Interreg Alpine Space
smartALTITUDE

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WP T2 – Smart Altitude Living Labs: developing and validating adaptation measures

Activity A.T2.3 “Smart Mountain Grid” Living Lab (Les Orres)

D.T2.3.1 Report on winter tourism smart grid impact and potential

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1. Executive summary

Through the example of Les Orres, this report describes the impact and potential of Smart Grid technologies in winter tourism regions, a system based on the local energy balance between production and consumption.

The document covers the conditions necessary for the development of a Smart Mountain Grid, from the strategy put in place by Les Orres, through the extension of the perimeter of its iEMS, to the cost-benefit analysis of different technical solutions.

It also explores the opportunities and solutions for improving the peak shaving and load management wheel that the Smart Altitude project has been working on.

The report ends by highlighting all the difficulties encountered in setting up a Smart Mountain Grid at the scale of a ski resort, in particular because of the multiplicity of actors involved and the variety of their respective objectives and issues. The analysis of the feedback allows to provide recommendations to the other ski resorts and to the decision makers on the decisions to be taken. In the future, these recommendations could allow Smart Grid technologies to enter the arsenal of energy efficiency solutions for ski resorts.

2. Introduction

Smart Altitude aims at enabling and accelerating the implementation of low-carbon policies in winter tourism regions. Technical solutions for the reduction of energy consumption and GHG emissions in mountain areas relying on winter tourism today exist, with up to 40% reduction potential. However, key trade-offs are at the heart of their slow uptake: they require stronger and innovative involvement to overpass strategic (goals, priorities, risks), economic (costs, financing) and organizational (partnership, stakeholder involvement) challenges.

During this project, four Living Labs have been created to provide real-field feedback on implementation and prepare for further innovation development through different themes.

This deliverable (D.T2.3.1) describes the impacts and potential of a Smart Grid implementation in winter tourism regions through the example of Les Orres "Smart Mountain Grid". This report presents the implemented solutions, the associated results providing a cost benefit analysis, and recommendations for replication in other winter tourism areas.

3. From an Integrated Energy Management System to a "Smart Mountain Grid"

3.1. Description of Les Orres mountain resort

Les Orres is located in the Hautes-Alpes in the southeast of France. The municipality of Les Orres is a typical mountain village in the Southern Alps comprising 9 hamlets for a permanent resident population of 530 inhabitants. The resort was created in 1970 with the historic resort center of Les Orres 1650. Les Orres 1800 was then created in the 2000s, grouping together a set of 3 * and 4 * tourist residences with all requested amenities and installations.

Figure 1 – Position of Les orres in the French Southern Alps

Les Orres is one of the major resorts in the Southern Alps, with 35 ski runs totaling 100 km from altitude 1,550 to 2,720, 17 ski lifts, and a hosting capacity of 14,500 tourist beds. The resort is operated by Semlore, a local semi-public company in which the municipalities of Les Orres and Embrun and "Caisse des Dépots et Consignation" are the shareholders, with an annual turnover of € 11 million and good economical performance. Les Orres benefits from the exceptional climate of the Southern Alps (300 days of sunshine per year) with very good snow quality due to its altitude, its exposure and its snow making installations. Overlooking Lake Serre-Ponçon, one of the major artificial lake in Europe and a high place for summer tourism, Les Orres capture this clientele by developing a significant summer offer, especially around mountain biking (ranked 3rd Mountain bike resort in France and 1st in Southern Alps) and full nature activities.

Map credit – Google Earth; photo credit: Tourism office of Les Orres – Tintin Photo – Agence Kros Rémi Fabre

Figure 2 – Les Orres winter and summer resort overlooking lake Serre-Ponçon

3.2. The Integrated Energy Management System in place

3.2.1. The AlpSTAR project

In 2012, fully aware of the weight of its energy consumption from an environmental and economic point of view, Les Orres was the first alpine mountain resort to carry out a complete audit of its energy consumption (snow making, ski lifts, technical buildings and amenities) and set up an integrated energy management system.

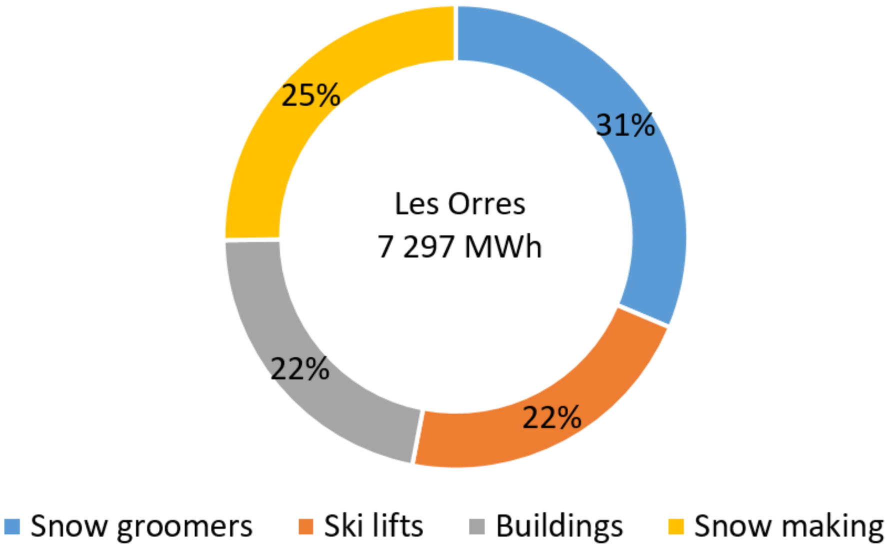

Figure 3 – Total final energy consumption in Les Orres (France) in winter 2016-2017.
Source: Les Orres energy Smart Altitude questionnaire.

These two operations were carried out as part of the interreg Alpine Space ALPSTAR program from 2012 to 2014. They made it possible to reduce the electricity consumption by 20%, electric bill by 25%, and GHG emissions by 100t CO2 annually. Since then, Les Orres has not stopped improving its systems and has been working with its partner EDF on the implementation of a mountain microgrid approach as part of the Smart Altitude project.

The installed electrical power of the Semlore electric grid is 5 MW, to be compared to 8 MW for the public electric grid supplying tourist accommodation, shops and the village. The total electrical energy consumption of the ensemble Les Orres muncicipality and resort is around 26 GWh per year. Les Orres is currently developing hydroelectric and photovoltaic production projects with a total capacity of around 24 GWh per year, thus approaching energy autonomy within 5 to 10 years. The goal of the smartgrid appraoch is to build a model integrating the resort operations, tourism housing, public lighting and other consumption endpoints from the one hand, local green energy production on the other hand, in a microgrid approach managed by a Local Energy Pilot system.

Over the past eight years, the mountain resort of Les Orres has gained a status of smart mountain leaders deeply involved in innovative solutions for energy consumption and greenhouse gas (GHG) emission reduction. The main actions directed towards energy management were carried out within the framework of two INTERREG Alpine Space projects, ALPSTAR and SMART ALTITUDE.

ALPSTAR 2012-2014, for which Les Orres was pilot field of application, first laid the foundation for the design of its integrated energy management system (IEMS) by conducting a full diagnosis of the energy consumption of the resort operations (ski lifts, snow making, heating of operation buildings and premises). Dialogs and exchanges between the solution developers and the resort operators took place to co-construct a solution fully adapted to the real needs and operational capacity of the semi-public company SEMLORE that runs the resort. In a second phase, the first fully integrated energy management solution in an Alpine resort was successfully implemented and run.

The 2018-2021 SMART ALTITUDE project is the extension of the IEMS by the integration of 1) additional major energy consumption areas, such has tourist accommodation, public buildings and public lighting, and 2) renewable energy production. This means also the possibility to build an energy community linking various stake holders such as SEMLORE, the municipality, private timeshared or muti-owner tourism residencies, in a global system. The goal of Les Orres and its main partner EDF in SMART ALTITUDE is to build a model of a Local Energy Pilot system to be set up, replicated and transferred to other resorts in years to come.

3.2.2. Achieved results

The ALPSTAR project results related to Les Orres included the following:

- a full energetic and energy consumption audit of the resort
- a set of 26 recommendations to lower energy consumption and GHG emission covering ski lifts, snow production, snow grooming, and buildings
- the implementation of the iEMS as describe above.

The recommendations covered 3 action levers:

- equipment optimization
- staff awareness and training
- energy and GHG emission monitoring for consumption management, peak shaving and cost reduction

Some immediate measures, such as the implementation of the iEMS, staff training and first measures for energy consumption reduction were taken before the end of the project. All together, their effect have been evaluated in the following year as follows:

Energy consumption: -20%.

Energy bill: -25%.

GHG emissions: -100 t CO_2eq

Since then, the resort has put in place a quality control process, invested in extending the initial actions to new areas and equipment, and extended the scope of its EMS to new consumption points. Thanks to the impetus given by AlpSTAR, the resort is constantly improving its performance and looking for additional areas of energy optimisation, as well as involving other ski resorts in the same process, as shown by the Smart Altitude project.

3.2.3. The electric grid of Les Orres

To better understand the project, let us present first the current IEMS developed by ***Roquetude***, a French Engineering SME based in Southern Alps. SEMLORE's electrical grid includes 18 transformers supplied by two independent 20,000 V connection points to the public electric grid. The two branches of the private grid are interconnected to ensure optimum efficiency and security of the power supply. Interconnection can be changed to dynamically adapt the configuration of the grid to seasonal needs.

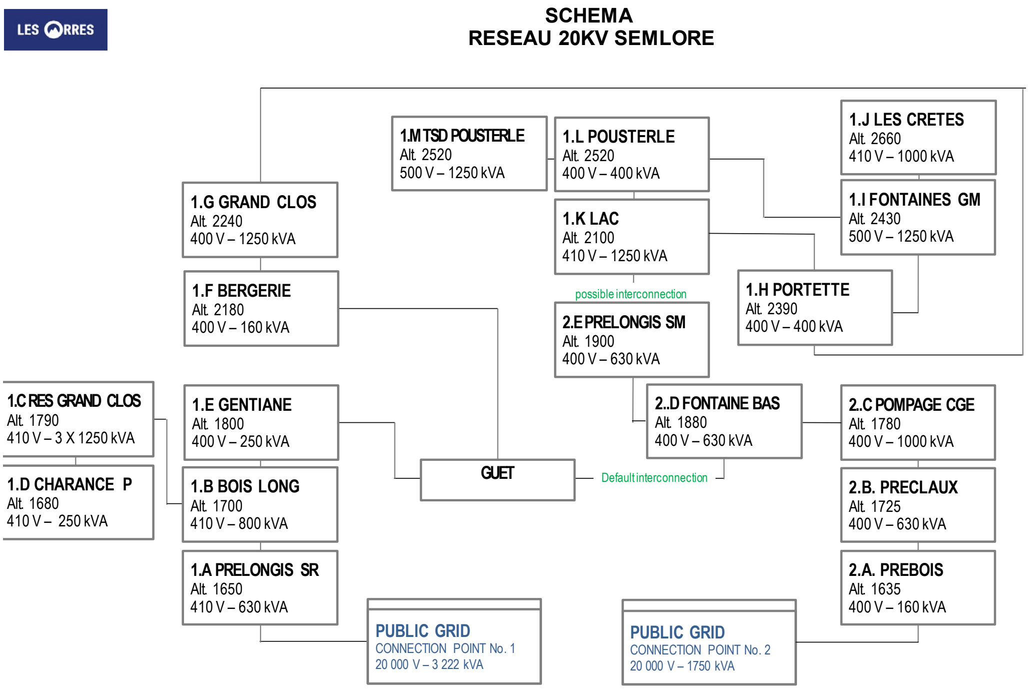

Figure 4 – overview of the resort's private electric grid (2020)

3.2.4. Electric equipment

Each electrical transformer supplies several types of equipment including snowmaking (pumps, compressors, guns, lances), ski lifts, heating systems, or specific facilities (ice rink, entertainment venue). Table 1 provides a synthetic view of the max power demand of the equipment connected to each transformer if all devices were run simultaneously at maximum power demand, which indeed never happens. The object of the IEMS is precisely to know in real time the power calls and offer manual or automatic load management capacity to lower the consumption peaks.

				SKILIFT		SNOWMAKING		BUILDING	
#	TRANSFO	TRANSFORMER POWER (KVA)	EQUIPMENT TOTAL POWER (KW)	P (KW)	N DEVICES	P (KW)	N DEVICES	P (KW)	N UNITS
1.A	PRELONGIS SR	630	794,0	124,0	4	570,0	19	100,0	2
1.B	BOIS LONG	800	303,0			298,0	53	5,0	1
1.C	RESERVE GRAND CLOS	3 750	2 925,0			2 920,0	13	5,0	1
1.D	CHARANCE	250	203,0			200,0	1	3,0	1
1.E	GENTIANE	250	183,0			180,0	6	3,0	1
1.F	BERGERIE	160	30,5	7,5	1	20,0	10	3,0	1
1.G	GRAND CLOS	1 250	920,0	710,0	2	190,0	13	20,0	1
1.H	PORTETTE	400	343,0	75,0	1	238,0	21	30,0	2
1.I	FONTAINE GM	1 250	783,0	633,0	1	150,0	5		
1.J	LES CRETES	1 000	480,0	450,0	2			30,0	2
1.K	POSTE DU LAC	1 250	1 185,0			1 180,0	15	5,0	1
1.L	POUSTERLE	400	259,0	59,0	1	150,0	5	50,0	1
1.M	POUSTERLE TSD	1 250	928,0	928,0	1				
2.A	PREBOIS	160	195,0	90,0	1	90,0	3	15,0	1
2.B	PRECLAUX	630	569,5	439,5	4	120,0	4	10,0	1
2.C	POMPAGE CGE	1 000	865,0			815,0	25	50,0	1
2.D	FONTAINES BAS	630	520,0	110,0	6	390,0	13	20,0	1
2.E	PRELONGIS SM	630	483,0	330,0	1	150,0	1	3,0	1
		15 690	**11 969**	**3 956,0**	**25**	**7 661,0**	**207**	**352,0**	**19**

Table 1 – Synthetic view of connected equipment by category of device

The metering of all electrical data collected by Raptor Managers allows to characterize in real time the electrical consumption of the entire domain (ski lifts, snow making, buildings ...) The installation of sub-metering devices on the characteristic points makes it possible to characterize the significant power points for load management.

The system reacts in real time, allowing load management for consumption peak reduction, and thereby achieving significant electricity cost savings. The system manages in parallel the consumption of fuel oil from grooming machines, the counting of skiers utilizing each ski lift device which gives very precise indicators on consumption and costs.

