations run under N-1 emergency configuration for various load levels in this seasonal period. These levels are very high because they correspond to the peak of the load duration curve for the primary substation. We see that there would be 2 hours per year during which it might be useful for the DSO to activate flexibility. The maximum useful flexibility is 450 kW if none of the independent producers is generating power. It drops to nil if generation stays at a level above the minimum recorded at times of the year during which constraints could be experienced.

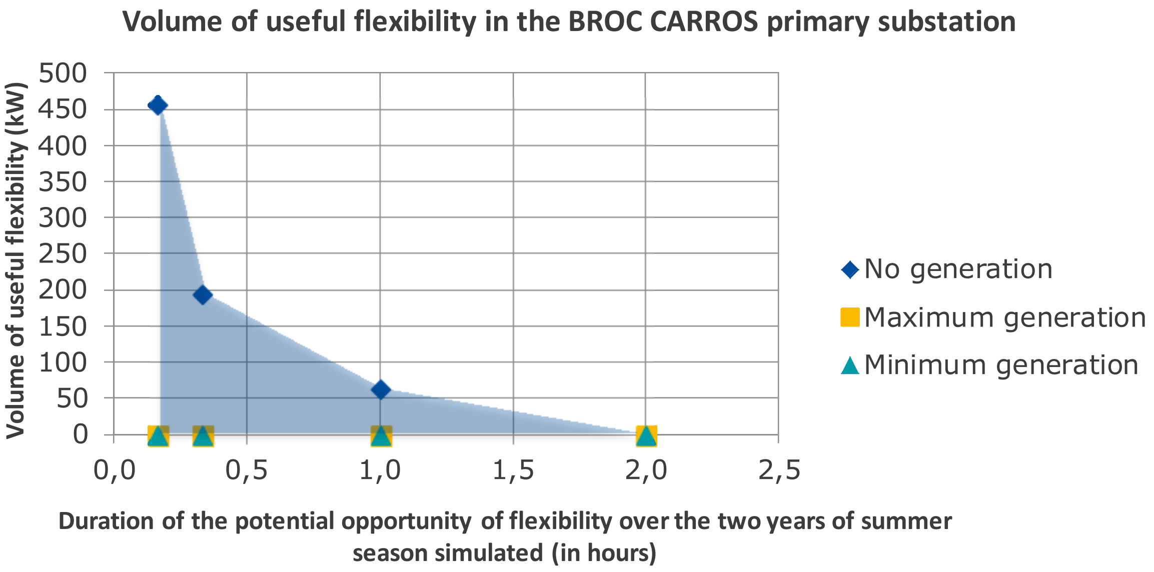


Figure 54. Useful flexibility in the BROC CARROS primary substation depending on the duration of constraints over the two-year period, assuming N-1 conditions at the transformer level

Following this presentation of the overall results, we now turn to the detailed results for specific durations and periods. Figure 55 shows a bar chart for the number of potential opportunities for flexibility in the summer months over the two-year period according to their duration.

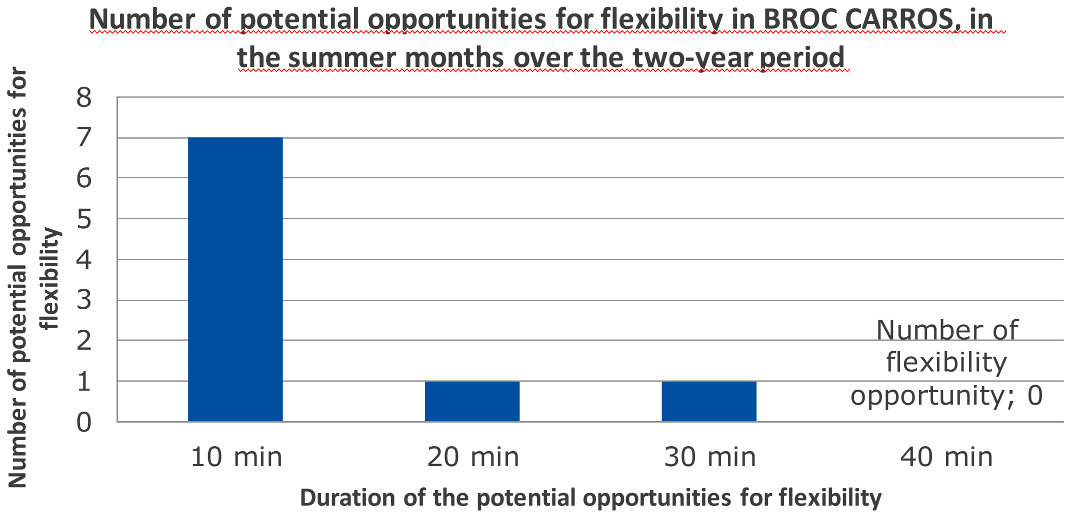


Figure 55. Number of potential opportunities for flexibility in the summer months over the two-year period, assuming N-1 conditions at the transformer level, according to their duration

Based on our simulations including two years of data for net demand at the primary substation receiving load relief, we note:

- a potential opportunity for flexibility of 1 hour per year;
- seven incidents having lasted for 10 minutes at most each;
- two incidents having lasted for more than 10 minutes each.

We note that, over the two years studied, the total duration of grid constraints would be 40 minutes. **It is also worth noting that all of these incidents occurred in July.**

Figure 56 shows the durations of useful flexibility activation at specific times of day. The graph includes a third dimension of analysis (in color) that shows the load level at the primary substation, providing information on the maximum useful flexibility. We see that all the activations occur between 11 a.m. and 3 p.m. This is due to the types of business customers located in the area in question.

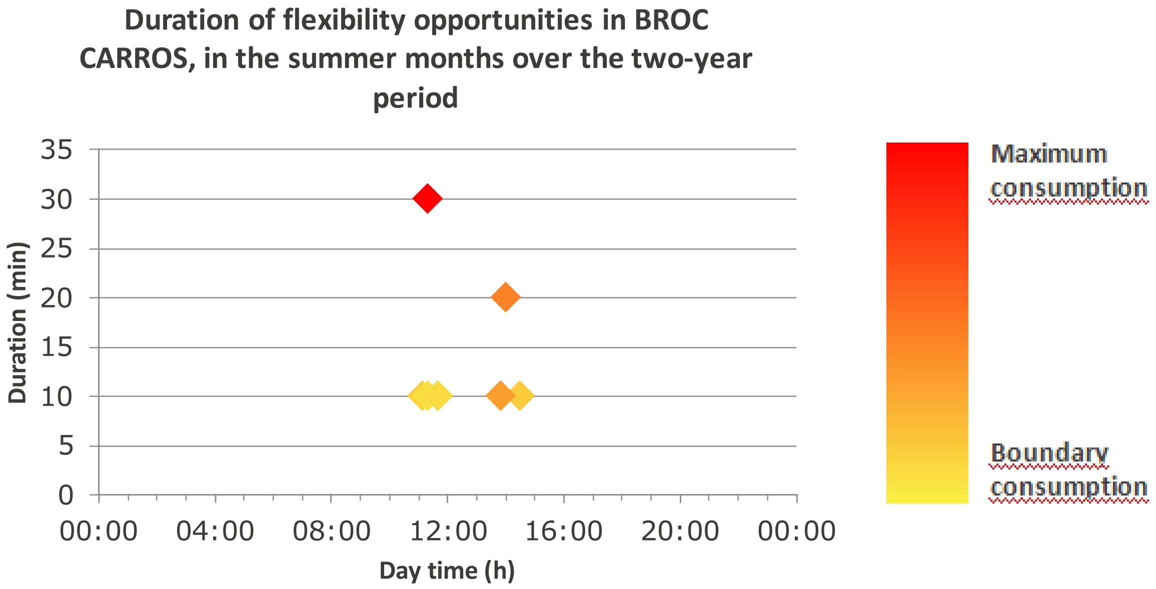


Figure 56. Duration of flexibility activation under N-1 conditions at the transformer level on a permanent basis, depending on the time of day over the two-year period, assuming N-1 conditions at the transformer level

1.4 Rate of occurrence

We have estimated the frequency of flexibility activation on the basis of the rate of occurrence in the tested scenario under N-1 emergency configuration. We have thus taken into account the failure rate of RTE and Enedis equipment, which has enabled us to determine the rate of occurrence for an incident involving equipment reliability. Next, by using a Poisson process, we determined the probability of occurrence of the tested scenario under N-1 emergency configuration, at the same time as a sufficiently high level of demand to require flexibility. In calculating the rate of occurrence, we did not take into account the fact that a manual intervention would entail an absence of flexibility. The rates calculated below will thus be broadly overestimated in relation to the cases in which they would be taken into account.

The results show that for the Bloc Carros area, and considering the load levels during the two previous years, the frequency of flexibility activation is once every 390 ± 60 years. Given the results obtained from the simulations, there was no outage greater than or equal to 40 minutes.

2. Isola

The aim of this section is to present the various analyses carried out in the area served by the ISOLA 2000 primary substation. In addition to a brief overview of the electrical grid in this area, the results of grid simulations, **all assuming operation under N-1 conditions**, are presented. Lastly, the frequency of flexibility activation is evaluated by studying the results of the simulations in conjunction with the failure rates of RTE equipment.

2.1 Overview of the Isola area

Figure 17 provides an overview of the electrical grid under normal conditions. Under normal conditions, the ISOLA 2000 primary substation is supplied from a high-voltage line between the portal structure and the ISOLA 2000 primary substation. But this very cable line is also one of the possible places for high-voltage line losses. When this happens, the ISOLA 2000 primary substation can no longer be supplied from the high-voltage line, which entails a need for reconfiguration in order to restore service to customers. It also shows the high-voltage scenario under N-1 conditions involved in the line loss mentioned above. The two main reconfiguration operations are:

- the closing of the high-voltage normally open terminal between the portal structure and ISOLA VILLAGE;
- the closing of the medium-voltage normally open terminal between ISOLA VILLAGE and ISOLA 2000.

