SMART ALTITUDE

– Deliverable D.T1.2.1 –
Live monitoring system specifications

WP Number – WP1

Activity Number – A.T.1.2.

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ERDF – European Regional Development Fund

Smart Altitude – Alpine winter tourism territories demonstrating an integrated framework for a low-carbon, high impact and resilient future

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, economic and organizational challenges.

The project will demonstrate the efficiency of a decision support tool integrating all challenges into a step-by-step approach to energy transition. The project clearly innovates by deploying a comprehensive approach of low-carbon policy implementation based on impact maximization accounting for technical, economic and governance factors. It is based on common performance indicators, monitoring systems and Energy Management Systems (EMS) in mountain territories, so as to build a shared situational awareness and take impactful decisions. The approach is implemented in 3 real-field demonstrations and prepares for replication in 20 other Alpine Space territories.

SMART ALTITUDE lasts from April 2018 to April 2021 and is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme.

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Summary

This report draws general specifications for a real-time monitoring system monitoring. It comprises two main sections.

The first one starts from a real-life example, the existing integrated energy management system (IEMS) of Les Orres, to describe the main components of its system and its environment. Then, it extracts the general functional specifications of any real-time energy consumption monitoring system.

The second section draws the specifications of an energy production real-time monitoring system, starting from the analysis of large-range energy management systems, then setting up the condition to a global energy consumption and production monitoring system.

Introduction

The objective of WP1 is to create tools for an integrated dashboard for energy transition in Alpine mountain areas, supporting the prioritization of low-carbon operations. This includes the development of situational awareness, actual performance assessment and Key Performance Indicators.

The activity A.T1.2 specifies the monitoring system on energy usage and production for the Living Labs (validated in WP2, integrated in WP3 Toolkit), based on T1.3 KPIs. The integrated monitoring system agglomerates energy data from multiple sources (snow making, snow grooming, ski lifts, buildings and other operation infrastructure) and performance indicators. It is developed for implementation in the three Living Labs to prioritize low-carbon operations.

This report describes the main components of a real-time energy monitoring system, first for energy consumption such as the existing system set up in Les Orres during the ALPSTAR Alpine Space 2012-2014 program and further extended since then, then a real-time energy production system and finally a combined global system to be set up in ski resorts in the near future, based on the Smart Altitude return of experience and toolset.

1. Overview of an integrated energy management system (IEMS): Les Orres

1.1. Project history

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.

1.2. 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 a major ski resort in the Southern Alps, with 33 ski runs totaling 100 km from altitude 1,550 to 2,720, 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.

1.3. The origin of the IEMS 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.

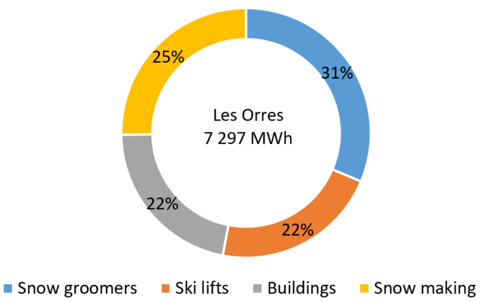

Figure 2– Total final energy consumption in Les Orres (France) in winter 2016-2017. Source: Les Orres energy Smart Altitude questionnaire

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 3 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 23 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.

1.4. Integrated Energy Management system: description

1.4.1. *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.