The total power subscribed by SEMLORE to its energy supplier is approximately 5 MW (2020 numbers). The total maximum power delivered by the 18 transformers is 15.7 MW, and the sum of the power of all the devices connected to the transformers is 12 MW, distributed as follows:

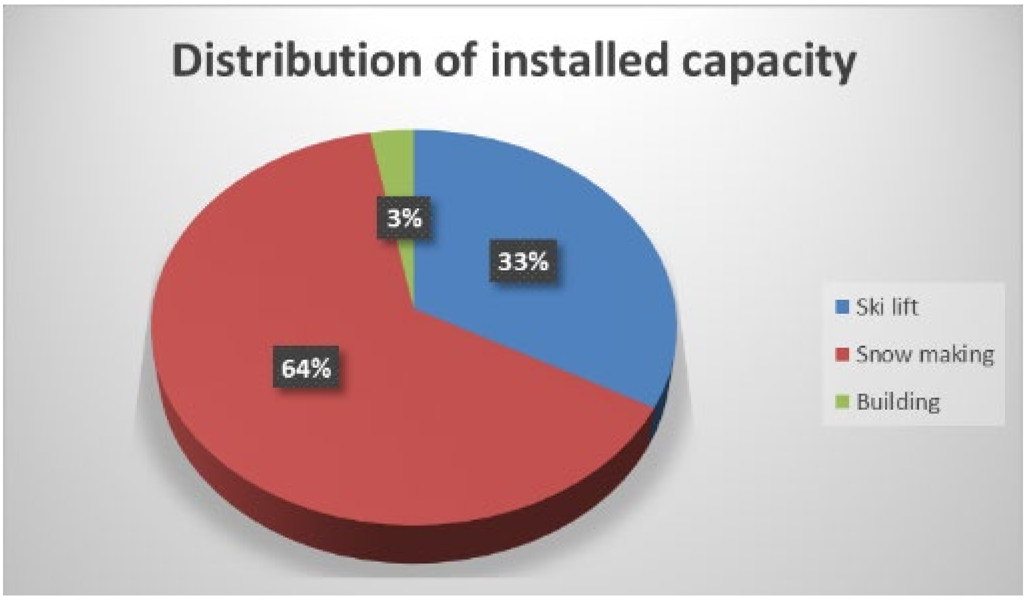

Figure 5 – Distribution of installed capacity

The following Table 2 shows the detail of installed power and equipment connected to each transformer.

#	TRANSFORMER	TRANSFORMER POWER (KVA)	VOLTAGE (V)	DEVICE No	CATEGORY	TYPE	NAME	POWER (kW)	NUMBER	EQUIPEMENT TOTAL POWER
1.A	PRELONGIS SR	630	410	1.A.1	SKILIFT	CHAIRLIFT	TS PRELONGIS	30,0	1	30,0
				1.A.2	SKILIFT	D-CHAIRLIFT	PIC VERT	25,0	1	25,0
				1.A.3	SKILIFT	SURFACE LIFT	STADE	59,0	1	59,0
				1.A.4	SKILIFT	SURFACE LIFT	JARDIN	10,0	1	10,0
				1.A.5	SNOWMAKING	GUN		30,0	19	570,0
				1.A.6	BUILDING		PRELONGIS	50,0	1	50,0
				1.A.7	BUILDING		TOURISM OFFICE	50,0	1	50,0
1.B	BOIS LONG	800	410	1.B.1	SNOW MAKING	AIR COMPRESSOR		110,0	1	110,0
				1.B.2	SNOW MAKING	LANCE	G1-G19	2,0	19	38,0
				1.B.3	SNOW MAKING	LANCE		2,0	30	60,0
				1.B.4	SNOW MAKING	LP CONNECTION		30,0	3	90,0
				1.B.5	BUILDING			5,0	1	5,0
1.C	RESERVE GRAND CLOS	3 750	410	1.C.1	SNOWMAKING	PUMP		315,0	2	630,0
				1.C.2	SNOWMAKING	PUMP		160,0	3	480,0
				1.C.3	SNOWMAKING	PUMP		400,0	3	1 200,0
				1.C.4	SNOWMAKING	AIR COMPRESSOR		250,0	2	500,0
				1.C.5	SNOWMAKING	AIR COMPRESSOR		50,0	1	50,0
				1.C.6	SNOWMAKING	GUN		30,0	2	60,0
					BUILDING			5,0	1	5,0
1.D	CHARANCE	250	410	1.D.1	SNOWMAKING	PUMP		200,0	1	200,0
				1.D.2	BUILDING			3,0	1	3,0
1.E	GENTIANE	250	400	1.E.1	SNOWMAKING	GUN		30,0	6	180,0
				1.E.2	BUIDLING			3,0	1	3,0
1.F	BERGERIE	160	400	1.E.3	SKILIFT	CHAIRLIFT	TS CRETE	7,5	1	7,5
				1.E.4	SNOWMAKING	LANCE		2,0	10	20,0
				1.E.5	BUILDING	HEATING		3,0	1	3,0
1.G	GRAND CLOS	1 250	400	1.F.1	SKILIFT	D-CHAIRLIFT	TS PIC VERT	700,0	1	700,0
				1.F.2	SKILIFT	SURFACE LIFT	CATEX	10,0	1	10,0
				1.F.3	SNOWMAKING	LANCE		2,0	10	20,0
				1.F.4	SNOWMAKING	LP CONNECTION		30,0	2	60,0
				1.F.5	SNOWMAKING	AIR COMPRESSOR		110,0	1	110,0
				1.F.6	BUILDING	HEATING		20,0	1	20,0
1.H	PORTETTE	400	400	1.H.1	SKILIFT	SURFACE LIFT	TK PORTETTE	75,0	1	75,0
				1.H.2	SNOWMAKING	LANCE	F1/F14	2,0	14	28,0
				1.H.3	SNOWMAKING	LP CONNEXION	REGARD BP	30,0	7	210,0
				1.H.5	BUILDING			5,0	1	5,0
				1.H.6	BUILDING			25,0	1	25,0
1.I	FONTAINES GM	1 250	500	1.I.1	SKILIFT	CHAIRLIFT		633,0	1	633,0
				1.I.2	SNOWMAKING	GUN		30,0	5	150,0
1.J	LES CRETES	1 000	410	1.J.1	SKILIFT	CHAIRLIFT		420,0	1	420,0
				1.J.2	SKILIFT	SURFACE LIFT	CATEX	30,0	1	30,0
				1.J.3	BUILDING			5,0	1	5,0
				1.J.4	BUILDING			25,0	1	25,0
1.K	POSTE DU LAC	1 250	410	1.K.1	SNOWMAKING	PUMP		45,0	2	90,0
				1.K.2	SNOWMAKING	PUMP		160,0	2	320,0
				1.K.3	SNOWMAKING	PUMP		250,0	2	500,0
				1.K.4	SNOWMAKING	BULLAGE		30,0	1	30,0
				1.K.6	SNOWMAKING	GUN		30,0	8	240,0
				1.K.5	BUILDING			5,0	1	5,0
1.L	POUSTERLE	400	400	1.L.1	SKILIFT	SURFACE LIFT	TK MARMOTTES	59,0	1	59,0
				1.L.2	SNOWMAKING	GUN		30,0	5	150,0
				1.L.3	BUILDING	RESTAURANT		50,0	1	50,0
1.M	POUSTERLE TSD	1 250	500	1.M.1	SKILIFT	D-CHAIRLIFT		928,0	1	928,0
2.A	PREBOIS	160	400	2.A.1	SKILIFT	CHAIRLIFT	TS PREBOIS	90,0	1	90,0
				2.A.2	SNOWMAKING	LP CONNECTION		30,0	3	90,0
				2.A.3	BUILDING	GARAGE		15,0	1	15,0
2.B	PRECLAUX	630	400	2.B.1	SKILIFT	SURFACE LIFT	TK BOIS MEAN	22,0	1	22,0
				2.B.2	SKILIFT	SURFACE LIFT	TAPIS	7,5	1	7,5
				2.B.3	SKILIFT	SURFACE LIFT	TAPIS	30,0	1	30,0
				2.B.4	SKILIFT	CHAIRLIFT	TS PRECLAUX	380,0	1	380,0
				2.B.5	SNOWMAKING	GUN		30,0	4	120,0
				2.B.6	BUILDING			10,0	1	10,0
2.C	POMPAGE CGE	1 000	400	2.C.1	SNOWMAKING	GUN		30,0	4	120,0
				2.C.2	SNOWMAKING	LANCE		5,0	15	75,0
				2.C.3	SNOWMAKING	PUMP		130,0	3	390,0
				2.C.4	SNOWMAKING	PUMP		200,0	1	200,0
				2.C.5	SNOWMAKING	PUMP		15,0	2	30,0
				2.C.7	BUILDING	GARAGE		50,0	1	50,0
2.D	FONTAINES BAS	630	400	2.D.1	SKILIFT	CHAIRLIFT	TS FONTAINES	20,0	1	20,0
				2.D.2	SKILIFT	CHAIRLIFT	TS POUSTERLE	20,0	1	20,0
				2.D.3	SKILIFT	SRFACE LIFT	TK PREVIEUX	18,5	1	18,5
				2.D.4	SKILIFT	SRFACE LIFT	TK GALOPIN I	11,0	1	11,0
				2.D.5	SKILIFT	SURFACE LIFT	TK GALOPIN II	22,0	1	22,0
				2.D.6	SKILIFT	SURFACE LIFT	TK RIOU SEC	18,5	1	18,5
				2.D.7	SNOWMAKING	GUN		30,0	13	390,0
				2.D.8	BUILDING			20,0	1	20,0
2.E	PRELONGIS SM	630	400	2.E.1	SKILIFT			330,0	1	330,0
				2.E.2	SNOWMAKING			150,0	1	150,0
				2.E.3	BUILDING			3,0	1	3,0

Table 2 – Detailed list of connected equipment

3.2.5. IEMS design

Components

All pieces of equipment that needs to be monitored and controlled such as pumps, compressors, snow making devices, ski lift engines, building heating and other energy uses are instrumented by sub-modules collecting data measured in real time or at fixed frequency by various measurement devices (electrical tension, active and reactive power, tangent phi, energy consumption, etc.).

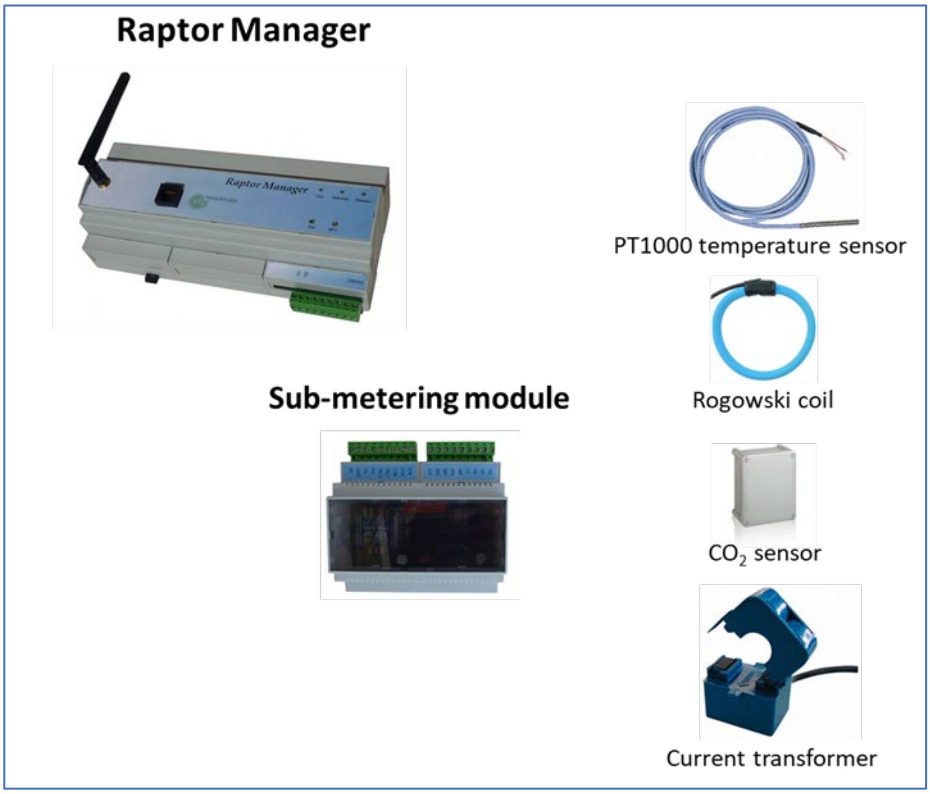

Figure 6 – Raptor system equipment

Network design

The Raptor network is an 868 MHz radiofrequency mesh network. Sub-metering modules collect the data measured by one or several sensors and transfer it by IP or 868 MHz radiofrequency to automata called raptor managers. Each raptor manager includes a SQL database and an embarked web server. The data is collected from the sub-metering modules via the radio network, then processed and transferred via IP protocol to the Roquetude dedicated supervision platform. Each Raptor transfers orders coming from the supervisor to the sub-metering modules and extensions (i.e. modbus gateways), thus applying calendar-programmed or threshold-defined or manual load shed instructions to its target equipment (ski lift engine, compressor, snow-making gun or lance, building heating zone…) The supervision platform is also interconnected with external data sources such as meteorological information or ski lift frequentation by coupling to the Skidata access control system.

Figure 7 below presents the organization of the Raptor network.

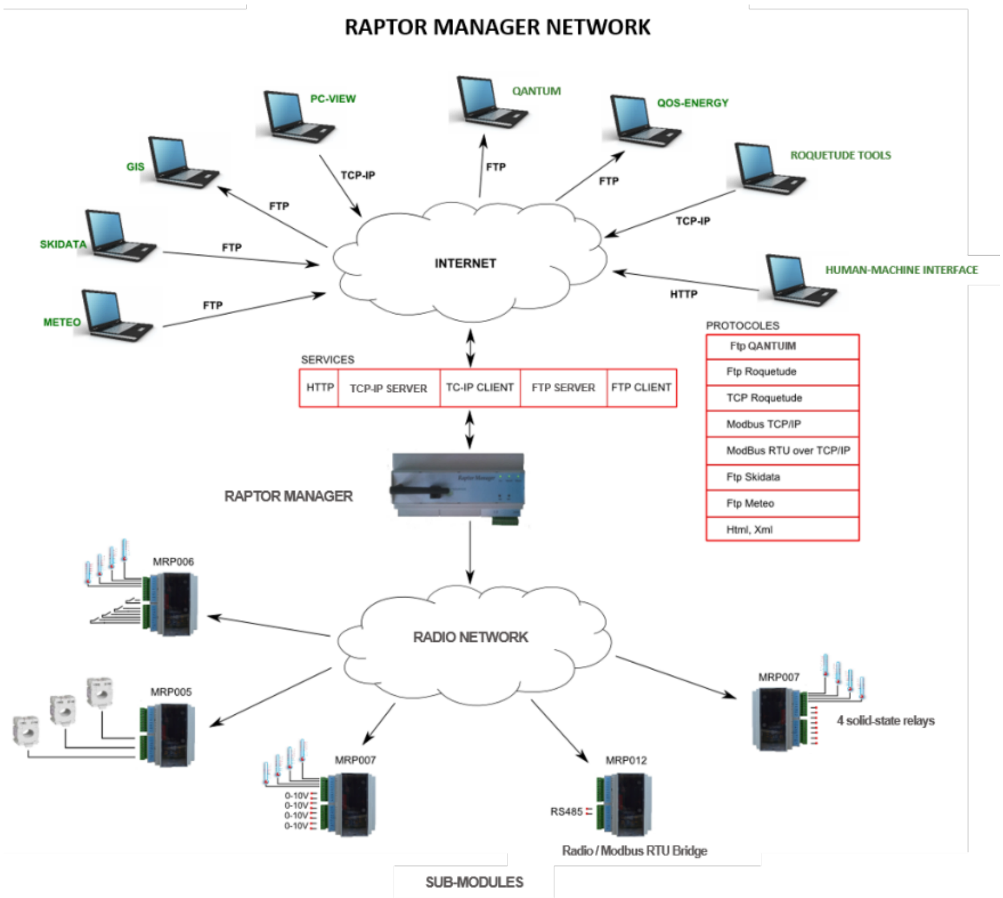

Figure 7 – Overview of the RAPTOR network

Interfaces

The supervisor platform makes it possible to build specific or custom designed real time views and analysis graphics, program alerts and control actions directed to the equipment, such as building heating zone shut off, engine speed control, load management, etc. These user-defined actions can be either time-based or triggered by threshold values or manually by the staff in charge of monitoring the energy system. The following screen captures present some examples of real-time display and energy consumption analysis.