The ISOLA 2000 loads are then supplied via the medium-voltage line coming from the transformation of 63 kV into 20 kV at the Isola Village substation.

As the features of medium-voltage lines are not the same as those of high-voltage lines, it turns out that there may be load levels that can result in grid constraints. This point is discussed in section 2.2 below.

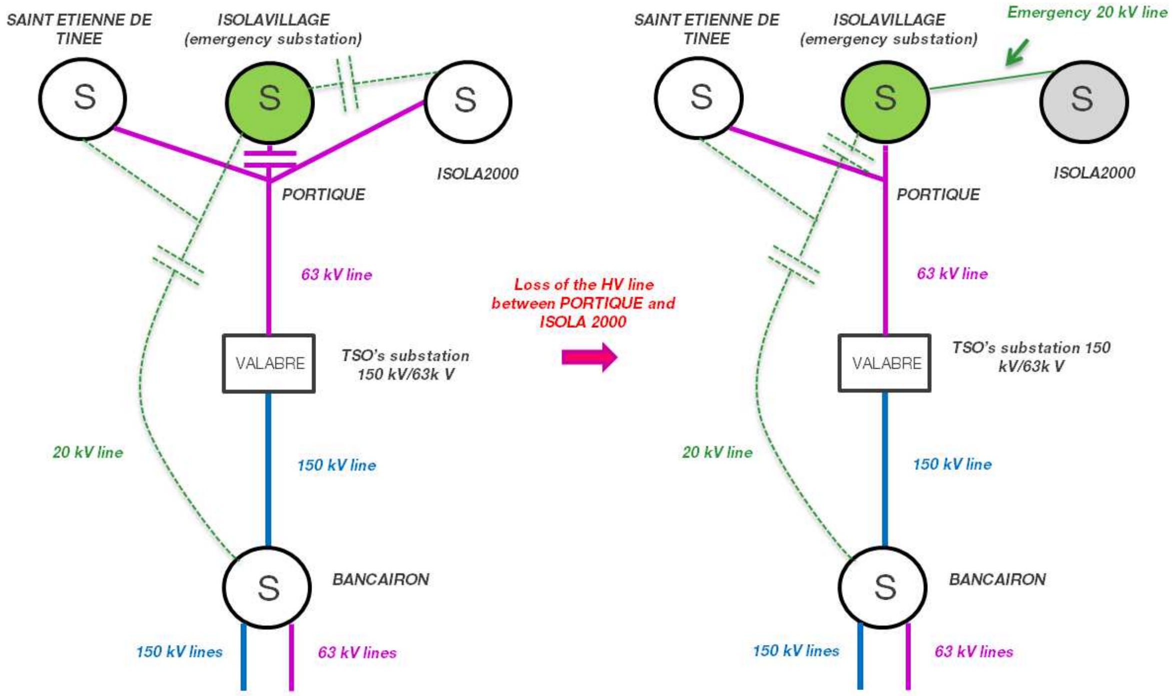


Figure 57. Overview of the electrical grid in the area under normal conditions (left) and under high-voltage N-1 emergency configuration (right)

In N-1 configuration, there is a total of 5.39 MW of hydraulic generation connected.

2.2 Grid simulations at the ISOLA 2000 primary substation

As mentioned above, the simulations presented in this section are based on **the hypothesis that the high-voltage N-1 emergency configuration is set in all simulations**. Consequently, they do not take into account the likelihood that an incident involving equipment reliability and a sufficiently high level of demand to require flexibility occur at the same time.

The simulations show that for the Isola area, only the winter and shoulder-season months offer opportunities for the DSO to make use of flexibility. For this reason, the results for the summer months are not presented here, because there are no opportunities for the DSO to make use of flexibility.

Figure 58 shows the load duration curve for the ISOLA 2000 primary substation based on two years of net demand curves (2015 and 2016). In particular, this load duration curve identifies the maximum load reached in the months from October to May over the two-year period.

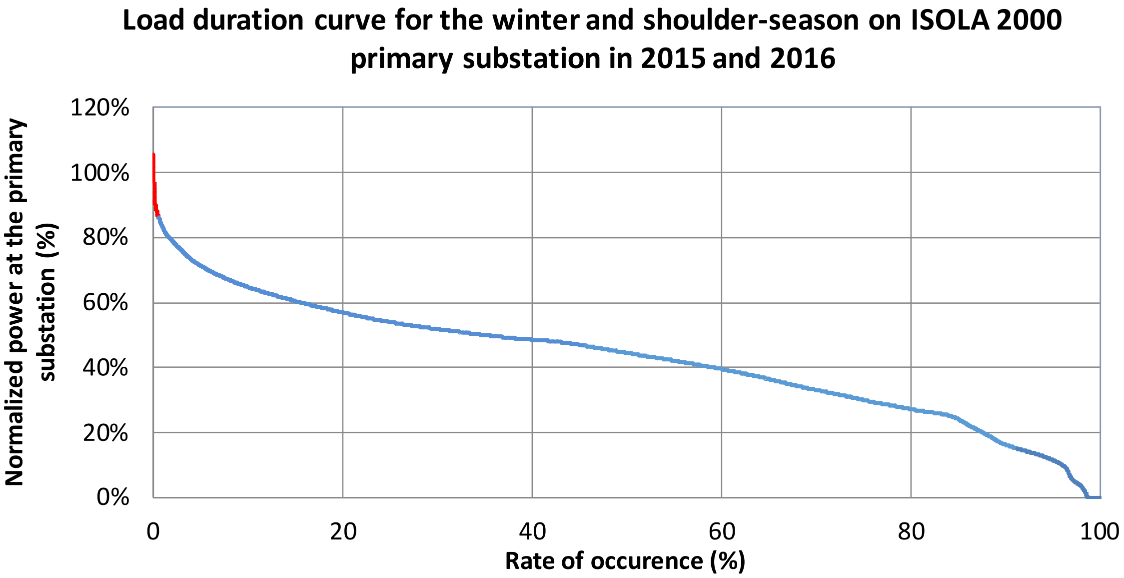


Figure 58. Load duration curve for the winter and shoulder-season in 2015 and 2016

The red portion of the load duration curve indicates the load levels that would entail the use of flexibility under high-voltage N-1 conditions. The boundary between the red and blue portions of the load duration curve will be referred to as $a_{\min}$ in the remainder of this document. This value is derived from the breakpoint load level between the scenarios with and without constraints, under high-voltage N-1 emergency configuration, at the load level of the normalized load duration curve.

Figure 59 below shows the results for the simulations run under N-1 emergency configuration for various load levels in this seasonal period. These levels are very high because they correspond to the peak of the load duration curve for the primary substation. We see that for 0.56% of the time, thus about 33 hours per year, it might be useful for the DSO to activate flexibility. The maximum useful flexibility is 2.5 MW if none of the independent producers is generating power. It drops to 1.3 MW if we take into consideration producers with minimum (and maximum) generation at times during the year when the load is very high.[45]

---

[45] This phenomenon is explained by the fact that there are two grid constraints (current and transformer). Minimum generation is high enough to remove the constraint at the transformer, but it is not well located to remove the current constraint.

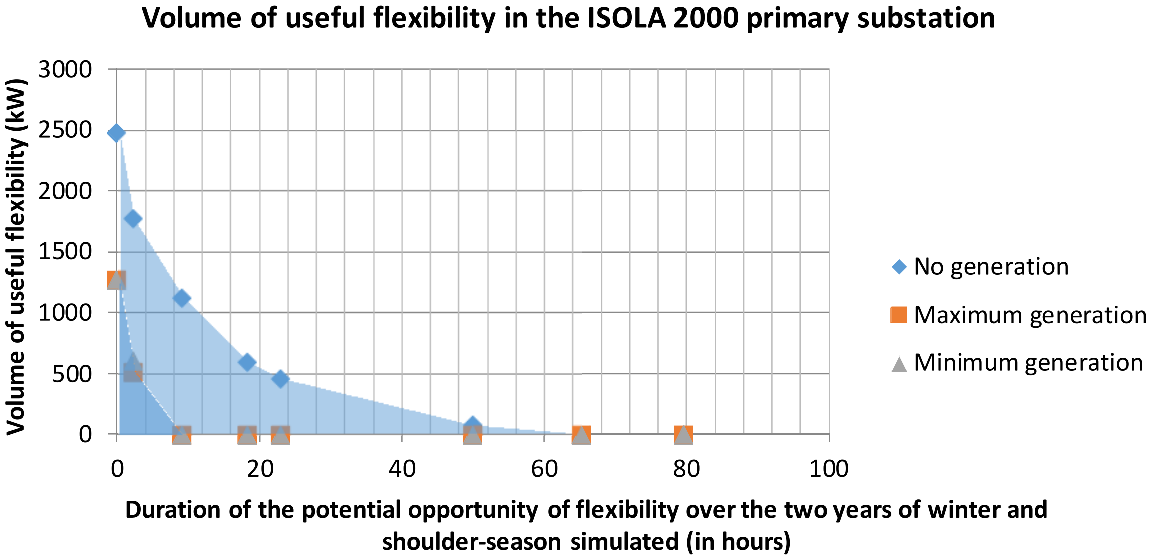


Figure 59. Useful flexibility in the ISOLA 2000 area depending on the rate of occurrence over the two years of simulations, assuming high-voltage N-1 configuration

Following this presentation of the overall results, we now turn to the more detailed results for specific durations and periods.