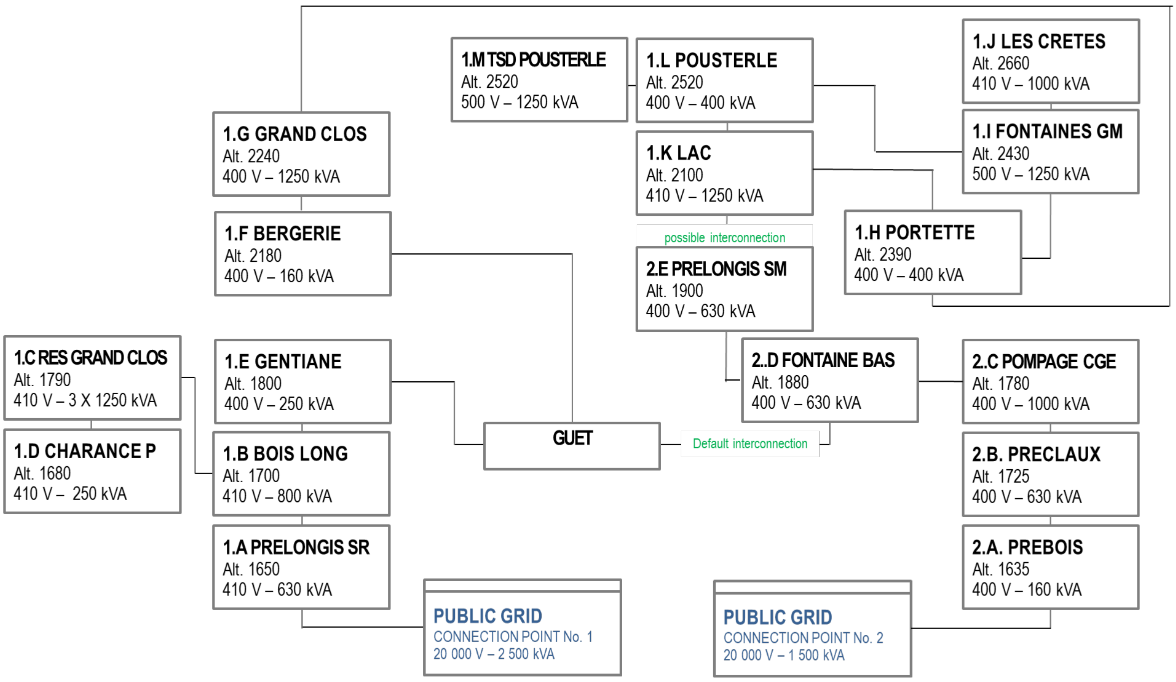

Figure 3– overview of the resort private electric grid

1.4.2. *Electric equipment*

Each electrical transformer supplies several types of equipment including snowmaking (pumps, compressors), 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 shedding capacity to lower the consumption peaks.

#	TRANSFO	INSTALLED POWER (KVA)	TOTAL EQUIPMENT (KW)	P (KW)	N DEVICES	P (KW)	N DEVICES	P (KW)	N DEVICES
1.A	PRELONGIS SR	630	794	124,0	4	570,0	19	100,0	2
1.B	BOIS LONG	800	805			800,0	24	5	1
1.C	RESERVE GRAND CLOS	3 750	2 940			2 940,0	12		
1.D	CHARANCE	250	203			200,0	1	3,0	1
1.E	GENTIANE	250	183			180,0	6	3,0	1
1.F	BERGERIE	160	61	7,5	1	50,0	10	3,0	1
1.G	GRAND CLOS	1 250	950	710,0	2	220,0	8	20,0	1
1.H	PORTETTE	400	575	75,0	1	490,0	21	10,0	1
1.I	FONTAINE GM	1 250	1 090			1 090,0	11		
1.J	LES CRETES	1 000	460			450,0	2	10,0	1
1.K	POSTE DU LAC	1 250	1 180			1 180,0	15		
1.L	POUSTERLE	400	259	59,0	1	180,0	5	20,0	1
1.M	POUSTERLE TSD	1 250	-						
2.A	PREBOIS	160	195	90,0	1	90,0	3	15,0	1
2.B	PRECLAUX	630	571	417,0	3	144,0	4	10,0	1
2.C	POMPAGE CGE	1 000	1 240			1 190,0	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	**12 509**	**1 923**	**20**	**10 314**	**180**	**272**	**15**

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

The metering of all electrical supply points (20KV or LV) with one or more Raptor Manager 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 (20KV transformer, chairlift, pumps) makes it possible to characterize the significant power points for load shedding.

The system reacts in real time for large power (> 1MW, and thereby achieves 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 following Table 2 shows the detail of installed power and equipment connected to each transformer.