The synoptic view, presented in figure 8 below, allow to follow in real time, at a glance, the major key energy indicators of each energy transformer in the resort grid : active and reactive power demand, as well as the measured temperature in each building monitored: Altitude sheds, operating buildings.

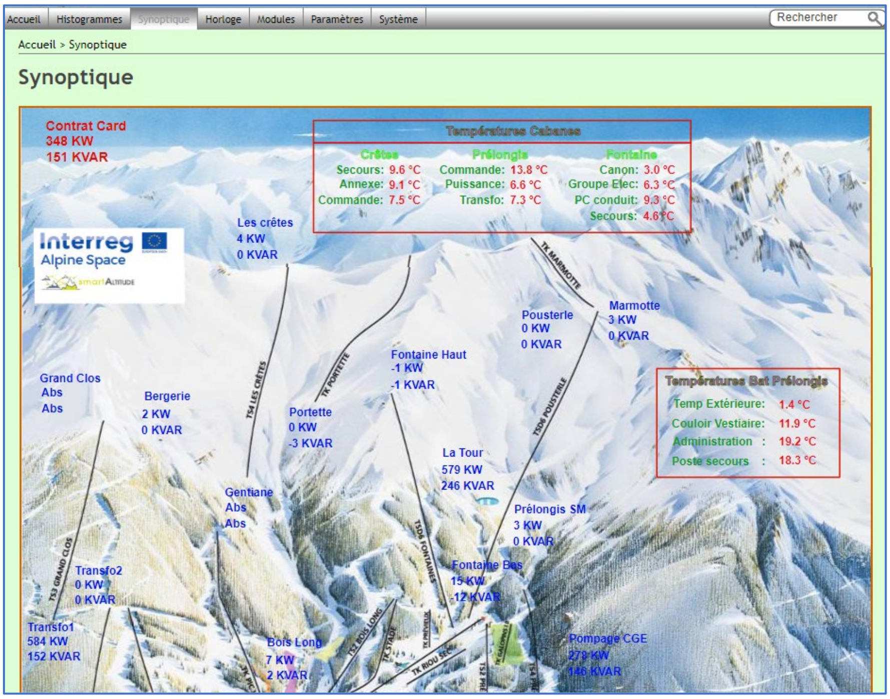

Figure 8 – Synoptic view of real time power calls (Roquetude platform)

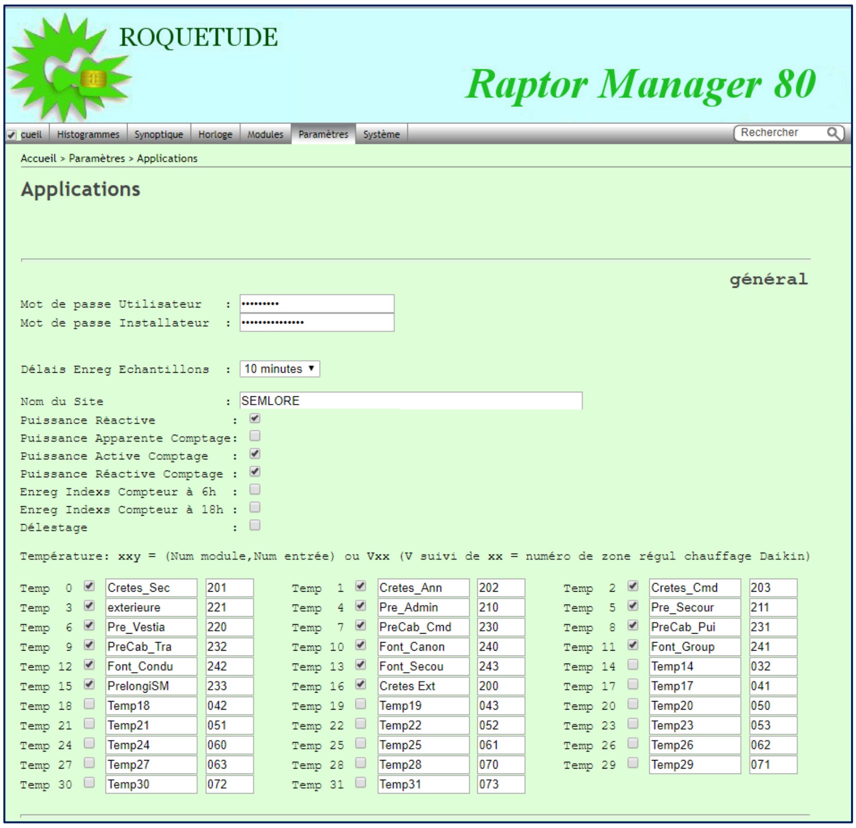

Figure 9 – Parameter interface for setting the applications

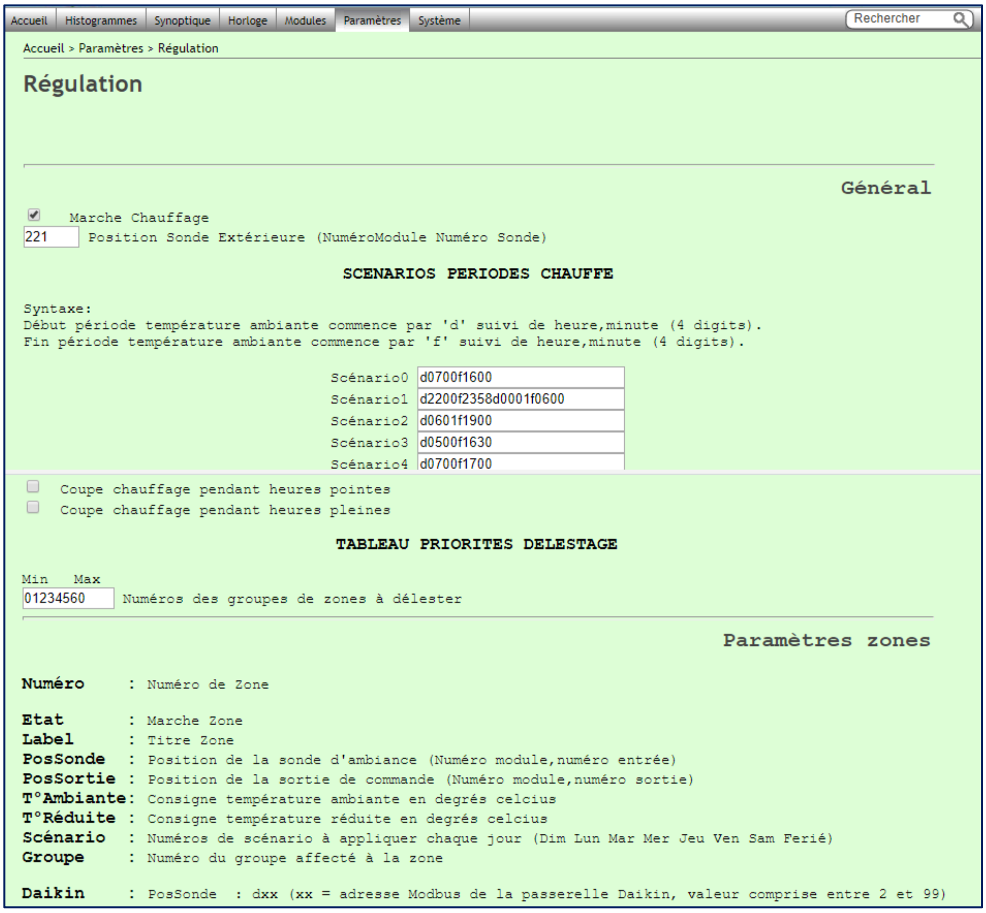

Figure 10 – Setting building zone heating scenarios and load management

The platform also allows for the historical tracking of all key indicators over a period of time, as well as the automatic generation of reports by defined period. Figure 11 shows an extract of an automatically generated report for a given week.

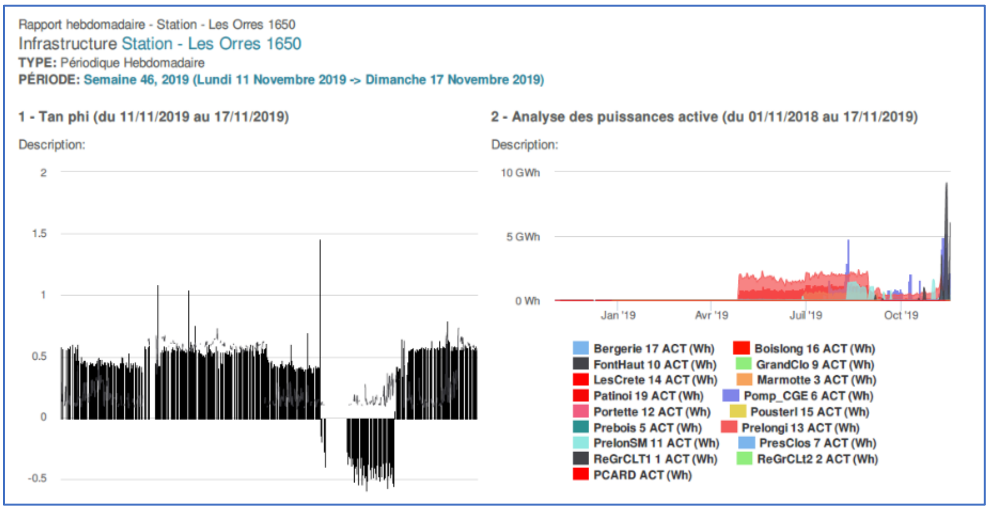

Figure 11 – Automatic weekly reporting (extract)

3.3. Missing elements for setting up a Smart Mountain Grid

3.3.1. From AlpSTAR to Smart Altitude

The AlpSTAR project aimed at setting up an integrated Energy Management System (iEMS) at the scale of SEMLORE, the ski lifts operating company in Les Orres. Although this system is efficient, it is somewhat different from a smart grid system. First, let us have a look at the particularities of a smart grid compared to an iEMS.

A Smart Grid is an electrical network based on communication technologies that makes it possible to ensure the balance between electricity production and consumption in real time. Depending on the energy needs and the power availability over the same perimeter, energy uses can be managed in real time to ensure the local balance between energy production and consumption. In order to maximise both the available energy and the load management capacity of the system, the smart grid perimeter is generally larger than that of an Energy Management System. A smart grid is therefore based on three main elements:

- A real-time data transmission concerning the power availability over the smart grid perimeter, whether the energy is locally produced or issued from the power grid.
- A large power capacity of electrical uses that can be managed in real time, over the smart grid perimeter.
- An integration and communication interface between these different production and consumption systems, to guarantee the power balance.

An integrated Energy Management System (iEMS) is based on a real-time and detailed energy consumption analysis with the aim of minimising this energy consumption without any negative impact on the ski resort operation. An iEMS therefore does not integrate the notions of balance between energy production and consumption. However, it is a good starting point, as in the case of Les Orres, for the implementation of a smart grid system.

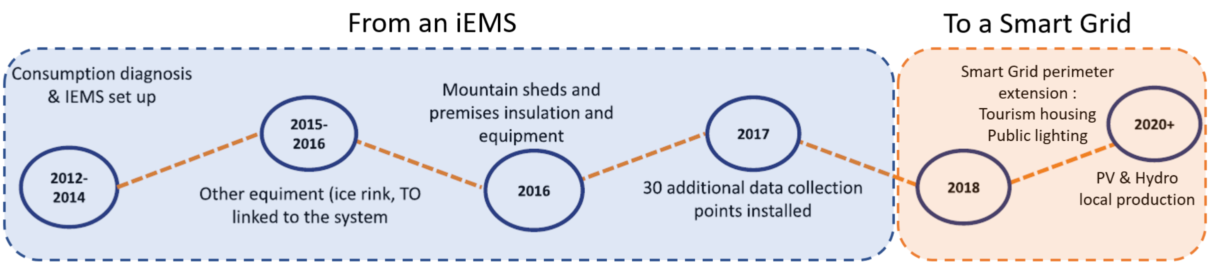

Figure 12 – Timeline of an evolution example from an iEMS to a Smart Mountain Grid (Les Orres)

3.3.2. Local power availability as input parameter

Real-time knowledge of the available power over the area covered is an essential element in the operation of a smart grid. It should be noted that it is important to talk about available power and not available energy. Available power is measured in real time, whereas available energy is measured over a time period. Balances between production and consumption are therefore made in terms of power, i.e. in real time, and not in terms of energy.

The total available power is the sum of the available power from several sources:

- The local energy produced and self-consumed (for instance a self-consumed photovoltaic system).
- The public power grid to which the smart grid is connected, depending on the subscribed power by each consumer.

If the energy is produced locally but resold to the electrical network, this energy will be considered as issued from the public power grid. For each energy delivery points within the perimeter of the smart grid, it is important to have real-time access to the available power, i.e. the difference between the power consumed at any time and the subscribed power. For instance, the subscribed power of the operating company of the ski lifts in Les Orres (SEMLORE) is about 5 MW, whereas all the electrical equipment of the resort represents a total added power of 12 MW (see Table 1). There can therefore be large differences in available power depending on the equipment in operation.

Of course, not all pieces of equipment operate at the same time over a given period. However, it may happen that operating constraints force the simultaneous use of particularly energy consuming equipment, such as ski lifts and snow makers. In order to avoid financial penalties due to exceeding the subscribed power, it is therefore necessary to carry out as much as possible, without affecting the operation of the resort, power load shedding by SEMLORE. The SEMLORE iEMS, as described above, allows the power consumed by the equipment to be displayed in real time and to act to avoid exceeding the subscribed power either manually or by programming automatic actions such as temporarily cutting off the heating of the operating buildings. (See figures 8-10.)