Figure 60 below shows a bar chart for a number of grid constraints in the months from October to May over the two-year period according to their duration.

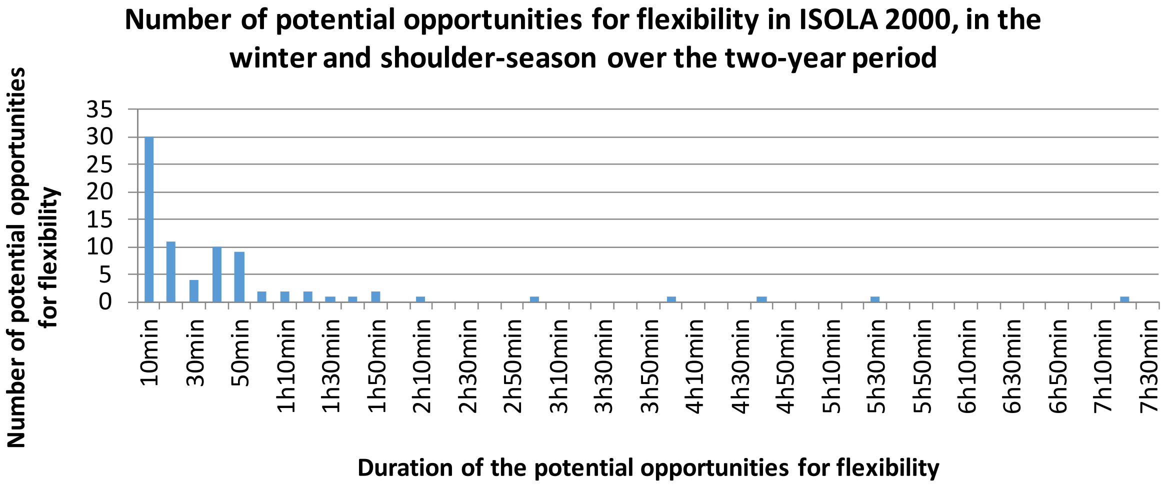


Figure 60 - Number of potential opportunities for flexibility in the winter and shoulder-season over the two-year period, assuming high-voltage N-1 configuration, according to their duration

Based on our simulations including two years of data for net demand at the primary substation receiving load relief, we conclude that, for these two years,

- 55 constraints would have lasted for less than 40 minutes;
- 25 constraints would have lasted for more than 40 minutes.

The incidents lasting longer than 40 minutes can be relatively lengthy, with a maximum of 7 hours and 20 minutes.

Figure 61 shows the breakdown of grid constraints for the months from October to May in the two years studied. We see that 85% of the flexibility activations would be concentrated in December and January.

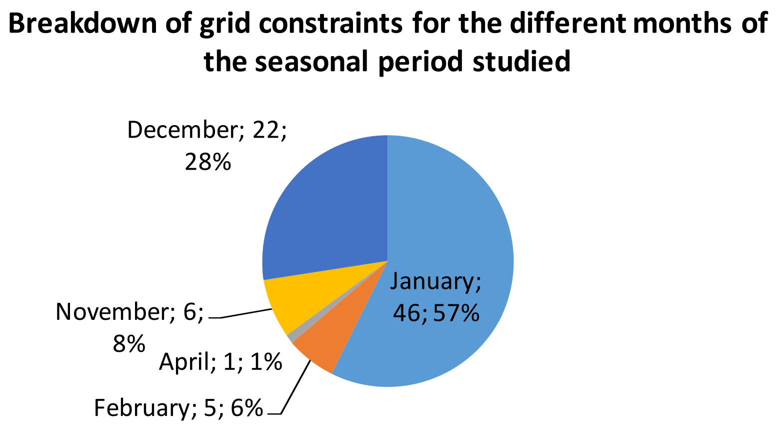


Figure 61. Breakdown of grid constraints for the different months of the seasonal period studied, assuming high-voltage N-1 conditions

Figure 62 shows the durations of useful flexibility activation at specific times of day. The graph includes a third dimension of analysis (in color) that shows the load level at the primary substation, providing information on the maximum useful flexibility. We see that all the activations occur between 10 p.m. and 5:30 a.m. This finding is **specific to the primary substation studied because one of its largest customers uses power during the night**.

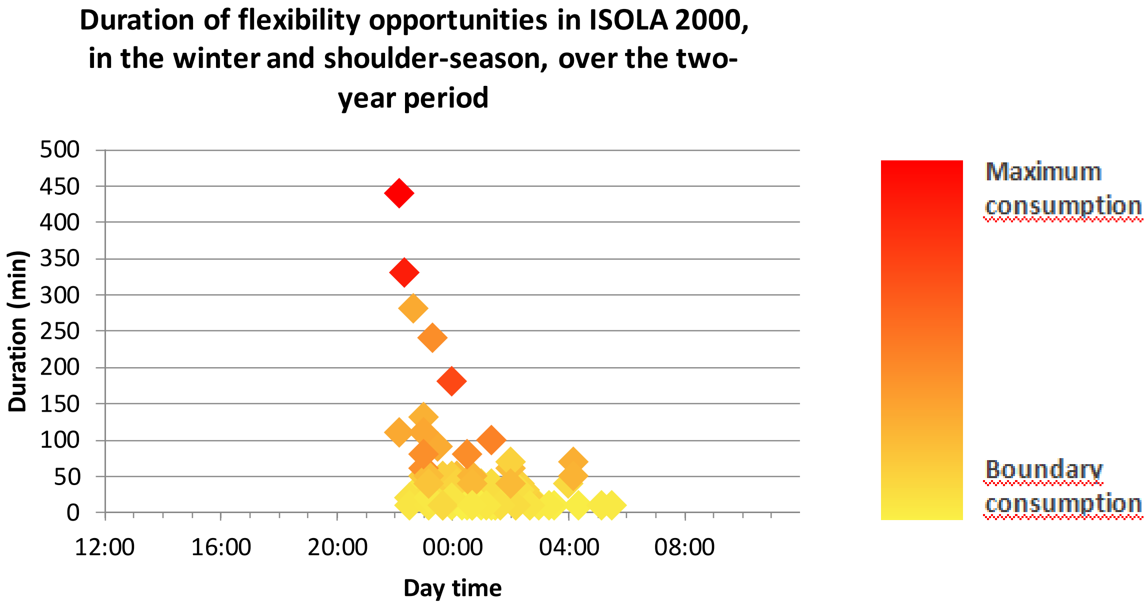


Figure 62. Duration of flexibility activation under high-voltage N-1 conditions, depending on the time of day over the two-year period

2.3 Rate of occurrence

We have estimated the frequency of flexibility activation on the basis of the rate of occurrence in the tested scenario under N-1 emergency configuration. We have thus taken into account the failure rate of RTE equipment, which has enabled us to determine the rate of occurrence for an incident involving equipment reliability. Next, by using a Poisson process, we determined the probability of occurrence of the tested scenario under N-1 conditions, at the same time as a sufficiently high level of demand to require flexibility.

The results showed that for the Isola area, and considering the load levels during the two previous years, the frequency of flexibility activation is once every 64 ± 6 years. We also found that the frequency of flexibility activation for a long outage, i.e. one lasting more than 40 minutes, would be once every 146 ± 15 years.

3. Guillaumes

The aim of this section is to present the various analyses carried out in the area served by the GUILLAUMES primary substation. In addition to a brief overview of the electrical grid in this area, the results of grid simulations, **all assuming operation under N-1 conditions**, are presented. Lastly, the frequency of flexibility activation is evaluated by studying the results of the simulations in conjunction with the failure rates of RTE and/or Enedis equipment.

3.1 Overview of the Guillaumes area

Figure 63 provides an overview of the electrical grid under normal conditions and under N-1 conditions. Under normal conditions, the GUILLAUMES primary substation is supplied from a 63 kV high-voltage line. In the event of a loss on this line and/or at the level of the 63 kV/20 kV transformer, supply can no longer be received directly from the ENTREVAUX primary substation.

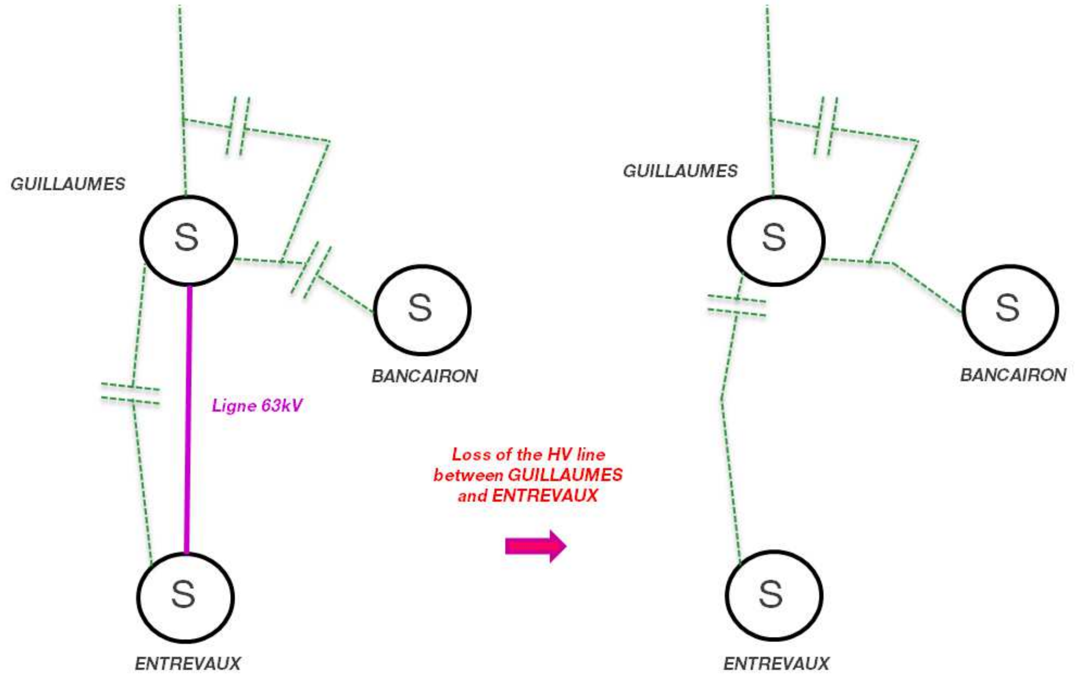


Figure 63. Overview of the electrical grid in the area under normal conditions and under N-1 conditions

In N-1 configuration, there are: 4.53 MW of hydraulic generation and 2.31 MW of photovoltaic generation installed.