LES ORRES edF Interreg Alpine Space smartALTITUDE

					EQUIPMENT					
#	TRANSFO	INSTALLED POWER (KVA	VOLTAGE (V	DEVICE No	CATEGORY	TYPE	NAME	POWER (kW	NUMBER	TOTAL MAX 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	30,0	19	570,0
				1.B.3	SNOW MAKING	LANCE		30,0	1	30,0
				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		80,0	1	80,0
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		5,0	10	50,0
				1.E.5	BUILDING			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		10,0	5	50,0
				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			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	20,0	14	280,0
				1.H.3	SNOWMAKING	LP CONNEXION	REGARD BP	30,0	7	210,0
				1.H.4	BUILDING			10,0	1	10,0
1.I	FONTAINES GM	1 250	500	1.I.1	SNOWMAKING	GUN		36,0	5	180,0
				1.I.2	SNOWMAKING	PUMP		45,0	2	90,0
				1.I.3	SNOWMAKING	PUMP		160,0	2	320,0
				1.I.4	SNOWMAKING	PUMP		250,0	2	500,0
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			10,0	1	10,0
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.5	SNOWMAKING	GUN		30,0	8	240,0
1.L	POUSTERLE	400	400	1.L.1	SKILIFT	SURFACE LIFT	TK MARMOTTES	59,0	1	59,0
				1.L.2	SNOWMAKING	GUN		36,0	5	180,0
				1.L.3	BUILDING	RESTAURANT		20,0	1	20,0
1.M	POUSTERLE TSD	1 250	500	1.M.1	SKILIFT	D-CHAIRLIFT			1	-
2.A	PREBOIS	160	400	2.A.1	SKILIFT	CHAIRLIFT	TS PRBOIS	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	TK JARDIN	15,0	1	15,0
				2.B.3	SKILIFT	CHAIRLIFT	TS PRECLAUX	380,0	1	380,0
				2.B.4	SNOWMAKING	GUN		36,0	4	144,0
				2.B.5	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		30,0	15	450,0
				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

1.4.3. *IEMS DESIGN*

1.4.3.1. Components

Each piece of equipment that needs to be monitored and controlled such as pump, compressor, skilift engine, building heating device or zone, is 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.)

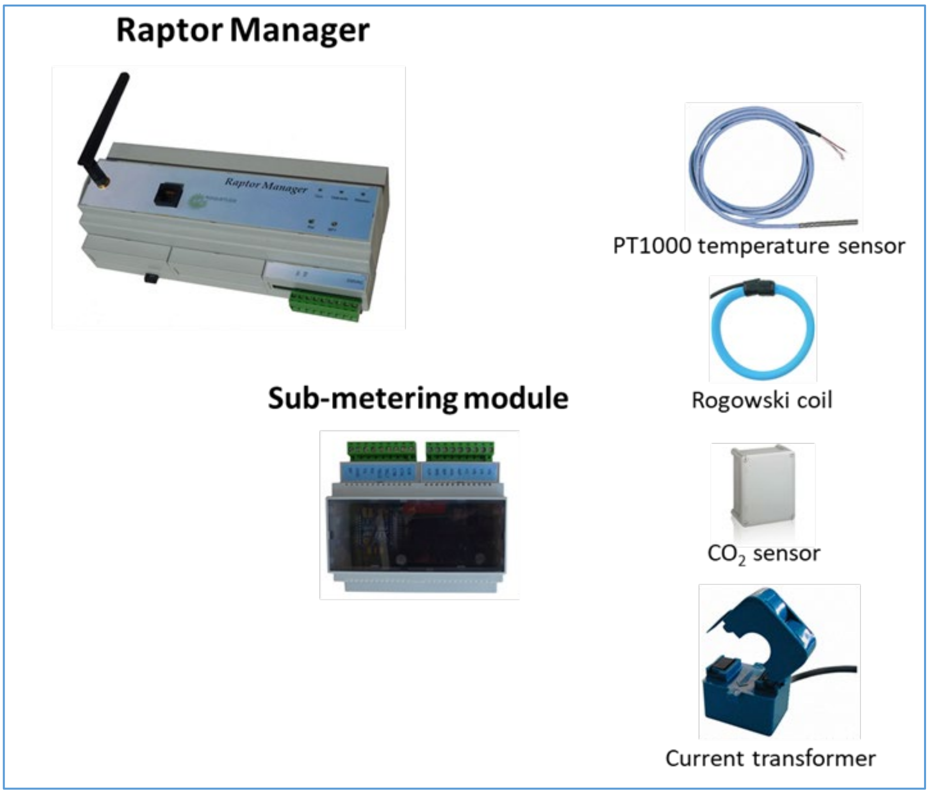

Figure 4– Raptor system equipment

1.4.3.2. 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 an 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 and/or a third-party data supervision platform such as Qantum by QOS Energy, a cloud-based data intelligence platform designed to drive up the performance of renewable plants and energy installations. Each Raptor transfers orders coming from the supervisor to the sub-metering modules and extensions (i.e. radio/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 5 below presents the organization of the Raptor network.