For a single actor (here SEMLORE), this power assessment is usually done by an iEMS. However, within the perimeter of the smart grid, the power assessment must be done for each consumer linked to the network. Although each consumer is limited by his subscribed power, the multiplicity of players makes it possible to pool the power available on the smart grid perimeter, thus offering considerably more margin for power shaving and load management.

To overcome the limits linked to the individual subscribed power, it may be appropriate to use other input parameters when setting up a smart grid. The energy carbon content, if available in real time, can also be used as an environmental decision factor to defer some electrical uses (figure 13).

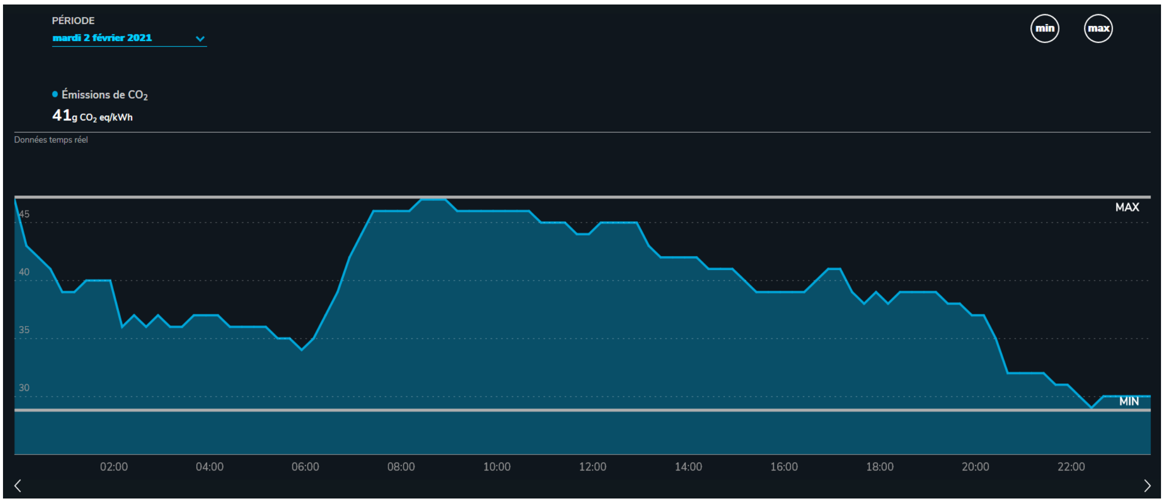

Figure 13 – CO_2 emissions per produced kWh in France (2 February 2021 – source: RTE eco2mix)

Operational parameters such as the weather are usually added to the energy and environmental input parameters.

3.3.3. Demand-side management and flexibility

Depending on these input parameters value, scenarios for managing electrical equipment in the smart grid perimeter are set up. Let us examine some simulated typical smart grid scenarios. These scenarios do not take into account local energy production capacities linked to the smart grid, their purpose is only to examine peak shaving offered by pooling various energy consumption sources such as resort operations, tourist housing and Public buildings and lighting.

Scenario 1

Tuesday 19 December, 3pm, -6°C, cloudy weather.

It is the beginning of the ski season. The lifts are open but there are not many people on the slopes because of the bad weather and the Christmas holidays that have not yet started (low season). Tourist accommodation is only 30% full. The snow cover on the slopes is low because there has not yet been enough natural snowfall or windows of opportunity for snowmaking. The current weather conditions are favourable for the production of artificial snow and it is therefore important to use this window of opportunity as intensively as possible. Let us now assume that there is not enough power available to operate all electrical equipment connected to the grid in the resort. Therefore, choices have to be made on the demand side.

All these data are the input parameters of our smart grid system. To compensate for the high power demand due to the activation of the snowmaking systems, it is possible to set several actions for peak shaving and load management:

1) reduce the speed of the lifts, as there are no queues at the lifts and the increase in lift time will not be perceived. Lowering the ski lift speed from 5 $m.s^{-1}$ to 4 $m.s^{-1}$ results in 16% energy consumption reduction[1].
2) Setting off to a minimum the heating of operational buildings during the power demand peaks. It is possible to rotate the zones of the building where the heating is reduced or switched off to avoid affecting the comfort of the staff.
3) Tourist accommodation such as condos, residencies and hotels or other collective housing represent a very significant power shedding capacity in relation to the resort's consumption. For those of them accepting to be part of the smart grid, the heating temperature of empty apartments, zones or rooms can be set to a minimum to reduce the global power demand. Systems set by load management operators have shown that is is possible to significantly reduce power calls by building heating without affecting the comfort of occupants. In the case of hotels, the system set in Les Orres allows to set heating of unoccupied rooms to a minimum and closely monitoring the heating of occupied rooms without affecting the occupant comfort. The hotels and buildings hot water production can also be limited to the strict needs of the users (about 50% with a margin) and not maintained at 100% of its capacity during peak of power demand.
4) The same apply to public building. In addition, the public lighting management system can allow to modulate and moderate the light intensity and thus its power demand, as there are few people in the ski resort, but it is unlikely to play a big role in maximum power demand shaving, since ski lifts stop their operations before the public lighting switches on.

[1] "Mesures et analyses des consommations énergétiques de la station des Orres (Hautes-Alpes). Propositions d'améliorations et perspectives de production d'énergies renouvelables. » AlpSTAR project, Roquétude & Ecomesures, 2014.

Scenario 2

Friday 2 March, 11am, 13°C, sunny weather.

We are in the last days of the winter school holidays and the resort is close to its maximum capacity (high season). The snow cover on the slopes is good and we are no longer in a period of snowmaking, so this is not a risk factor for exceeding the available power. However, the queues to access the lifts are long and it is therefore necessary to operate the lifts at their maximum speed, which is more intensive in terms of power demand. At the same time, holidaymakers will be leaving the resort and it may be relevant to anticipate the recharging of their electric vehicles, which will become a significant factor to consider in the coming years.

Response to this kind of scenario that can be activated automatically thanks to smart grid technologies. The power demand can be lowered by the hotels' electric heating system, which can be set down by a few degrees due to the spring temperatures, as seen previously. Consumers can be requested to use public and private electric vehicle charging points by night if they plan to leave the resort on Sunday, so that they do not add to daily power demand which will be at his high due to all domain slopes open and all ski lift running at their maximum.

The connection of many electrical equipment to this smart grid is necessary for the entire scenario to be operational. In our case: ski-lifts, snow production system, tourism housing heating and hot water production systems, public lighting, charging stations for electric vehicles.

3.3.4. Widening the scope of action

As we have just seen, extending the perimeter of the smart grid to many players is really important if we want to set up a complete demand-side scenario.

In the living lab Les Orres, during the project, the iEMS was limited to the management of the equipment of the ski area operating company (SEMLORE): ski lifts, snow production, operating buildings. When implementing a smart grid, many other energy consumers can be involved in the process. The integration of the demand side actors allows for a more efficient and virtuous use of the energy scenarios.

Among the electrical equipment that can be included in a Smart Mountain Grid perimeter, we can mention:

- Tourist accommodation (heating systems, hot water production systems, ventilation...)
- Public lighting
- Charging stations for electric vehicles
- Swimming pools (water heating)
- Ice rinks (cooling systems)
- Cinemas (heating, lighting)
- Shops (heating, lighting)
- Restaurants (heating, cooking equipment, hot water production)
- Offices (heating, hot water production)
- Etc.

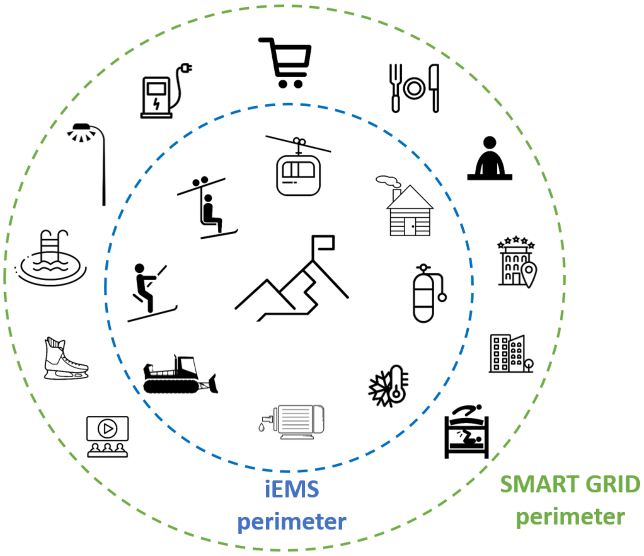

Figure 14 – Example of a perimeter evolution from an iEMS to a smart grid

4. Evaluating the implementation of a Smart Mountain Grid in Les Orres

4.1. Renewable energy production

4.1.1. Photovoltaic potential

The potential for photovoltaic energy production is extremely high in the Southern Alps, as shown in the map below. In addition, cold winter temperatures and high albedo due to snow cover are two further factors that make Les Orres a very favourable location for the deployment of photovoltaic production installations within the resort. However, there are also some adverse factors to take into consideration:

There are also adverse factors to be considered, in particular these:

- The maximum production takes place in summer, when the resort's consumption is minimal;
- Except at the summits, there are significant masking effects from the peaks surrounding the ski area;
- Because of the necessary trade-offs between uses and because of environmental constraints, there are only a few sites that allow the deployment of large production units;
- Due to the resort's classification as a 20th century architectural heritage site, the deployment of rooftop photovoltaic installations seems compromised.

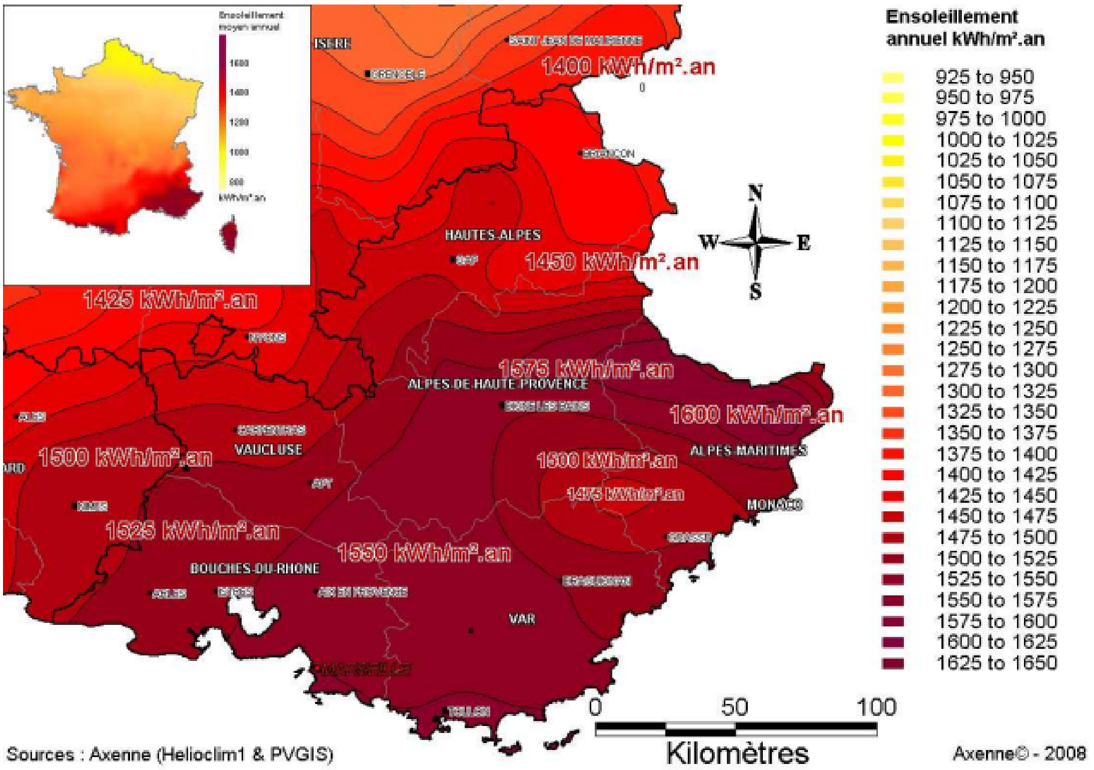

Figure 15 – annual solar irradiation in kWh/m²/year

Several photovoltaic projects of deployment of photovoltaic installations have been explored before and during the project. The main identified deployment site is a vast parking lot area on which solar shades could be deployed. In addition, a pilot deployment of bifacial solar panels, taking full profit of the albedo for up to 30% production performance, is planned with CEA-Tech and TOTAL Quadran to measure the effectiveness of such equipment in high altitude condition. This last action, initially planned within the Smart Altitude project, has been delayed due to the covid pandemics. Finally, some other types of small-scale projects, such as photovoltaic covering of a ski carpet, are under investigation.

Overall, the installed capacity would be around 365 kWp for a production of 445 MWh per year. It is very likely that this production will be injected and sold to the public energy grid rather than used in self-consumption mode, due to the time lag between solar production and energy consumption mentioned above as well as financial considerations. Nevertheless, this will contribute to the resort's quest for energy autonomy.

4.1.2. Hydroelectric potential

In the three last years has been explored the unemployed hydroelectric potential of Les Orres domain. A study has been conducted and a project is under development, for a total possible capacity of 6 MW and 23,7 GWh yearly, to be compared with the 26 GWh of energy consumption per year (resort + municipality).

As with solar energy, hydroelectric production is not well coupled with energy demand: the peak of production is in spring (snow melt) and autumn, when energy consumption is low, with two low flows in winter and summer, during the high season. As there is currently no high-capacity energy storage solution available to deal with the seasonal imbalance, there is no alternative but to inject the generated energy into the public energy grid.

Nevertheless, overall, the amount of energy produced that is injected into the grid is approaching the balance point between energy produced and energy consumed.

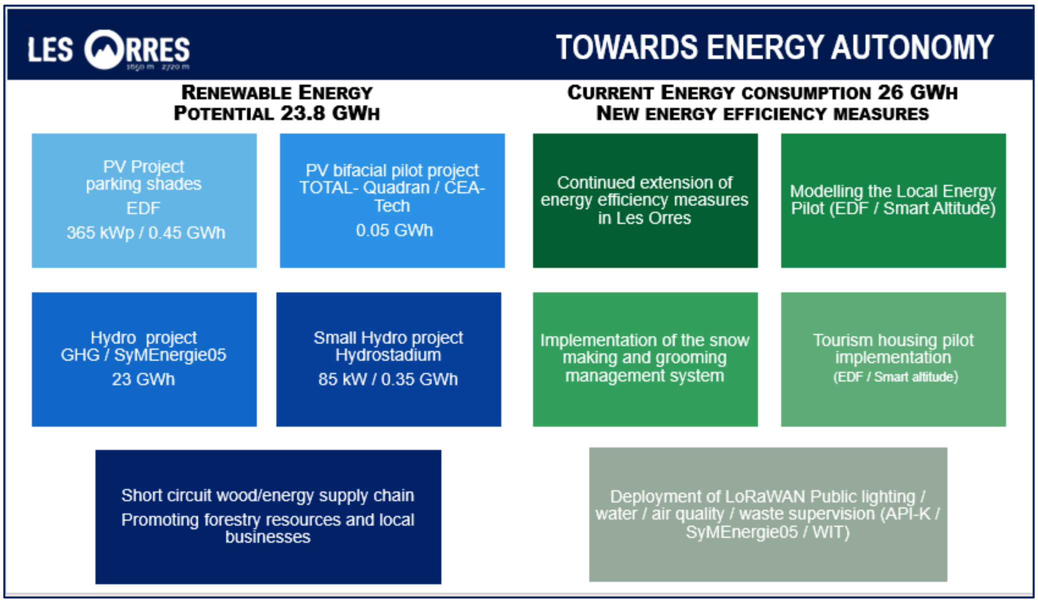

Figure 16 – Towards the energy autonomy

4.2. Widening the Smart Mountain Grid perimeter

4.2.1. SEMLORE Energy additional usage control

Several measures have been identified that would make it possible to continue the energy efficiency approach undertaken by SEMLORE and to find additional sources of shaving capacity. We list them in the table below.