3.2 Grid simulations at the GUILLAUMES primary substation

As mentioned above, the simulations presented in this section are based on **the hypothesis that the N-1 security criterion is satisfied in all cases**. Consequently, they do not take into account the likelihood that an incident involving equipment reliability and a sufficiently high level of demand to require flexibility occur at the same time (this point is covered in paragraphs ▫ and ▫ below).

The simulations show that for the Guillaumes area, only the winter and shoulder-season months offer opportunities for the DSO to make use of flexibility. For this reason, the results for the summer months are not presented here.

Figure 64 shows the load duration curve for the GUILLAUMES primary substation based on two years of net demand curves (2015 and 2016). In particular, this load duration curve identifies the maximum load reached in the months from October to May over the two-year period.

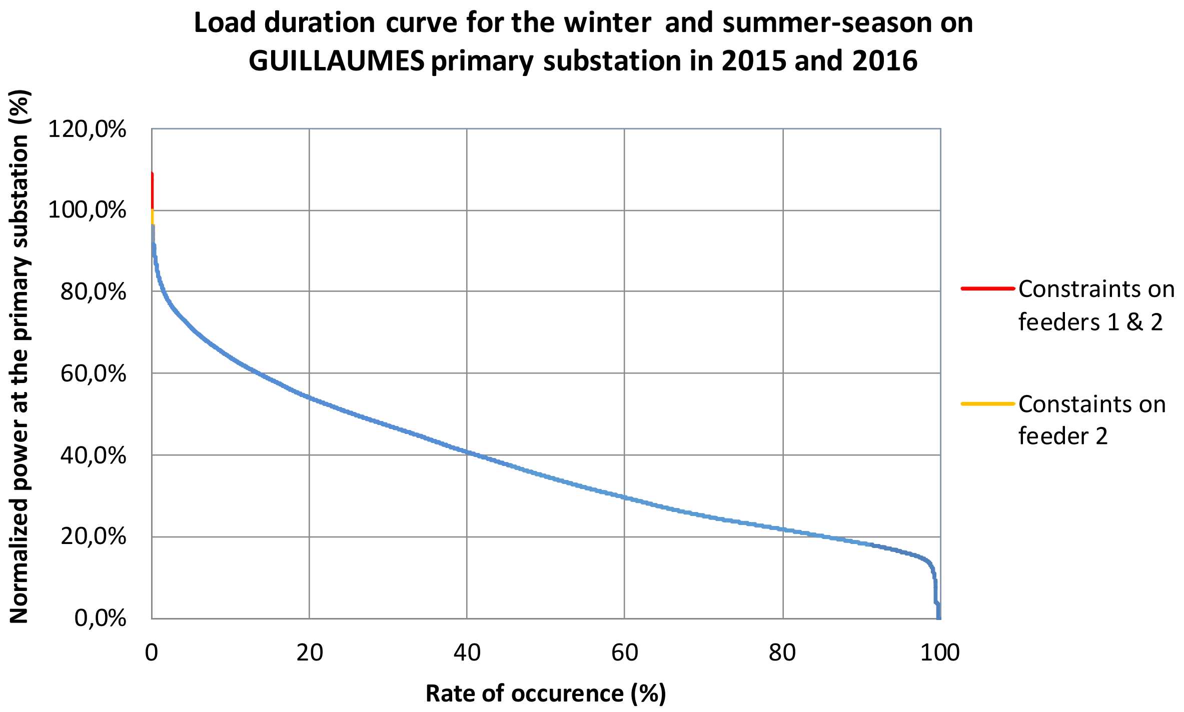


Figure 64. Load duration curve for the months from October to May in the years 2015 and 2016

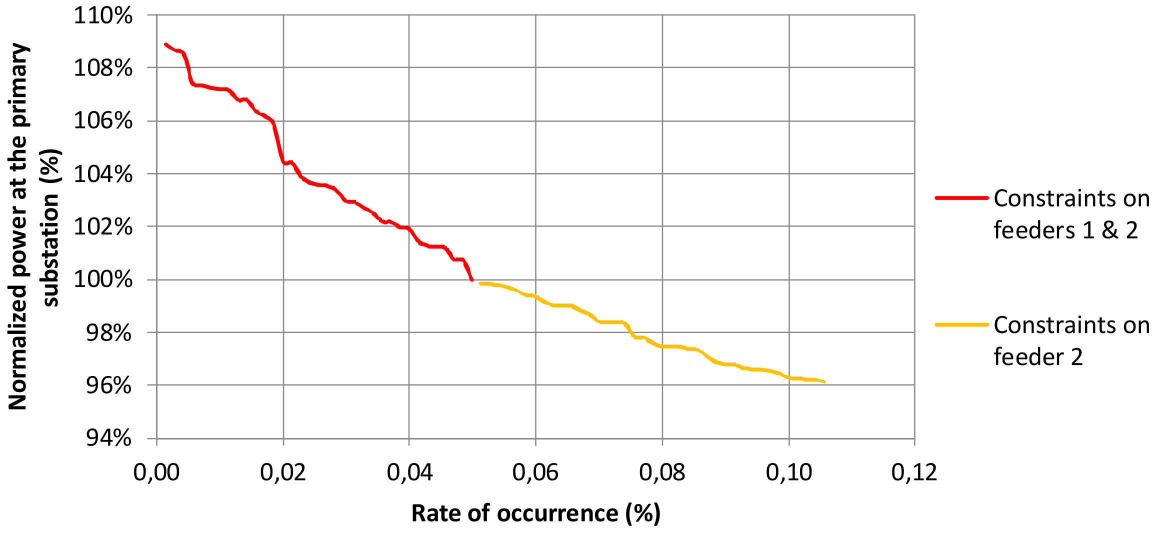


Figure 65. Enlarged detail of portion of load duration curve under constraint in the months from October to May in the years 2015 and 2016

The red portion of the load duration curve indicates the load levels that would entail double current constraints under N-1 conditions (i.e. in the event of a loss of high-voltage supply). The orange portion shows the load levels for which only a single current constraint is involved. The boundary between the orange and blue portions of the load duration curve will be referred to as a_{min} in the remainder of this document. This value is derived from the boundary load level between the scenarios with and without constraints, under N-1 conditions, at the load level of the normalized load duration curve.

In the Guillaumes area, the scenario tested under N-1 emergency configuration entails four constraints with, for each feeder providing load relief: one current constraint and one voltage constraint. **The analyses in the following two sections uniquely involve the alleviation of current constraints from the two feeders.** The levels of flexibility able to alleviate the voltage constraints at both feeders have not been fully determined at this time and will be available at a later date.

3.3 Feeder 1

Figure 66 below shows the results for the simulations run under N-1 conditions for various load levels during the winter and shoulder-season months. We see that there would be 2 hours and 55 minutes per year during which it might be useful for the DSO to activate flexibility. The maximum useful flexibility is 0.5 MW if none of the independent producers is generating power. It drops to 0.12 MW if we take into consideration producers with minimum (and maximum) generation at times during the year when the load is very high.[46]

---

[46] This phenomenon is explained by the fact that there are two grid constraints (current and transformer). Minimum generation is high enough to remove the constraint at the transformer, but it is not well positioned to remove the current constraint.

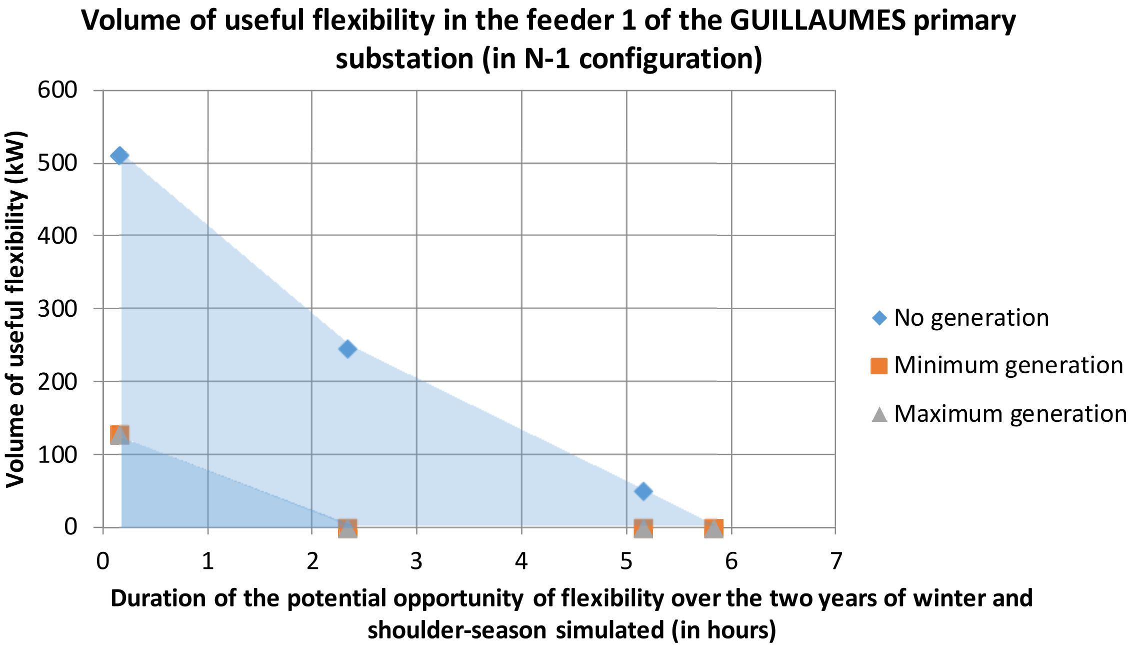


Figure 66. Useful flexibility level in the Guillaumes area (Feeder 1), depending on the rate of occurrence over the two years of simulations

Following this presentation of the overall results, we now turn to the more detailed results for specific durations and periods.