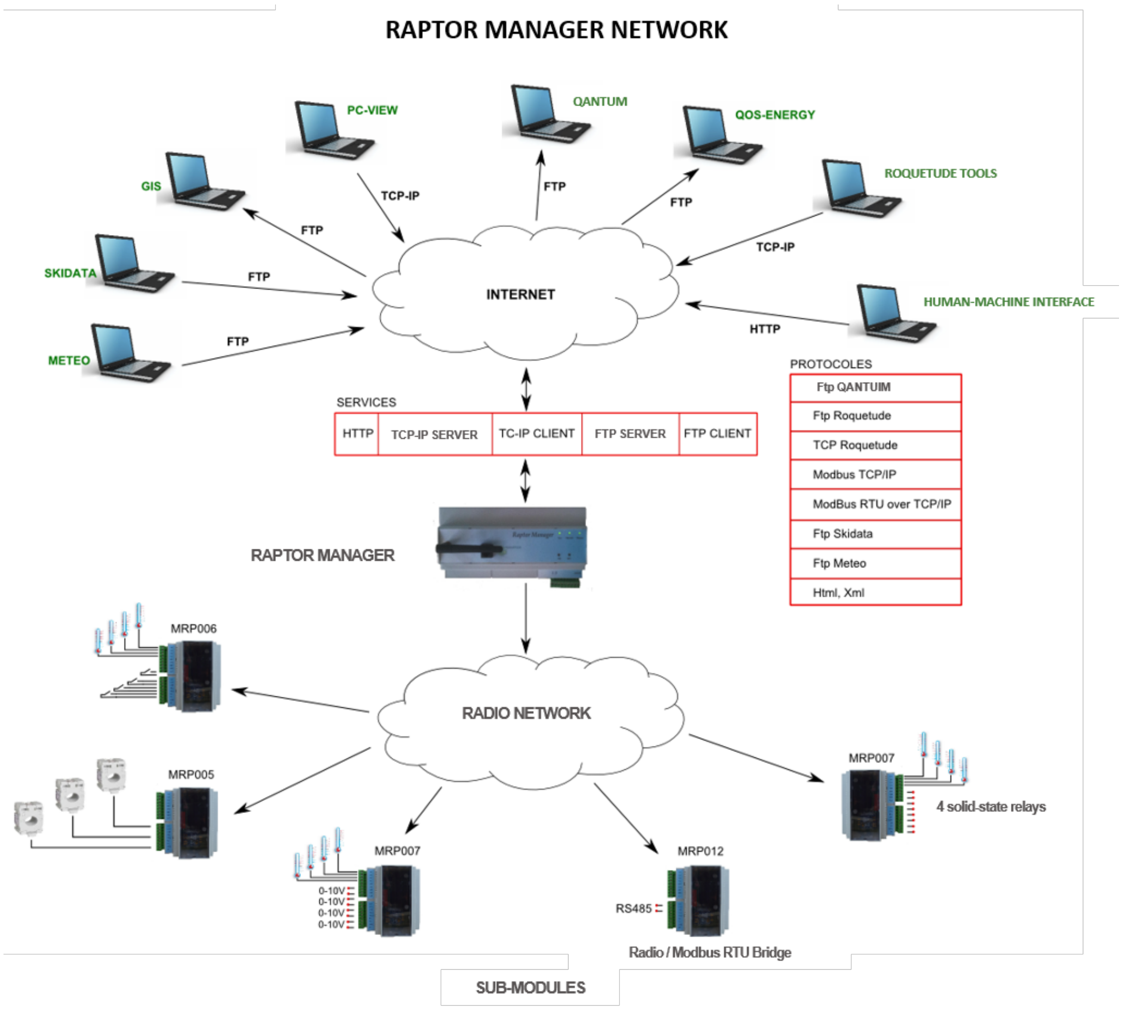

Figure 5– Overview of the RAPTOR network

1.4.3.3. 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 shedding, 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 (Roquetude) and energy consumption analysis (Qantum).