Measure	Energy efficiency	Cost reduction	Peak shaving
SKI LIFTS			
Thermal insulation of high-altitude sheds not yet rehabilitated	√	√	
End-of-season shutdown procedure to avoid leaving heating and frost protection equipment on	√	√	
4 additional power transformers to be equipped with solar panel for disconnection in off-season	√	√	
SNOWMAKING			

Set up the snow supervisors for automatic shutdown depending on what other equipment is running.			√
Snowmaking at off-peak rates whenever possible		√	
Use waste heat from compressors for space heating.	√	√	
BUILDINGS			
Switching to biomass energy (ERC, technical services, and garage buildings)	√	√	
Insulation and renovation of the Technical Services	√	√	
Insulation of manholes	√	√	
Refurbishment of the heating system in the power station and engine room	√	√	

Table 3 – Additional measures to be taken by SEMLORE

As we can see in Table 3, there are very few measures that could be taken by SEMLORE to improve load management and peak shaving. The reason is simple: the iEMS has already evolved and expanded its scope since 2014 with the integration of new buildings and their control / load management commands already developed in the platform. All other peak shaving mentioned in previous sections, such as building load management by zone or entire building, ski lift speed reduction, optimizing snow making with regard to peaks of power demand, etc. are already functional.

4.2.2. Public lighting

For the past five years, the Commune has been converting its lights to low-energy LEDs, first in the hamlets and now in the resort. At the same time, thanks to the European Smart Altitude project, the 114 light points that have been replaced, have been fitted with additional equipment to control the entire system remotely, via the Exedra interface created by Comatelec-Schreder.

Figures 17-20 present the management interface of the supervision platform, allowing to set up rules, program time management, alerts, control, etc.

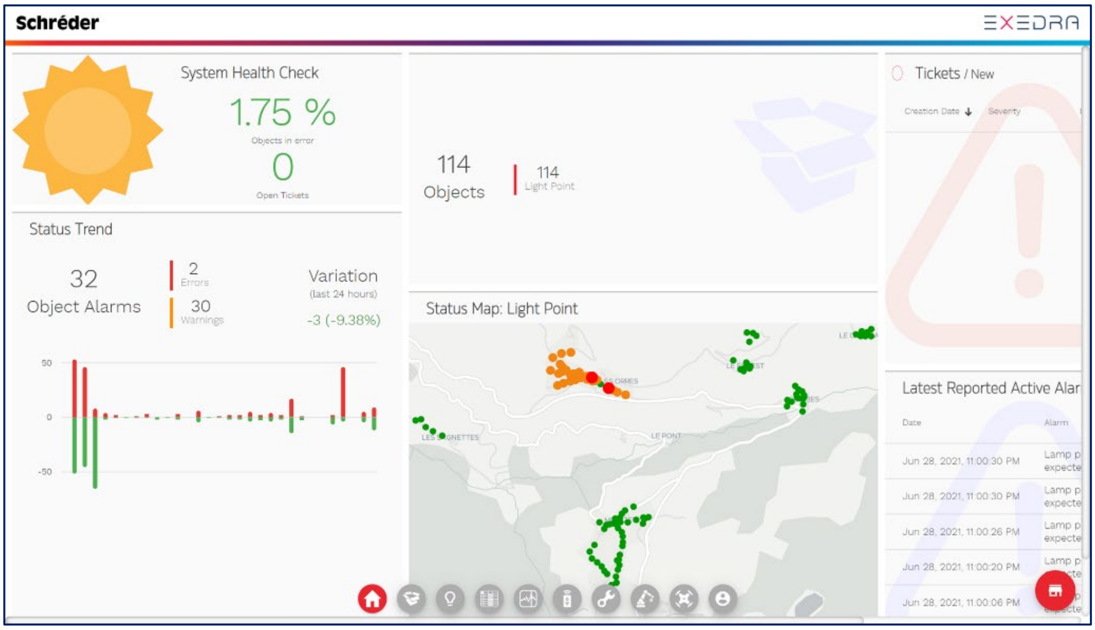

Figure 17 – Home page of the Supervision system

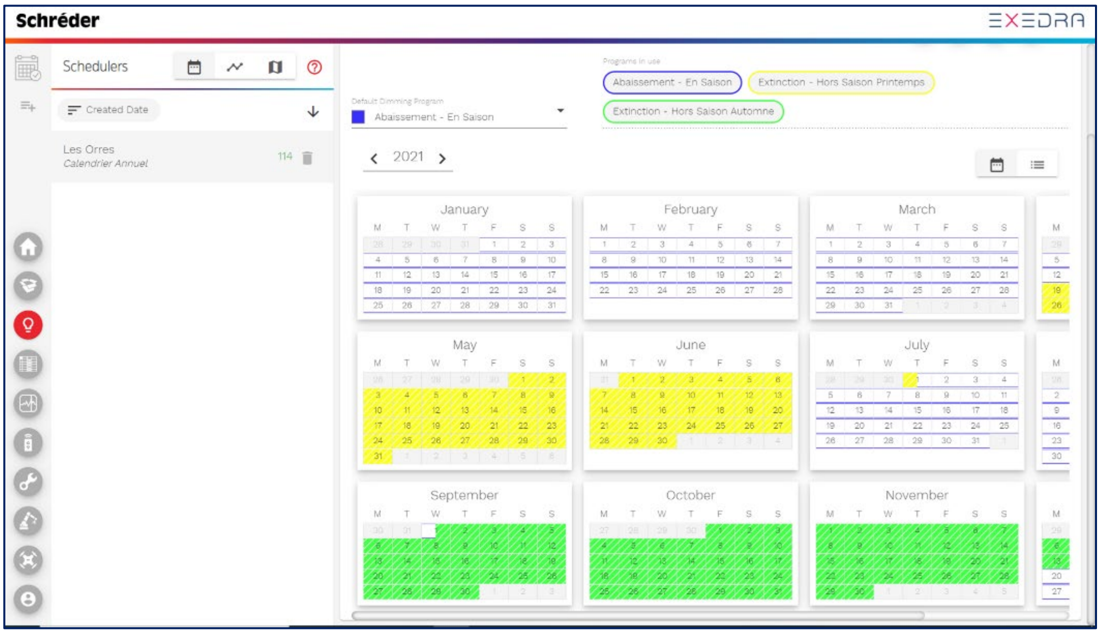

Figure 18 – Calendar programming of lighting periods

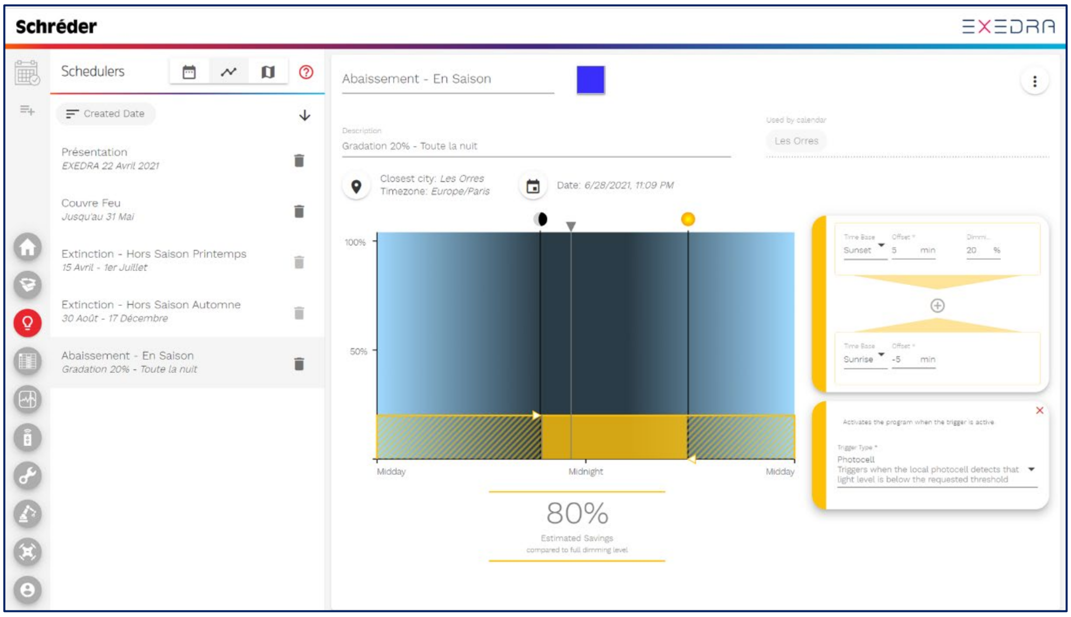

Figure 19 – Visualisation of estimated savings

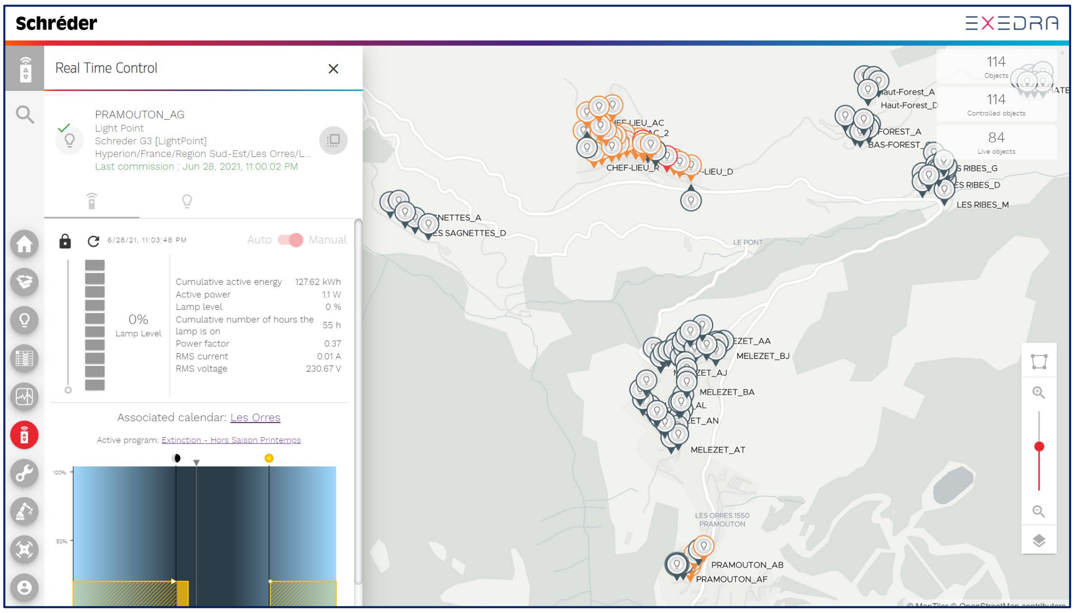

Figure 20 – real time control

Since 2014, Les Orres has been awarded the "Star Village" label for its numerous actions to reduce night-time visual pollution, in particular by switching off public lighting between 10:30 pm and 6 am every night outside the tourist season. As part of its proactive energy management policy, Les Orres has set up a service that is both necessary and has great potential for savings.

Comatelec-Schreder was looking for partner local authorities to pilot deploy its promising public lighting supervision solution in development, with a view to obtaining feedback that would enable possible improvements to be made to the product so that it fully meets needs. The Commune of Les Orres was fully committed to the process and was thus able to demonstrate the effectiveness and high potential of the tool, which can be replicated in any other territory equipped with public lighting.

The control platform allowed to reduce the power of the streetlights to 20% of their nominal capacity, which makes it possible to maintain a satisfactory level of lighting. The total energy savings (switch to LED + control) are estimated at around 50%. Extrapolated over a full year to all the streetlights, this represents a potential annual saving of more than 100 MWh, i.e. approximately €7,500 yearly tax included, and 6,4 tCO_2eq/year, for a total yearly consumption of 200 MWh.

From a load management perspective, public lighting represents a significant quantity of energy that could be used for demand-side management, especially in winter by night when the snow makers are running at full capacity. However, the systems run already only at 20% of its intensity, so there is not much room left to reduce the power called. Also, safety and security issues have to be taken into consideration. Therefore, the gain expected for demand-side management is minimal.

4.2.3. Management of tourism housing energy consumptions

Tourist accommodation is a major source of electricity consumption in a ski resort, at least in France where the heating system and the production of domestic hot water is mainly electric. For instance, the annual consumption of SEMLORE, the ski lift operating company, is about 7.3 GWh, while the annual consumption of the whole ski resort (including SEMLORE) is about 26 GWh. The max power demand is about 5 MW for SEMLORE against 11 MW for the resort.

Compared to the ski lifts and the snowmaking systems, tourist accommodation represents a very high electricity consumption and power demand. Including tourist accommodation within the perimeter of the smart grid would therefore considerably increase the system's capacity for power flexibility and demand-side management. To do that, an energy study was carried out on 3 pilot buildings with the aim of selecting one building to develop and test an innovative IoT solution. This IoT solution aims at managing both heating and hot water production systems. Three types of building have been studied:

- Condominiums (Les Cembros)
- Hotels (Les Ecrins & L'Escale Blanche)
- Tourist residences (Les Hauts Préclaux & UCPA Centre)

The energy systems' characteristics of these different buildings are summarised in the table below:

	Description	Heating system	Domestic Hot Water Production
Condominium Les Cembros	56 appartments 1971	Mix Gas/Electric Hydraulic convector heater (base) + Electric convector (complement)	Hot water tanks 3x3000 L Electric
Hôtel Les Ecrins	Hôtel ** 1972 40 bedrooms Total : 1400m²	Full electric Underfloor heating Electric convectors	Gas boiler
Hôtel L'escale Blanche	Hôtel *** 40 bedrooms Total : 1400m²	Mix Gas/Electric Hydraulic convector heater (base) + Electric convector (complement)	Hot water tanks 3x700 L Electric
Tourism Residence Les Hauts Préclaux "Les Monts du Bois d'Or"	294 appartments over 7 buildings (2 parts) 2006	Full electric Underfloor heating Electric convectors	10 Hot water tanks Electric
Tourism Residence Les Hauts Préclaux "Les Mélèzes d'Or"	6123 m² + 5753 m²	Full electric Underfloor heating Electric convectors	8 Hot water tanks Electric
Tourism Residence UCPA Centre	130 dorms - 240 people/week 1979 3600 m²	Full electric Underfloor heating Electric convectors	5 Hot water tanks Electric

Table 4 – Heating & hot water production systems comparative table

In order to benefit from a high load management capacity, 100% electric system (both heating and hot water production system) has been favoured over a gas system or a mixed system. Therefore, our choice for a pilot tourist housing building quickly turned towards tourist residencies (Les Hauts de Préclaux) and collective housing (UCPA Centre). Although both buildings had a strong potential, the "Intelligent Building Control" solution has been implemented at the UCPA Centre (for contractual reasons).