Figure 67 below shows a bar chart for a number of grid constraints in the months from October to May over the two-year period according to their duration.

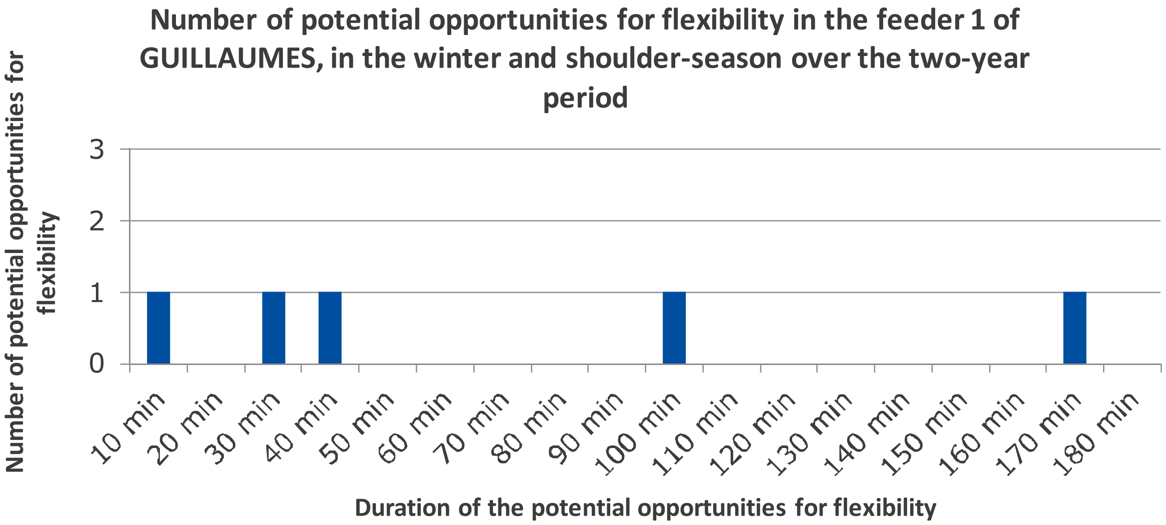


Figure 67. Number of potential opportunities for flexibility in the months from October to May over the two-year period, assuming N-1 conditions, according to their duration

Based on our simulations for two years of data on net demand at the primary substation receiving load relief, we conclude that there would be 5 hours and 50 minutes of potential flexibility activation over the two-year period, thus 2 hours and 55 minutes per year.

Figure 68 shows the breakdown of grid constraints for the months from October to May in the two years studied. We see that the flexibility activations would be concentrated in December and January.

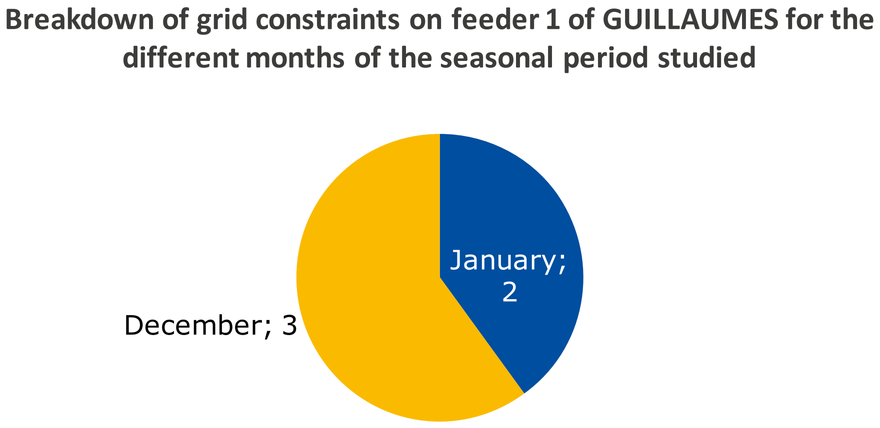


Figure 68. Breakdown of grid constraints for the seasonal period studied, assuming N-1 conditions

Figure 69 shows the durations of useful flexibility activation at specific times of day. The graph includes a third dimension of analysis (in color) that shows the load level at the primary substation, providing information on the maximum useful flexibility. We see that all the activations occur between 11 p.m. and 2 a.m. This finding is **specific to the primary substation studied because one of its largest customer uses power during the night**.

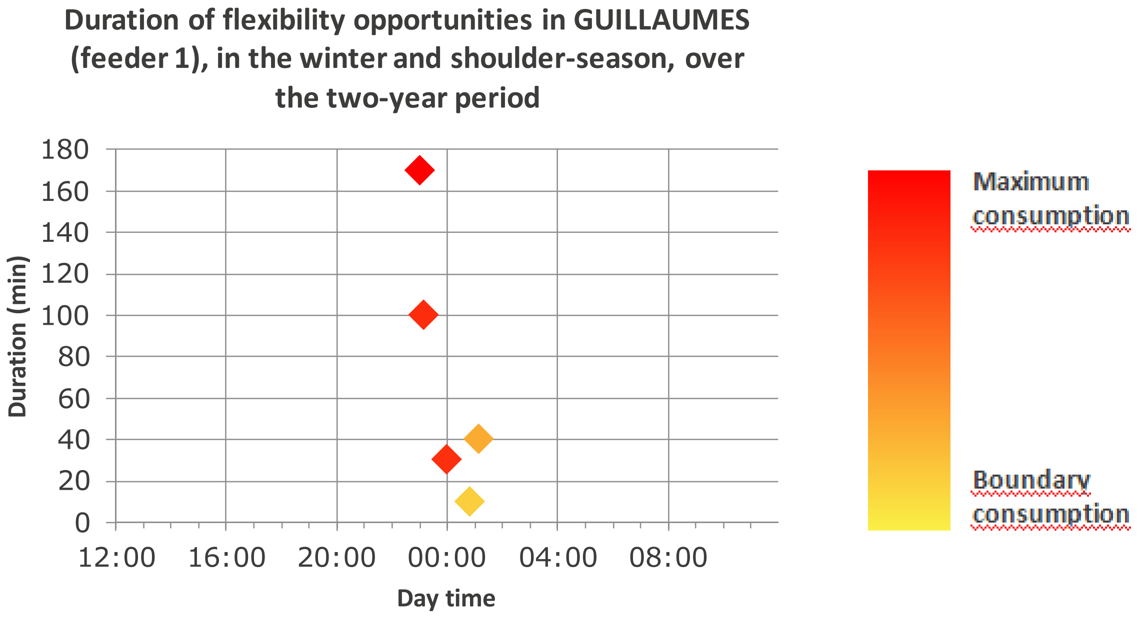


Figure 69. Duration of flexibility activation, assuming N-1 conditions, depending on the time of day over the two-year period

- **Rate of occurrence**

We have estimated the frequency of flexibility activation on the basis of the rate of occurrence in the tested scenario under N-1 conditions. We have thus taken into account the failure rate of Enedis and RTE equipment, which has enabled us to determine the rate of occurrence for an incident involving equipment reliability. Next, by using a Poisson process, we determined the probability of occurrence of the tested scenario under N-1 conditions, at the same time as a sufficiently high level of demand to require flexibility.

The results showed that for Feeder 1 of the GUILLAUMES primary substation, and considering the load levels during the two previous years, the frequency of flexibility activation is once every 320 ± 40 years. We also found that the frequency of flexibility activation for a long outage, i.e. one lasting more than 40 minutes, would be once every 570 ± 130 years.

3.4Feeder 2

Figure 70 below shows the results for the simulations run under N-1 conditions for various load levels in the winter and shoulder-season months. We see that there would be 2 hours and 55 minutes per year during which it might be useful for the DSO to activate flexibility. The maximum useful flexibility is 0.66 MW if none of the independent producers is generating power. It is brought down to 0 MW if we take into consideration producers with minimum (and maximum) generation at times during the year when the load is very high.

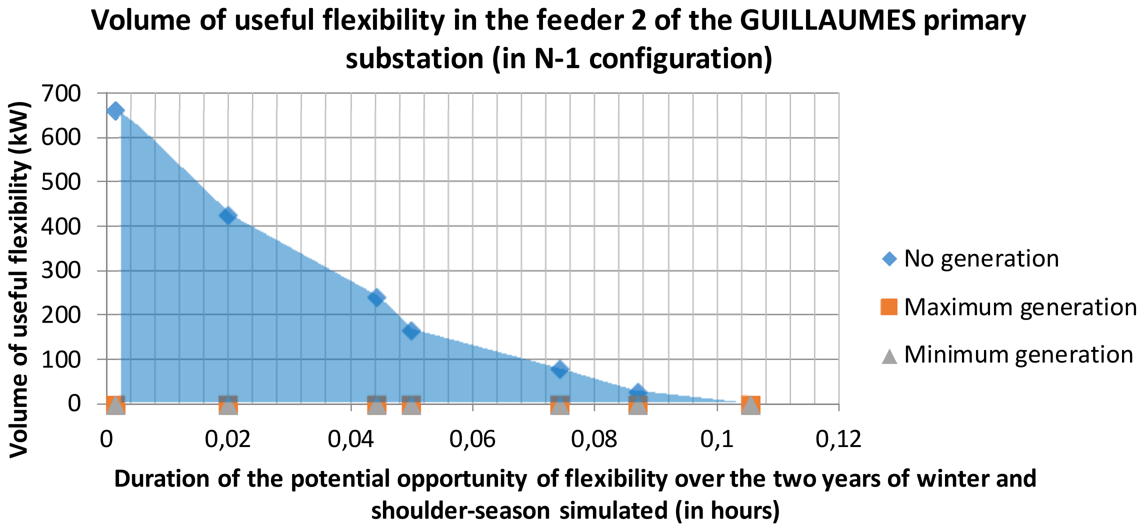


Figure 70. Useful flexibility in the Guillaumes area (Feeder 2), depending on the rate of occurrence over the two years of simulations

Following this presentation of the overall results, we now turn to the more detailed results for specific durations and periods.

Figure 71 below shows a bar chart for a number of grid constraints in the months from October to May over the two-year period according to their duration.

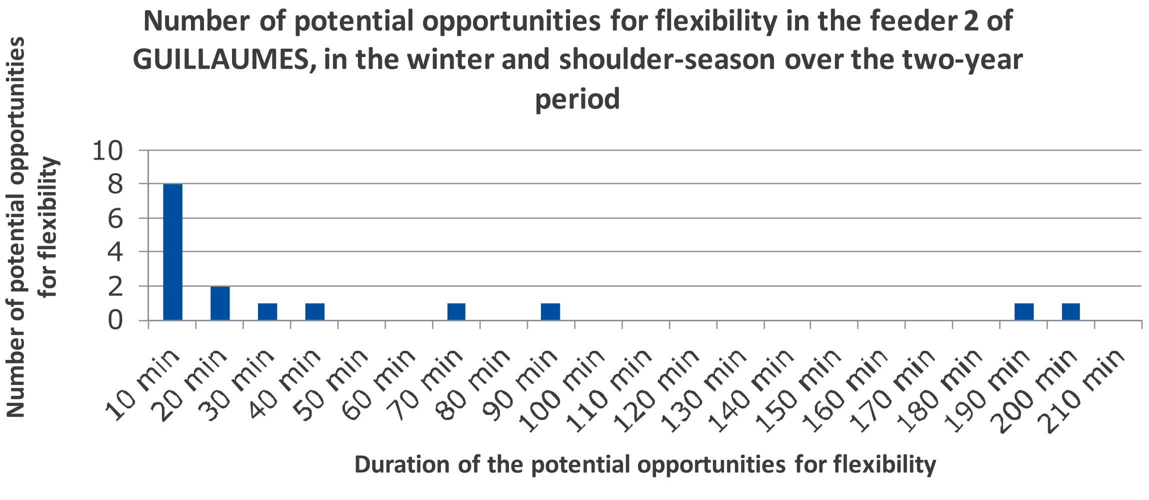


Figure 71. Number of grid constraints in the months from October to May over the two-year period, assuming N-1 conditions, according to their duration

Based on our simulations including two years of data for net demand at the primary substation receiving load relief, we conclude that, for these two years, there would be 12 hours and 20 minutes of potential flexibility activation over the two-year period, thus 6 hours and 10 minutes per year.

Figure 72 shows the breakdown of grid constraints for the months from October to May in the two years studied. We see that, in the event of incidents, flexibility activation would be concentrated in December and January.

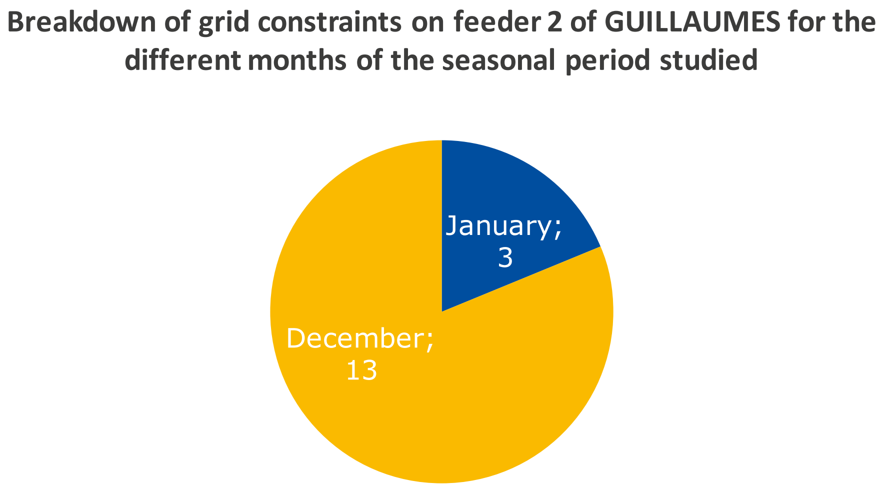


Figure 72. Breakdown of grid constraints for the seasonal period studied, assuming N-1 conditions

Figure 73 shows the durations of useful flexibility activation at specific times of day. The graph includes a third dimension of analysis (in color) that shows the load level at the primary substation, providing information on the maximum useful flexibility. We see that all the activations occur between 7 p.m. and 4 a.m.

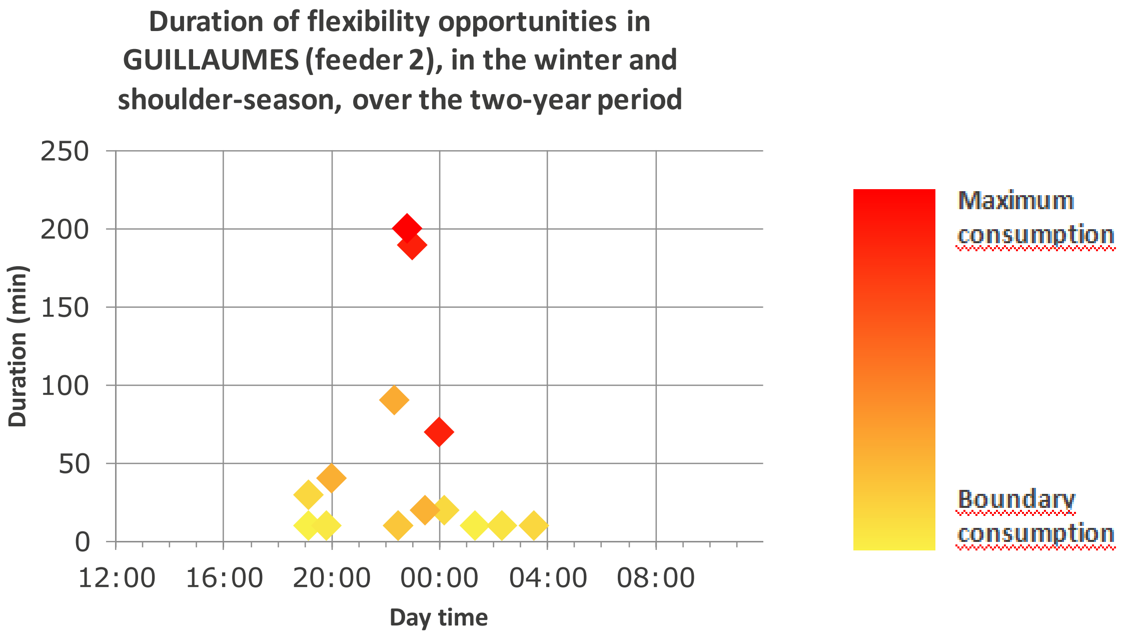


Figure 73. Duration of flexibility activation, assuming N-1 conditions, depending on the time of day over the two-year period

- **Rate of occurrence**

We have estimated the frequency of flexibility activation on the basis of the rate of occurrence in the tested scenario under N-1 conditions. We have thus taken into account the failure rate of Enedis and RTE equipment, which has enabled us to determine the rate of occurrence for an incident involving equipment reliability. Next, by using a Poisson process, we determined the frequency of occurrence of the tested scenario under N-1 conditions, at the same time as a sufficiently high level of demand to require flexibility.

The results showed that for Feeder 2 of the Guillaumes primary substation, and considering the load levels during the two previous years, the frequency of flexibility activation is once every 104 ± 20 years. We also found that the frequency of flexibility activation for a long outage, i.e. one lasting more than 40 minutes, would be once every 340 ± 50 years.

APPENDIX 4 – ISLANDING SCENARII AND KPI

1. Step by step analysis of the scenarios

This section describes the **step by step analysis of different scenarios of actors and equipments**. The primary scenarios describe the normal/expected situation whereas secondary scenarios describe what would happen in case of an issue.