This IoT system's functioning, summarised below, is based on 3 functional bricks:

- Sensors and meters to collect real-time energy data from heating and hot water systems.
- A central data transmission system (ModBus protocol) coupled with artificial intelligence to define and send control orders. This system makes it possible to manage energy consumption, depending on the status of the smart grid.
- A control system based on actuators to activate these control orders.

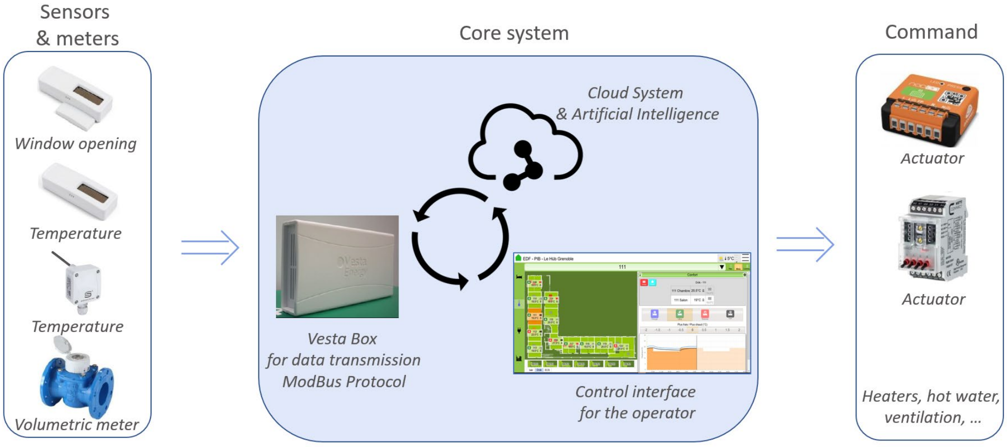

Figure 21 – Intelligent Building Control Architecture

For example, such a system makes it possible to automatically control rooms' heaters by group of rooms according to the centre's affluence (coupled with the booking system). In the same way, the domestic hot water production is controlled according to the occupancy rate. Three of the five hot water tanks are thus heated if the occupancy rate is only 50%.

This type of system is totally open. This means that in reality the central system is able to analyse an external load management command (from the smart grid) and act on the control devices (heaters, hot water production, ventilation, etc.) in order to participate in the energy balance of the smart grid.

The control interface for the operator is designed as follows (figure 22 to 26):

- A schematic plan of the residence
- The possibility to select a status (frost protection / free / reserved) for each room or group of rooms
- A scalable programming of the temperature set points according to the selected status
- A possible offset on the temperature (+/- 2°C) according to the feeling in real time
- Real-time display of electrical consumption (heating and domestic hot water)

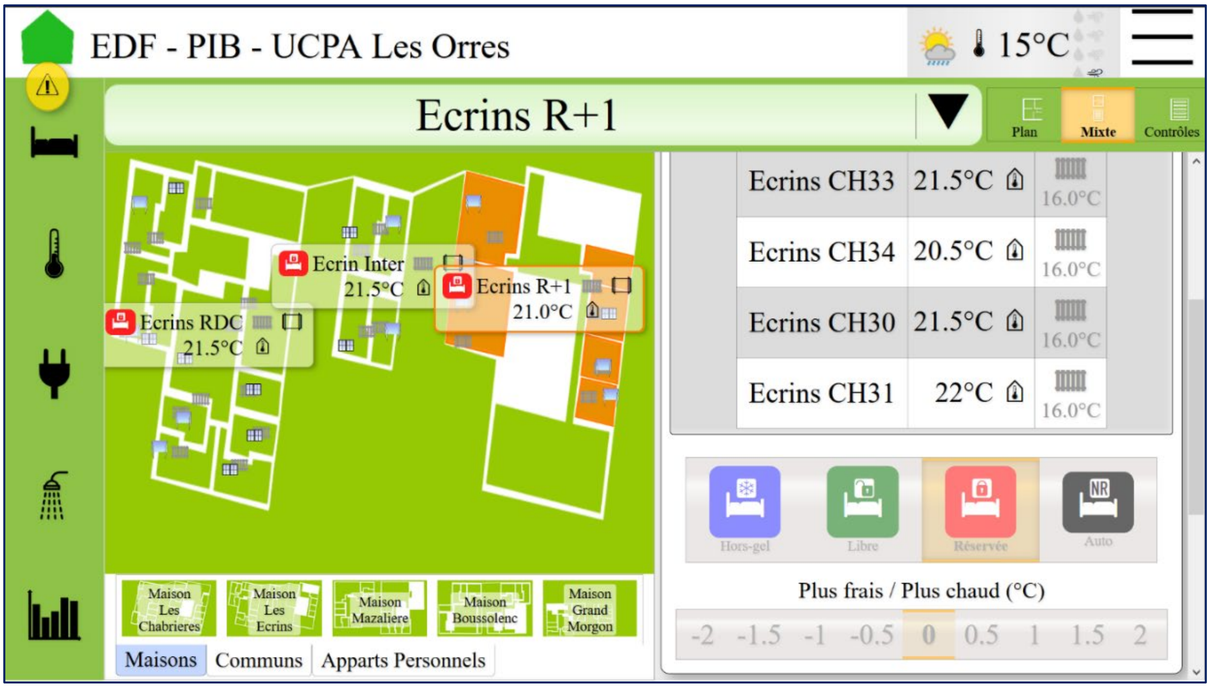

Figure 22 – Control Interface for the operator

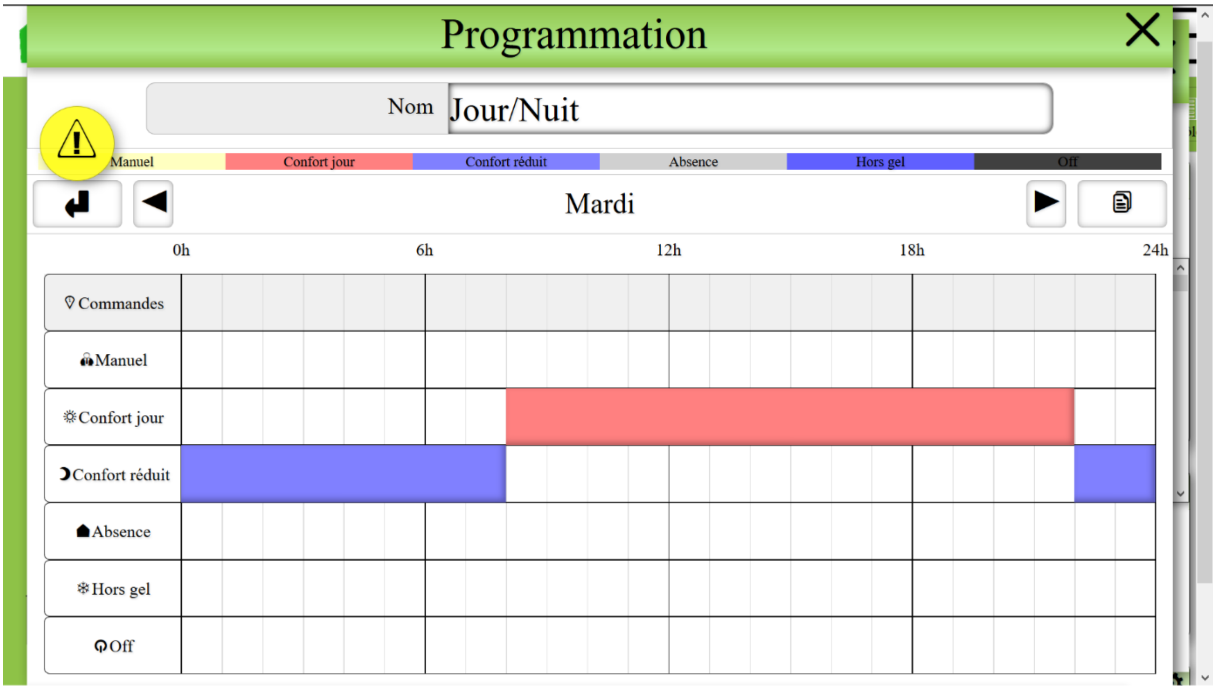

Figure 23 – Modification of a heating period program (Temperature setpoints definition)

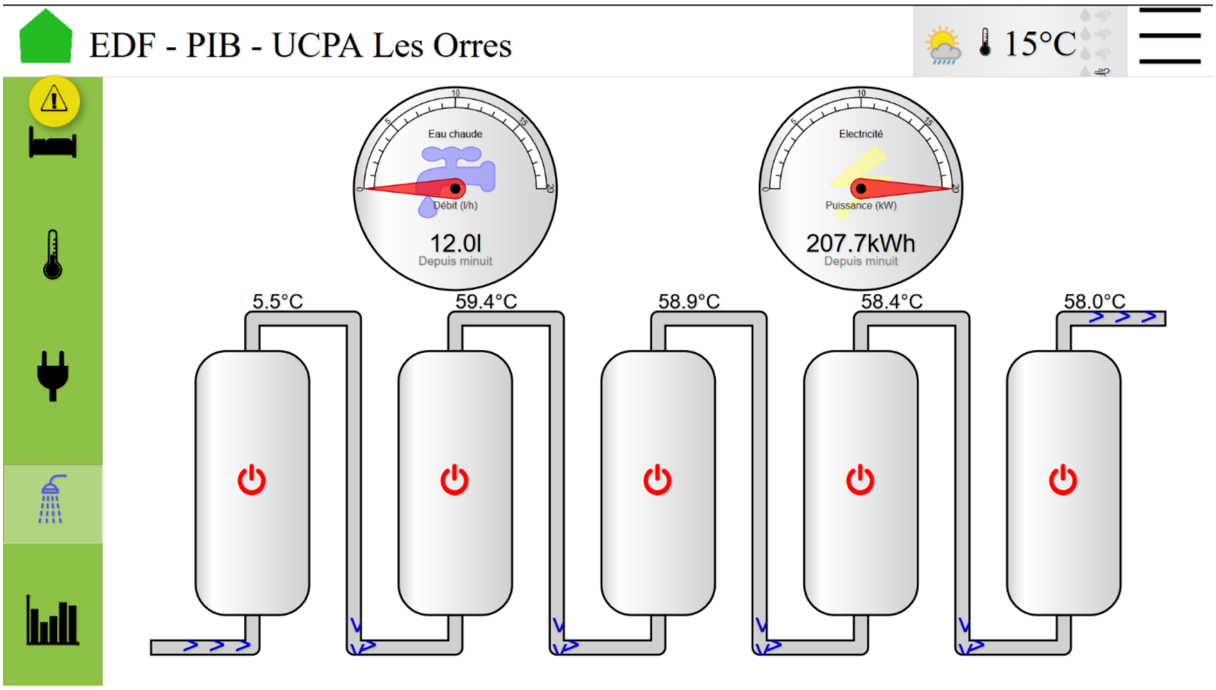

Figure 24 – Real-time visualisation of hot water production

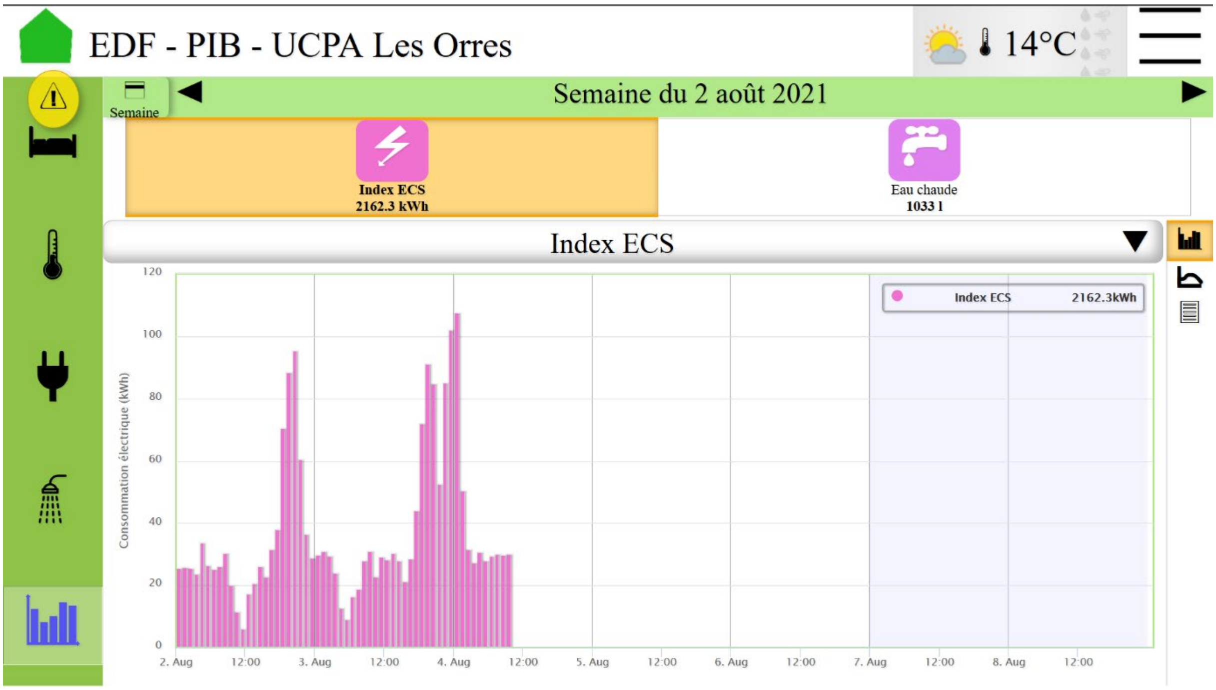

Figure 25 – Historic of hot water electrical consumption

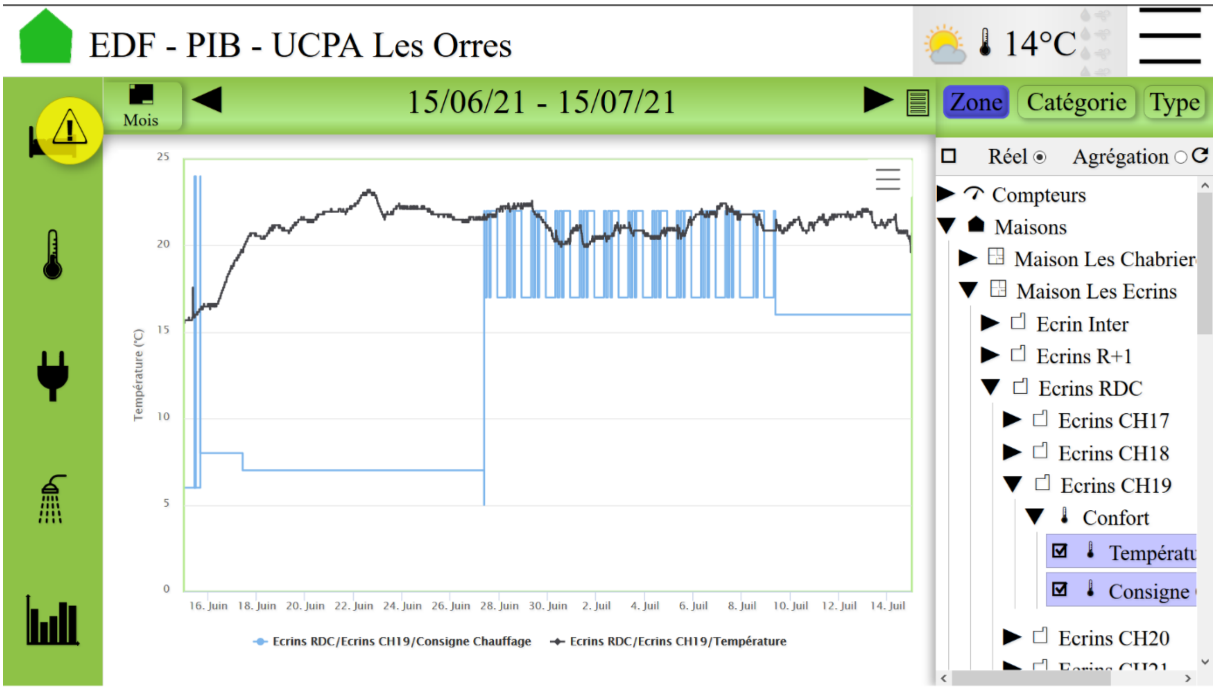

Figure 26 – Historic of heating temperature vs. setpoints (summer 2021)