Table 16. List of the scenarios for islanding

Scenario No.	Scenario Name	Scenario Description	Triggering Event	Pre-Condition	Post-Condition
PS1	Short-term islanding required by the DSO	The DSO needs to start an islanding in order to maintain the power supply of the islandable area	The DSO needs to start an islanding		**Islanding started**
PS2	Mid-term islanding scheduled by the DSO	The DSO needs to schedule an islanding in order to maintain the power supply of the area for works needs for example	The DSO needs to schedule an islanding		**Islanding scheduled & Aggregator informed**
PS3	Automatic islanding to overcome a blackout	A blackout occurs upstream, the GFU assesses whether an islanding is possible. If yes, the islanding starts with a black start.	A blackout occurs upstream	GFU's indicators are good & Regional control room authorizes the islanding & Failure comes from upstream	
PS4	GFU's state of charge is too low	The islanding's life is in danger because the GFU does not have enough charge to supply the clients in the islandable area (consumption	Islanding in progress	Low state of charge of the GFU & overconsumption on the islanding area	**Increase of islanding duration**
PS5	GFU's state of charge is too high	The islanding is in danger because the GFU has no more space to charge the storage system (generation >	Islanding in progress	High state of charge of the GFU & overgeneration on the islanding area	**Increase of islanding duration**
PS6	Enedis requires a reconnection of the islandable area	The islanding must be stopped to be reconnected to the main distribution grid.	Voltage upstream & Enedis' requirement	Islanding in progress	**Islandable area reconnected to the main grid**

PS7	Net load exceeds the GFU's capacity	The local net load is too high in comparison with the GFU capacity. The islanding is in	Islanding in progress	Overconsumption on the islanding area exceeding the GFU's capacity	**Islanding lasts longer**
AS1	A fault appears into the islandable area	The GFU detects a fault into the islanding area.	Detection of a fault	Islanding in progress	**End of islanding OR fault elimination**

Primary scenario

PS1: Short-term islanding required by the DSO

Table 17. PS1: Short-term islanding required by the DSO

Step No.	Event	Description of Process/Activity
01	The DSO needs to start islanding in the short-term	**The DSO needs to start an islanding in order to maintain the power supply of the islandable area.**
02	The DSO checks the GFU's indicators	**DSO checks the storage system indicators to verify whether islanding could start. If every indicator is good, the islanding is required by the regional control room. If at least one indicator is outside the range, the islanding cannot start.**
02bis	The GFU indicators are good	**ENEDIS assesses whether curtailments are required to start the GFU taking into account the local power available.**
02ter	Curtailment level is known	**Aggregators activate curtailments in order to adapt the local load to the GFU capacity.**
03	Load level is correct	**The GFU can start finding the balance point: consumption = generation.**
04	**Balance generation = consumption found**	**The GFU opens the islanding breaker and supplies the islanding area.**

PS2: Mid-term islanding scheduled by the DSO

Table 18. Mid-term islanding scheduled by the DSO

Step No.	Event	Description of Process/Activity
01	The DSO needs to schedule an islanding in the mid term	**The DSO needs to schedule an islanding in order to maintain the power supply of the area in the future.**

02	The DSO informs the aggregator about the scheduled islanding	**The DSO informs the aggregator about the future islanding.**
03	Scheduled islanding must be started	**DSO checks the storage system indicators to verify whether islanding could start. If every indicator is good, the islanding is required by the regional control room. If at least one indicator is outside the range, the islanding cannot start.**
03bis	The GFU indicators are good	**ENEDIS assesses whether curtailments are required to start the GFU taking into account the local power available.**
03ter	Curtailment level is known	**Aggregators activate curtailments in order to adapt the local load to the GFU capacity.**
04	Load level is correct	**The GFU can start finding the balance point: consumption = generation.**
05	Balance generation = consumption found	**The GFU opens the islanding breaker and supplies the islanding area.**

PS3: Automatic islanding to overcome a blackout

Table 19. Automatic islanding to overcome a blackout

Step No.	Event	Description of Process/Activity
01	A blackout occurs on the islandable	**The GFU checks its indicators.**
02	GFU's indicators are good	**The GFU checks whether the failure is provoked by the LV grid.**
03	Failure comes from upstream (MV or HV)	**The GFU questions the regional control room if an islanding is possible.**
04	Islanding authorized by the regional control room	**The GFU opens the islanding breaker.**
04bis	The GFU's indicators are good	**ENEDIS assesses whether curtailments are required to start the GFU taking into account the local power available.**
04ter	Curtailment level is known	**Aggregators activate curtailments in order to adapt the local load to the GFU capacity.**

05	Islanding breaker open	**The GFU starts a black start.**
06	**All customers**	**The GFU holds voltage magnitude and frequency in the range.**

PS4: GFU’s state of charge is too low

Table 20. GFU’s state of charge is too low

Step No.	Event	Description of Process/Activity
01	The GFU’s charge is too low	**The islanding’s life is in danger because the GFU does not have enough charge to last longer (consumption > generation).**
02	The GFU requires help from the local customers and the GSU	**The GFU injects a voltage with a low frequency to let the customers and the GSU know that they can help the islanding to last longer.**
03a	GSU injects power	**After receiving the frequency signal, GSU injects power depending on the frequency measurement.**
03b	Local customers decrease their	**To be defined.**
04	**Islanding lasts longer**	**Islanding duration increases as the levers into the islanding help the GFU to maintain stability.**

PS5: GFU’s state of charge is too high

Table 21. GFU’s state of charge is too high

Step No.	Event	Description of Process/Activity
01	The GFU’s charge is too high	**The islanding is in danger because the GFU has no more space to charge the storage system (generation > consumption).**
02	The GFU requires help from the local generation, the GSU and the flexible customers	**The GSU injects a voltage with a low frequency to let the generators and the GSU know that they must help the islanding to last longer. *The order of the three next steps is not defined yet in the project*.**
03a	GSU charges	**The GSU charges depending on the frequency measurement (priority to GSU charges).**
03b	Local consumer increase their loads	**Local consumers anticipate load in order to consume local generation**
03c	Local producers decrease their generation	**Local producers decrease their generation depending on the frequency measurement.**
04	**Islanding lasts longer**	**Islanding duration increases as the levers into the islanding help the GFU to maintain stability.**

PS6: Enedis requires a reconnection of the islandable area

Table 22. Enedis requires a reconnection of the islandable area

Step No.	Event	Description of Process/Activity
01	Power supply from the upstream main grid is detected	**The GFU proposes the end of islanding to the regional control room.**
02	Regional control room validates the end of the islanding	**The GFU stops the islanding**
03	**Voltage magnitude and phase are the same as the main grid’s**	**Automatic reconnection to the main grid by closing the islanding breaker with no blackout.**

PS7: Net load exceeds the GFU’s capacity

Table 23. Net load exceeds the GFU’s capacity

Step No.	Event	Description of Process/Activity

01	An islanding must be started or is in progress	**The GFU assesses the net load of the islandable area to verify whether the GFU can balance the net load.**
02	Net load is higher than GFU's capacity	**The GFU requires the aggregators to reduce the overall consumption on the islanding area to meet the GFU's capacity.**
03	**Islanding lasts longer**	**Islanding duration increases as the levers into the islanding help the GFU to maintain stability.**

Secondary scenarios

AS1: A fault appears into the islanding area

Table 24. A fault appears into the islanding area

Step No.	Event	Description of Process/Activity
01	Detection of a fault in the islanding area	**The islanding must be stopped for safety reasons**
02	**Fault elimination attempt**	**The GSU tries to eliminate the fault. If it works, islanding remains. If it is impossible, GFU must stop the islanding.**

2. Islanding KPI

Table 25. List of KPIs

ID	Name	Description
1	Voltage deviation during islanding	The difference in percentage between the average magnitudes of the voltage measured every 10 minutes and the voltage set point of the MV/LV transformer according to EN 50160. The objective is to have a voltage deviation under 10%, 95% of the time.
2	Frequency deviation during islanding	The difference in percentages between the measured frequency for each time step t and the set frequency value of the grid forming unit. The objective is to have a frequency deviation of 50 Hz ± 1%, 99.5% of the time and 50 Hz +4% / -6%, 100% of the time.
3	Total harmonic distortion	Total harmonic distortion in islanding mode based on measurements made at the grid forming unit level over the overall islanding period. The objective is to have a total harmonic distortion under 8%.

4	Voltage unbalance	The ratio in percentage between the negative sequence voltage component and the positive sequence voltage component. The objective is to have a voltage unbalance under 2%.
5	Total islanding duration	The sum in hours of the different durations of the islanding tests overall experimentation. The objective is to test islanding more than 10h overall the experimentation.
6	Duration of avoided blackout for customers	Duration determined overall the experiment. For each islanding experiment, the avoided duration of the customer's blackout is determined by subtracting the duration of blackout that the customer would have had if there were no islanding system to the duration of the islanding experiment. These durations are summed to get the total duration of avoided blackout.
7	Fraction of consumers/producers actively taking part in the islanding test	The fraction in percentage of the number of consumers who respond to dynamic request by lowering or time-shifting their energy usage to increase the potential duration of islanding and the total number of day-ahead or intraday load shedding/shifting requests.
8	Total energy lost had the blackouts occurred	The amount of energy that consumers connected to the islanding system would have lost over one year had all blackouts occurred
9	Number of successful islanding maneuvers	The total number of islanding maneuvers over one year that have both: - Avoided a blackout entirely or reduced its duration; - Reconnected without power loss for the consumer.
10	Total number of islanding maneuvers	The total number of islanding maneuver attempts over one year

APPENDIX 5 – GLOSSARY

Aggregation platform

An information system including sensor and remote control devices that the aggregators use in order to manage their flexibilities assets (e.g. demand side management at customer premises, storage and local generation). It allows for operating the flexibilities in order to monetize them for example to solve local grid constraints. This platform includes mainly the following functionalities: flexibility forecasting, aggregating and dispatching

Aggregator

An entity that combines the flexibility offers from multiple loads and/or generators and/or storage systems. It first prospects for the flexibility potentials in a given area, contracts these flexibilities and installs the necessary equipment. It then operates the flexibility through an aggregation platform in order to either sell on national markets/mechanims or to solve local grid constraints.

Ancillary services

Services necessary to the operation of a transmission or distribution system, including balancing and non-frequency services, but not congestion management. In France, these services are divided into two categories: the frequency control and voltage control. There are three reserves keeping the frequency control, called, by order of activation, the primary, the secondary and the tertiary reserves. The primary reserve is activated automatically and is a European reserve. Its function is to stop the frequency drift. The secondary reserve is also activated automatically, but each country is responsible for its own. It brings the frequency back to its nominal value. Finally, the tertiary reserve, also called the “balancing mechanism” (or “*mécanisme d’ajustement* (MA)” in French), allows the primary and secondary reserves to recover and is manually activated by the Transmission System Operator (TSO).

Balancing Responsible Party (BRP)

Market participant financially responsible for imbalances. In France, each BRP signs a contract with the Transmission System Operator, establishing the financial compensations if the BRP’s perimeter is not balanced. As of April 2017, France’s Transmission System Operator listed 194 BRPs on its website[47]. According to the French Energy Regulation Agency (CRE), a BRP “may be an energy supplier (national or foreign), a consumer (a company’s facility or a company designated by a group of companies) or any other third party agent (banks or brokers)”[48].

---

[47] http://clients.rte-france.com/lang/fr/include/data/services_clients/telecharge/liste_RE.pdf

[48] http://www.cre.fr/operateurs/responsables-d-equilibre

Cloud storage

A storage system shared by multiple users that are in the same area, allowing collective self-consumption, opposed to a private storage system serving individual self-consumption. In a concept analogous to the “cloud storage” in data servers, each client uses a virtual part of the shared battery.

Collective self-consumption

Self-consumption among several consumers and producers, associated under the same legal person, and connected to the same secondary substation. In France, this operation is regulated by a specific transitory regulatory framework, the Self-Consumption ordinance of 2016 and the Self-Consumption decree of 2017.

Common Information Model (CIM)

The Common Information Model is a data format model approved by the International Electrotechnical Commission that allows actors of the electric sector such as DSOs, TSOs and energy generators to exchange data in an standardized way. Besides exchanging data concerning the grid itself, CIM can be used to exchange market information, and may be used by the local flexibility market as its standard data format as well.

Grid constraint

The condition in which the voltage or the current going through a feeder attains values outside the acceptable margins, as established by the European standard EN50160. For instance, when it comes to voltage levels on the LV level, this European standard imposes that 95% of the 10 minute mean values of the supply voltage shall be within the range of U_n ± 10%, and all 10 minute mean values of the supply voltage shall be within the range of U_n +10%/-15%, where U_n is the nominal supply voltage.

Constraints represent an economic loss for several actors connected to the distribution grid. Besides reducing the quality of the energy delivered to the final consumer, it reduces the lifespan of the distribution grid assets. Renewable resources connected to the grid may also be forced to limit their production (“curtailment”). Constraints may be solved either by reinforcing the grid or by using flexibilities, as in the *Nice Smart Valley* demonstrator.

Demand response

A temporary change in power consumption by final consumers, in response to price signals or remote controls.

Distributed Energy Resources (DER)

Small energy supplies and power sources (such as power generators and energy storage systems) connected to the distribution grid and closer to the final consumer.

Distribution Grid

It is the grid that connects the high voltage transmission grid to the final consumer, going from the primary substation to the delivery points. In France, the 2,240 primary substations step the voltage down, from high voltage to medium voltage. The energy is then transmitted on the MV grid, totaling more than 600,000 km of cables. From the medium voltage grid, the voltage is once again stepped down at the 757,770 secondary substations, and the energy is delivered at low voltage through feeders, adding up to almost 700,000 km in LV. The final step before consumption is the energy meter, which determines the total energy consumed. There are approximately 35 million energy meters in France.

Distribution System Operator (DSO)

The entity responsible for the monitoring and the operation (the maintenance of the grid) of the grid, the control of grid system such as transformers, the planning and the construction and, finally the connection of the renewable energies and clients at the LV and MV grid.

Flexibility

Any active means of load, storage or production management, able to temporarily modulate their load curves to serve grid purposes. *Nice Smart Valley* will study the flexibilities connected either to the LV or to the MV grid.

Flexibility areas

An electrically connected area that serves as a demarcation area for the aggregators recruiting flexibility from a certain zone.

Flexibility entity

A group of clients recruited by an aggregator on the same flexibility area and that is treated as a single entity when offering flexibilities.

Forecast management tool (FMT)

It is a continuous process of real-time grid planning. It consists of a set of information systems, electrical grid sensors, procedures and organizations that help grid control and operation to manage the changing uses of the grid

It improves grid observability for the DSO. It also serves as a support to the interfaces between Enedis and the transmission system operator and energy generators.

Gas/Electrical Flexibility (GEF)

In the *Nice Smart Valley* demonstrator, gas/electrical flexibilities are flexibilities that leverage the synergies between electric and gas distribution systems. Hybrid boilers (i.e heating, and in some case cooling systems which combine a condensing boiler and an electric heat pump) and combined heat and power systems are the main gas / electrical flexibilities used in the project. They can respectively modulate the power consumption or production according to the distribution grid needs.

Grid Forming Unit (GFU)

Power unit that controls the voltage and the frequency of the islanding grid.

Grid Supporting Unit (GSU)

A unit that offers more capacity to the local islanded grid.

Islanding

Disconnecting a part of the distribution grid and ensuring its power supply with local energy resources (such as storage systems or photovoltaic panels) for a given amount of time.

Local flexibility system

It is a set of information systems allowing for the DSO to anticipate grid constraints and to activate flexibilities managed by aggregators. It is composed of two main tools, the forecast management tool and the aggregator portal.

Low voltage (LV)

Voltage ranging from 50 to 400 V under French DSO’s standards. In France, low voltage is usually supplied in either 230 V (phase-to-neutral) or 400 V (phase-to-phase).

Merit order

In the context of a flexibility market, the merit order is a ranking of all possible flexibilities that can be used at a particular moment ordered by their price. The flexibilities are activated from the cheapest to the most expensive, according to the volume of flexibility needed.

Medium Voltage (MV)

Voltage ranging from 400 V to 20,000 V under French DSO’s standards.

“N” and “$N-1$” configurations

The normal grid configuration is called the N configuration, in contrast with the conditions in which one component malfunctions, which is said to be the $N-1$ configuration. This nomenclature can be generalized to the loss of any number k of components, a situation called the $N-k$ configuration.

Power Conversion System (PCS)

In the context of this report, the PCS is the power electronics system responsible for converting DC voltage from the battery into AC to be injected into the grid and vice-versa.

Prosumer

A consumer that may also produce or store energy.

Regional Control Agency (ACR, or “Agence de Conduite Régionale”, in French)

Regional agency responsible for managing the medium voltage grid. Through remote controls, it ensures 24/7 the optimum energy flow in the grid and reroutes the flow if a part of the grid becomes unavailable (“N-1” configuration). Its employees may be compared to air traffic controllers as they provide routes for power flow on the grid. It is also responsible for managing the contract giving access to the transmission grid for the DSO at each primary substation level. The ACR responsible for the *Nice Smart Valley*’s area is located in Toulon, in the South of France.

Self-consumption

The condition in which a client consumes part or all of the energy its installations produce. A self-consumer will try to maximize its self-consumption rate, i.e. it will try to consume all the energy it produces.

Self-production

The condition in which a client produces part or all of the energy its installations consume. A self-producer will try to maximize its self-production rate, i.e. it will try to produce all the energy it consumes.

Settlement

The procedure that determines the amount of energy exchanged between two or more consumers, producers or storage systems. In the *Nice Smart Valley* demonstrator, it consists in verifying whether the demand response worked well and satisfied the requirements imposed by the Distribution System Operator.

Smart Grid Architecture Model (SGAM)

A model which allows the representation of interoperability of Smart Grids, mapping the structure of smart grids into their possible domains (generation, transmission, distribution, DER, customer premises) and zones (process, field, station, operation, enterprise, market). The first axis represents the electrical energy value chain, while the second represents the levels of power system management.

Smart meter

A meter that receives orders and remotely sends data. It offers several advantages compared to traditional meters: it reduces reading costs, allows a greater integration of renewable resources into the grid, opens the possibility of new offers and services in the energy markets and improves the overall operation of the distribution grid by increasing observability. In France, the electrical smart meter from Enedis is called “Linky’

State of Charge (SoC)

A percentage number that indicates the state of charge of the shared battery.

Storage System/Power Storage System

In the *Nice Smart Valley* demonstrator, it is a system consisting of a battery, a power conversion system and auxiliary systems, capable of absorbing power and reinjecting it back later. The *Nice Smart Valley* demonstrator is going to use a storage system to provide constraint relief, provide ancillary services, participate in arbitrage on the energy markets and support self-consumption.

Transmission System Operator (TSO)

The entity responsible for operating, maintaining and developing the transmission system in a given area, i.e. the high voltage grid. It is also responsible for balancing supply and demand on the national grid, organizing and buying services from the ancillary services market and managing interconnections to other countries. In the case of the *Nice Smart Valley demonstrator*, RTE is the Transmission System Operator.

Vehicle To Home (V2H)

To use the energy stored in the battery of an electric car to supply a home