5. Implementation of a Smart Mountain Grid in Les Orres: results

5.1. Balance between energy production and consumption

5.1.1. In average over a year

According to Les Orres' renewable energy potential study, an annual production of approximately 24 GWh/year could be achieved.

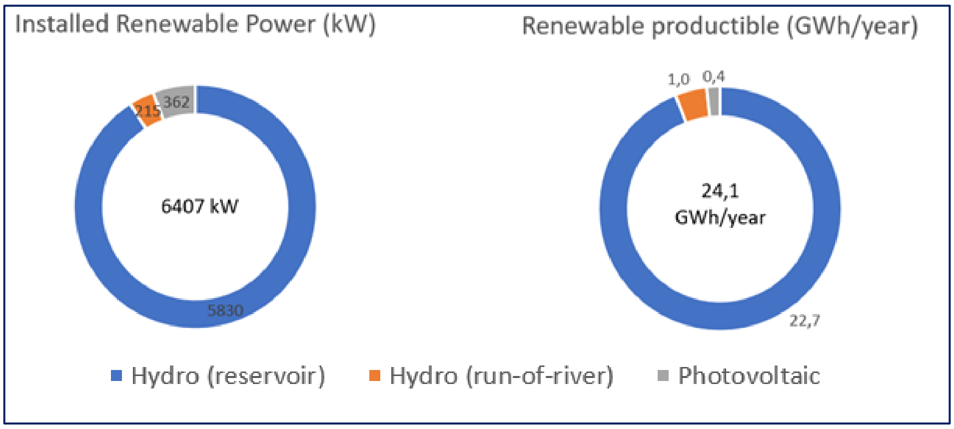

Figure 27 – Les Orres hypothetic installed renewable power and associated energy production per year

Compared to the annual electricity consumption of SEMLORE (7.3 GWh), 329% of the needs would be covered by renewable energy production local systems. By extending the perimeter of the smart grid to the entire ski resort of Les Orres, and in particular by including tourist accommodation, electricity consumption is much higher (26 GWh/year). 92% of the ski resort's electricity needs could thus be covered by local renewable energy.

However, considering the necessity for a real-time balance between production and consumption, the capacity of 6.4 MW of renewable production does not cover the 11 MW of the ski resort's needs. On the other hand, some renewable energy production systems, such as photovoltaic panels or run-of-river hydroelectric systems, are intermittent. The electrical generated power by these systems cannot be used at any time to cover the power needs because it depends on the sunshine or on the river flow.

In our case, the power capacity to be used at any moment would be about 5.8 MW, in the hypothetical case where the reservoirs are full all year round. This energy balance shows that the renewable production would theoretically cover the electrical consumption on average over a year (92%) but cannot cover the power needs in real time without any demand-side energy management system.

5.1.2. Toward real-time balancing

To get a real-time balance between production and consumption, several systems can be set up:

- Storage capacity to store excess energy production
- Usage activation and load management capacities to align electricity consumption with production in real time.

In the example of Les Orres, we worked on the demand-side capacities according to the available power (see above sections). With the integration of the public lighting and the UCPA Centre into the Smart Mountain Grid perimeter, the total demand-side capacity of the Smart Grid is distributed as follow:

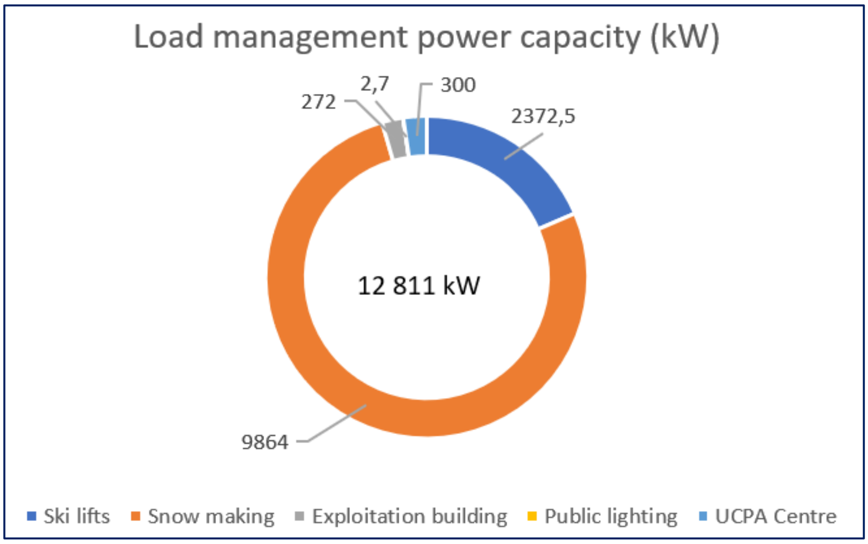

Figure 28 – Load management capacity of Les Orres Smart Mountain Grid by type

First of all, it should be noted that the total demand-side capacity of the SEMLORE's equipment (ski lifts, snowmaking system, operating buildings) is about 12,8 MW whereas the power subscribed by the SEMLORE is only 5 MW. Permanently, and in order to avoid overtaking power penalties, 75% of the SEMLORE's equipment is therefore managed in a natural way. The subscribed power has thus been optimized to 5 MW thanks to the load management capacity offered by the implementation of the iEMS in 2012-2014 and its further development. Any additional load management effort to balance energy at the smart grid perimeter is however extremely limited, as evidence has been given before. The day-to-day operation of the SEMLORE's equipment is indeed really crucial, in particular during snow production periods.

Public lighting (2,7 kW) and the UCPA Centre (300 kW) are added to this load management capacity. Theoretically, if all the residential buildings (17,000 beds) of the ski resort were equipped with a solution similar to the one implemented in the UCPA centre, the total load management capacity related to tourist accommodation would be about 21 MW (assuming similar electric heating and hot water production systems to those of the UCPA Centre). The theoretical load management capacity of tourist accommodation (21 MW) is therefore much higher than that of ski lifts (2.3 MW) and snowmaking systems (9.8 MW).

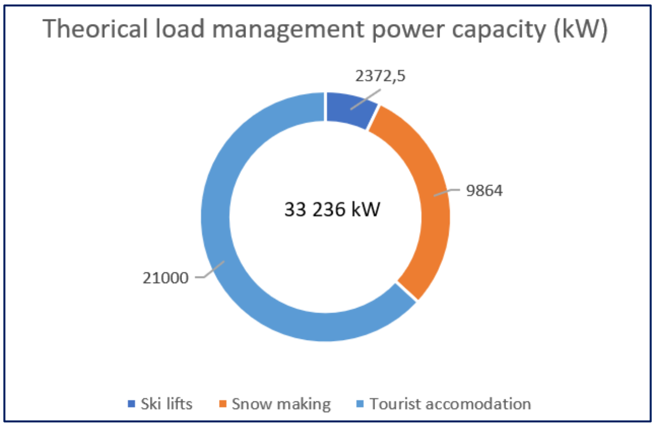

Figure 29 – Theorical load management capacity of Les Orres Smart Mountain Grid by type

It is through the integration of several load management capacities at the Smart Mountain Grid perimeter, and the activation of these capacities according to the available power, that it is possible to balance in real-time production and consumption.

5.2. Energy consumptions flexibility

As evidenced in section 4.1.1, any additional consumption flexibility on the SEMLORE side is extremely limited. Similarly, section 4.1.2 showed that public lighting does not offer much capacity. Therefore, the real capacity to consider is the one coming from buildings, and especially tourism housing.

5.2.1. Intelligent Building Control at the UCPA Centre

The intelligent building control solution implemented at the UCPA Centre has been proposed in a 5-year rental/sale contract in order to avoid an investment by the UCPA Centre. With the material cost covered by the Smart Altitude project (30 000€), the monthly cost for the UCPA Centre is €550 (excl. VAT). This service includes the operation of the system, annual reports and the equipment guarantee throughout the life of the contract. At the end of the 5th year of the contract, the equipment is retroceded to the UCPA Centre. Two options are then possible: continuing the initial contract or closing it. In this second case, the customer still has the possibility to use the control equipment but in a degraded way since he will no longer benefit from the artificial intelligence of the system.

The energy savings associated with the control of heating, domestic hot water and ventilation thanks to this equipment are about 20%, i.e. €1,000 per month on average (overall annual consumption of

605 MWh/year). That corresponds to a 6 tons CO_2 savings per year. The UCPA centre is therefore making net savings of €450 per month, i.e. 9% savings on its initial electricity bill (€60 000 excl. VAT per year).

20 %	**121**	**1000**	**6**
Electrical consumption reduction	MWh / year Electrical savings	€ / month Bill reduction	tons / year CO_2 savings

With a smart grid approach, this solution also increases the station's load management power capacity. Indeed, the system in place makes it possible to receive load management orders and translate them into concrete actions on the UCPA Centre (see section 4.2.3). For example, to cover a 100 kW load management demand, the heating system can be temporarily lowered by a few degrees, without disturbing the comfort of the occupants. The heaters to be switched off are selected according to both the occupancy and the current temperature of each room.

The total erasing capacity of the UCPA Centre (heating, domestic hot water, ventilation) is thus about 300 kW, which corresponds to the power of a large ski lift.

5.2.2. Financial valuation of load management capacities

The various systems installed in Les Orres generate energy, cost and environmental savings. More globally, by integrating these different building blocks into a smart grid system, it is possible to generate financial value by aggregating load management capacities. Indeed, in order to guarantee a national balance between production and consumption, and to integrate increasingly intermittent renewable energies, load management capacities must be expanded. A target of 6 GW in 2023 has thus been set at the French level. In 2017, this capacity reached 1.9 GW.

To enter the load management service markets, a minimum power of 1 MW is required. To reach this minimum power, it is possible to aggregate different load management capacities. By participating in this mechanism, the players must modulate their energy consumption according to the requests they receive. Depending on the markets affected, this solicitation is known a few days before, a few hours before or a few seconds before the load management to be carried out. The associated financial remuneration therefore depends on this reaction time and the capacities erased. Two different financial valuations are then possible:

In power on a half-hourly step: 9 €/MW

In energy: 50 €/MWh

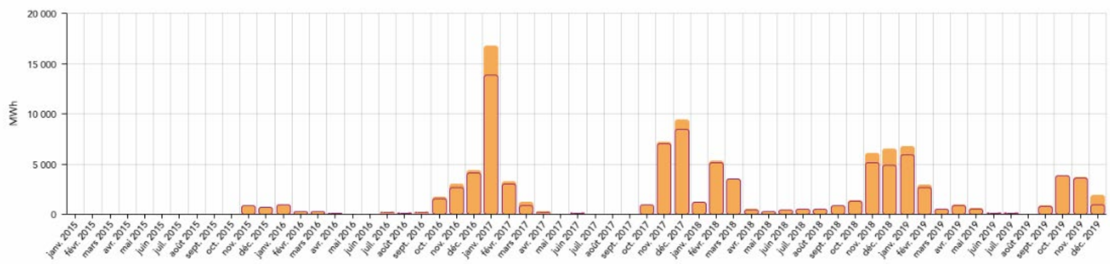

Figure 30 – Load management volumes declared on the load management service market

Hourly, daily and seasonal variations are observed on the load management service market. It can be noted that the need for demand-side management mainly coincides with the winter period. The ski lifts, the snowmaking system and the tourist accommodation of a ski resort therefore present a real value in terms of load management capacity. However, to get money from these load management capacities requires a good knowledge of the day-to-day operation so as not to disturb the comfort of users. It would be a shame to get stuck on a chairlift for financial matters…

The total shutdown of the ski resort's operations (ski lifts and snowmaking system) as well as the UCPA centre's equipment for 1 hour could bring in nearly €6,000 on the load management service markets (12.8 MW for 1 hour). However, this amount should be compared to the financial operating losses of the ski resort during this shutdown.

6. Difficulties encountered & recommendations for replication

6.1. Difficulties encountered during the implementation

6.1.1. Renewable production systems implementation

The main EnR production project considered in Les Orres is hydroelectricity. Two components of this project should be rather trivial to be set up. The fist one is the small 80 kW project called "Sources de Jerusalem", and the second one the one resulting from the study made by Hydrostadium, using the existing pipes of the snow production system.

The big hydroelectricity project is much more complex and will require at least 5 years before the production can start. The reason is that there are some issues with land ownership, especially for the sub-project involving another municipality, and others with biodiversity and the protection of fishes. Hydroelectricity projects very often take 5 to 10 years to get all studies done and all administrative authorizations delivered. We suspect that similar delays can be expected in other countries as well, because there are some conflicts of interest between preserving the natural sites and improving the energetic autonomy of territories.

PV production also requires filing administrative requests, but delays are generally shorter because the environmental studies are simpler to conduct. Furthermore, solar shades deployed over an existing parking lot, an area already de-vegetated and intended for amenity use, are less subject to environmental constraints other than landscape integration. Deploying high altitude installations are more complicated because of potential conflicts of land use for pastoralism, avalanche risks, and costs of connecting to the nearest connection point through mountain slopes when the connection point is far from the production site. Recent regulatory changes in France have removed some of the disincentives to self-consumption that were previously seen, notably through the creation of local energy communities.

As mentioned previously, deploying roof installations can be difficult or made impossible with regard to the protection of built sites, such as Les Orres that is classified "Patrimoine architectural du 20" siècle".

6.1.2. Stakeholder involvement in the Smart Grid implementation

One particularity of a smart grid network is the multiplicity of players involved in balancing power over the same perimeter. The needs of some may therefore be contrary to those of others. For instance, the favourable periods to produce artificial snow are becoming shorter and shorter as a result of global warming. Whenever possible, the operator produces artificial snow. If the period is favourable to snow production, it is because it is very cold in the ski resort. It is therefore necessary to heat tourist accommodation for the occupants' comfort. In this case, all players want to use their energy equipment at the same time. There is no question of demand-side management for the needs of others.

Major difficulties may therefore be encountered in integrating new players into the perimeter if the smart grid system is presented to them in this way.

6.2. Recommendations for a Smart Grid replication

6.2.1. Pay attention to system compatibility

With the emergence of smart solutions, many players could potentially integrate the perimeter of a smart grid. For example, there are many solutions on the market that allow you to lower the heating temperature of a room from an interface, or even automatically. However, open solutions capable of communicating with a global energy management system are less common.

An open solution must be able to receive load management orders and translate it locally into a set of concrete actions to manage energy. It is therefore essential to ensure compatibility between the overall energy management system and the individual control solutions. Either all systems are open: every system can communicate with each other regardless of the chosen communication protocol; or the communication protocol is defined by the global energy management system and the individual control solutions are adapted to this protocol.

In both cases, it is necessary to pay attention to system compatibility when integrating a new player into the smart grid perimeter.

6.2.2. Create a network of involved stakeholders

In order to overcome difficulties related to the integration of new players within the smart grid perimeter, several strategies can be set up. If there are already many players in the smart grid perimeter, the participation of an additional player will further diversify the energy systems and thus the demand-side power capacity. Thanks to this great diversity of uses, it is easier to find actors with the capacity to manage their energy systems when others need power.

The difficulty of involving a new player becomes real when implementing a smart grid with few players. It is no more possible to use the "diversity of uses" argument. Two other arguments can then be used to convince potential players to join the smart grid perimeter:

- The financial argument, linked to the energy savings and to the valuation on the load management service markets (see section 3.2).
- The environmental argument, thanks to the participation in balancing production and consumption and therefore in inserting renewable energies.

The creation of a network around these energy and environmental gains is essential when implementing a smart grid.

6.2.3. Extend the Smart Grid perimeter to new territories

Including additional actors in the smart grid perimeter can extend the load management and peak shaving capacity. Les Orres is working with the Energy syndicate of the Hautes-Alpes to develop a supervision system for the public buldings and amenities, using a long range low rate low consumption network (LoRaWAN), which has the characteristics to require few gateway modules to cover a large area, while consuming minimal energy. For instance, the study conducted in Les Orres concluded that 2 gateways only could cover most of the domain and municipal area, with sufficient power to collect data from communicating water meters inside buildings, as well as other energy, heat and air quality sensors or heat regulation actuators (piloted valves, heating systems. A few additional gateways woudl allow to cover not only the resort, but also the valley, thus expanding the energy and other needs supervision capatcity to a much wider territory.

Figures 31-34 display the current interface of the supervision platform

Figure 31 – position of the two gateway modules covering the domain for energy and water management and other services.

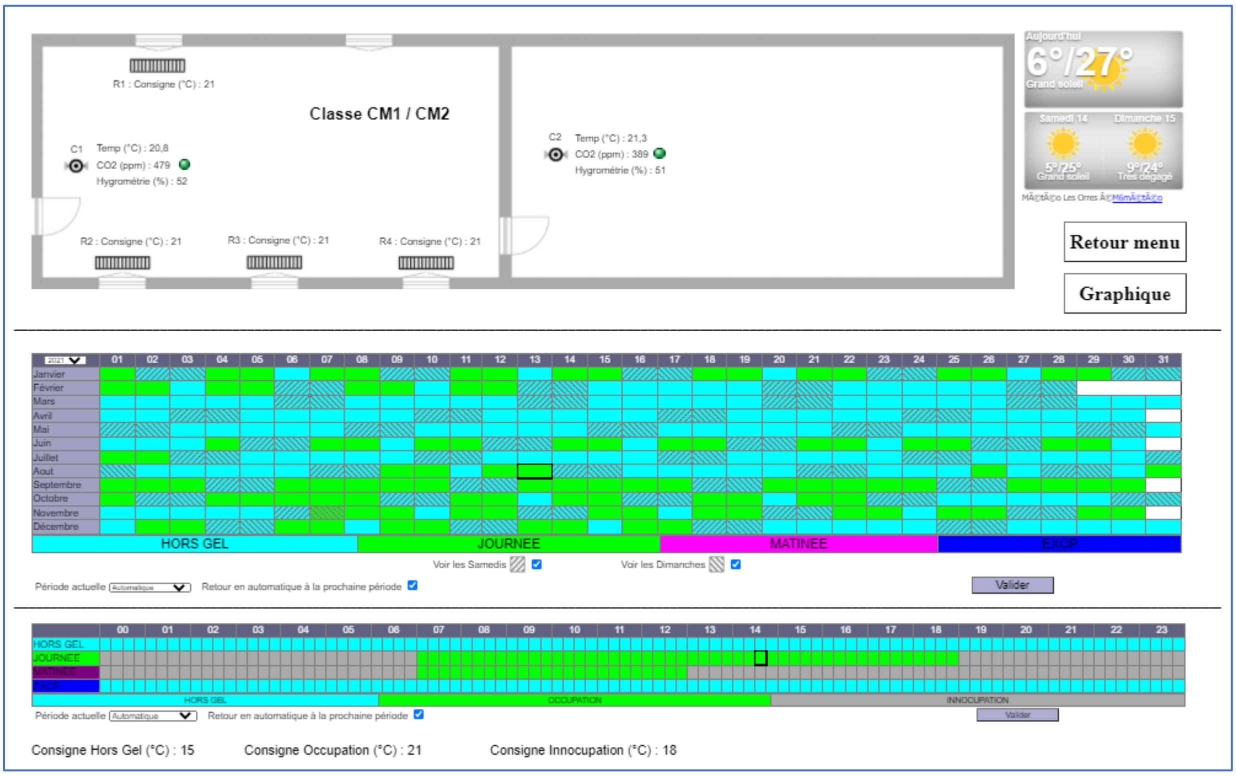

Figure 32 – scheduling interface of a classroom heating regulation

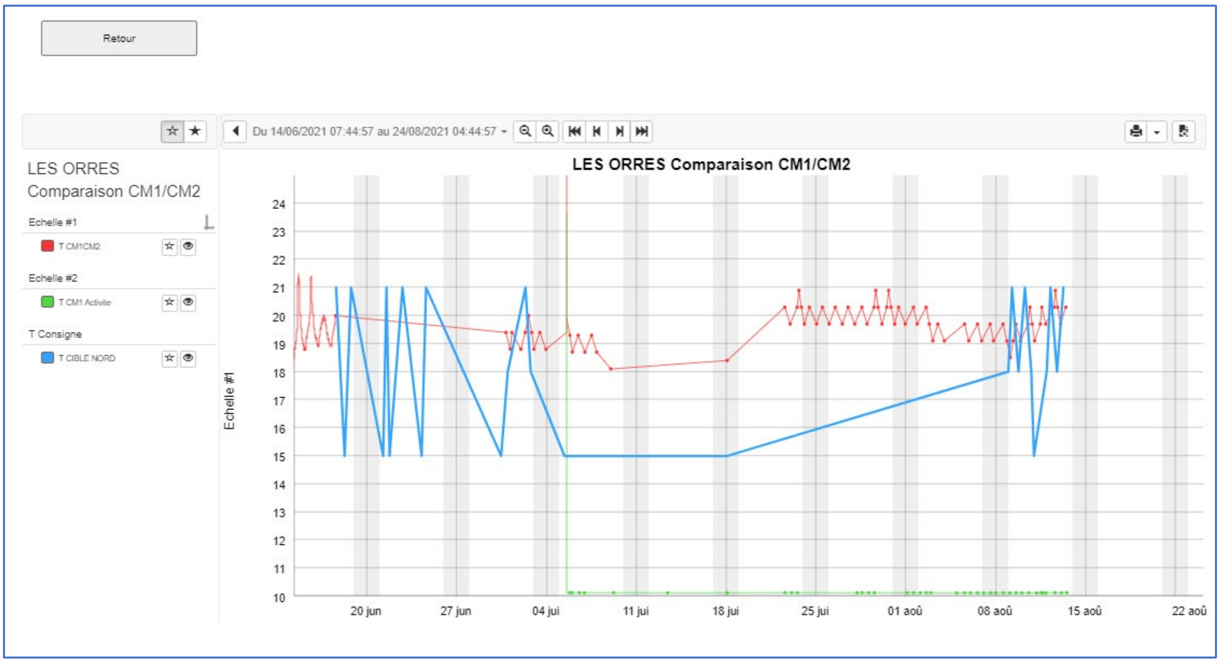

Figure 23 – historic view of the temperature evolution in 2 classrooms

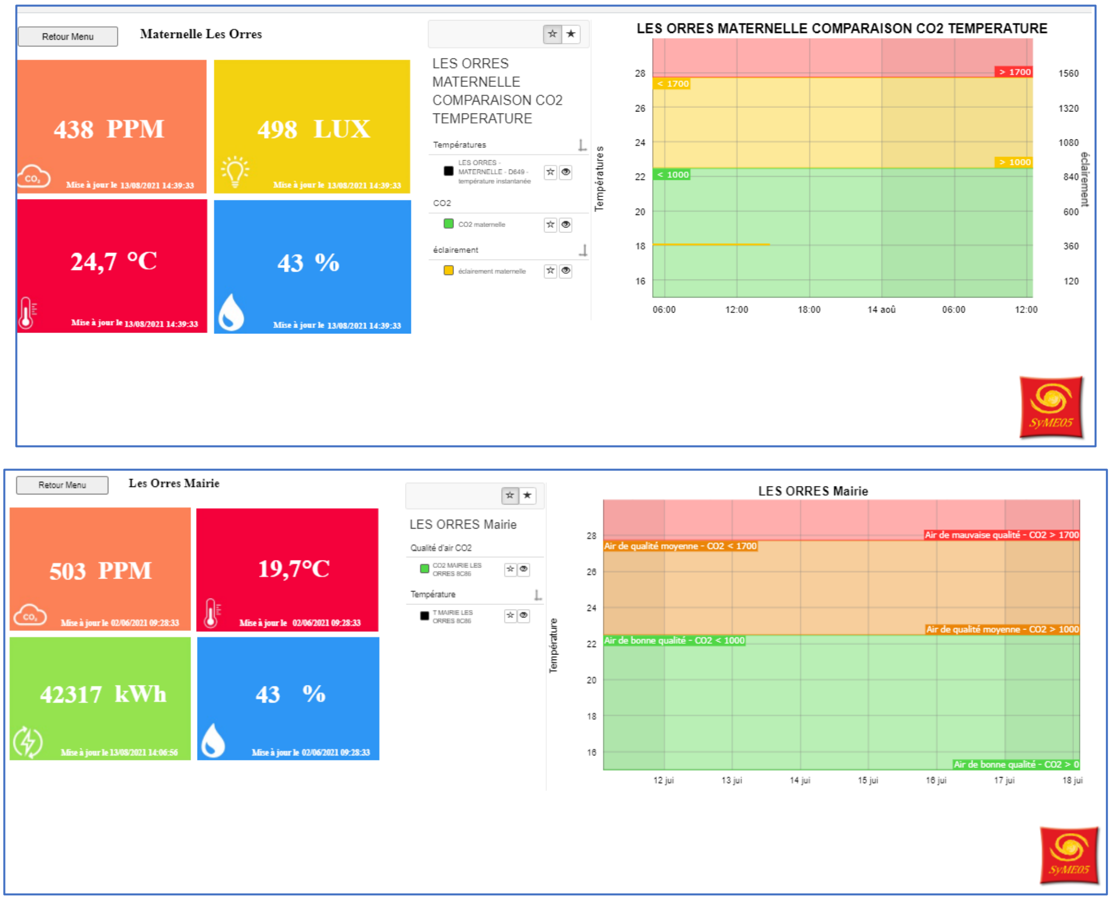

Figure 24 – Home page of Les Orres' kindergarten and Municipality office

6.2.4. Work on the business model

As previously seen, each player makes energy and costs savings thanks to the implemented smart solutions. That therefore justifies a financial investment. However, the participation of these players in balancing the smart grid is more complex. This participation requires limiting energy consumption for a few moments according to specific requests. Repeatedly, limiting consumption could therefore have an impact on user comfort. It is estimated that a load management of 10 minutes over a 1-hour lap time is the maximum period of time without major comfort modifications. On the other hand, this load management generates direct savings on the bill (by lowing energy consumption) and financial remuneration via the load management service markets (see section (5.2.4).

Although there is a growing need to integrate new renewable energy sources, and thus demand-side capacities (6 GW in 2023 in France), the financial remuneration for such load management services keeps relatively low (€9/MW/0.5h - €50/MWh) in comparison with the required effort. This low remuneration is due to the high resilience of the European power grid. With the massive insertion of renewable energies and in the absence of additional storage capacity, the power grid would become less and less resilient. The load management mechanism could therefore become more valuable in the coming years.

7. Conclusion

Based on the integrated Energy Management System (iEMS) already installed on SEMLORE's equipment, this report outlines the strategy for improving this iEMS to a Smart Mountain Grid (section 3).

To achieve the implementation of a Smart Mountain Grid, the conditions for extending the scope of the iEMS have been outlined (section 4):

- Integrating new renewable energy sources (photovoltaic / hydro)
- Integrating new demand-side energy uses (additional control points on SEMLORE’s equipment, public lighting, tourist accommodation…)

Individually, each of the technical implemented solutions allows energy savings and a reduction in the carbon footprint of the ski resort's uses (section 5). Overall, a renewable production of 24 GWh could cover 92% of the ski resort's uses. In parallel, the integration of new pilotable energy uses could offer a total demand-side power capacity of 33 MW.

However, the global management in Smart Grid mode of these energy sources and uses in a ski resort comes up against many problems (section 6.1). The renewable energy production (photovoltaic during the day, especially in summer / hydro during the off-season) is not concomitant with the energy uses of the ski resort. Moreover, the ski resort's operations, such as the production of artificial snow, are not flexible enough to participate actively in the ski resort's energy balance. Finally, the multiplicity of stakeholders in the ski resort, and their respective goals and issues, creates real difficulties in developing a common strategy for energy balance at the ski resort level.

Recommendations for a common strategy for the implementation of a Smart Mountain Grid have been made (section 6.2). This feedback has been shared with other ski resorts in the framework of WP 4 “Replication and knowledge transfer” in order to see this type of technology emerge in a massive way in the future.