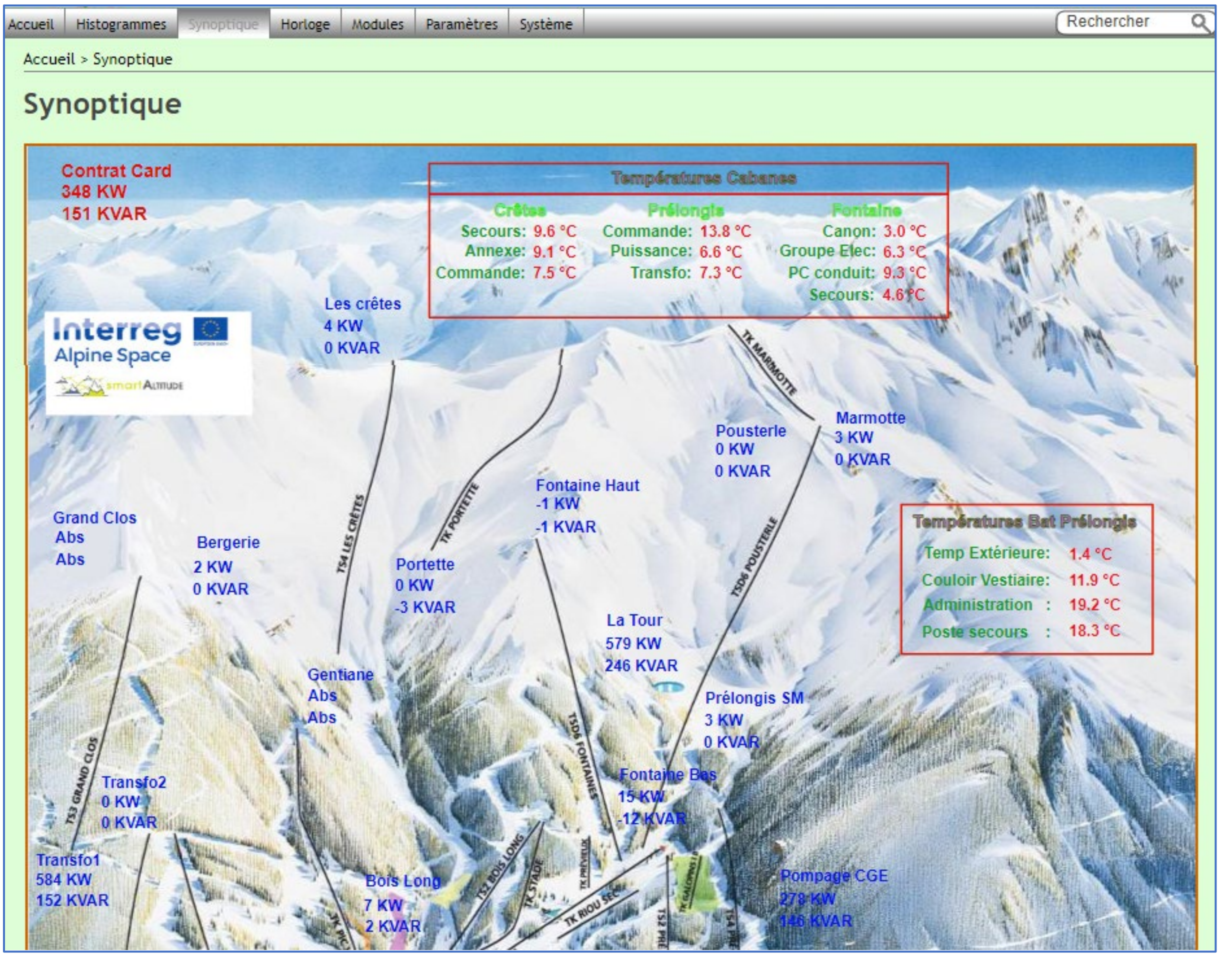

Figure 6– Synoptic view of real time power calls (Roquetude platform)

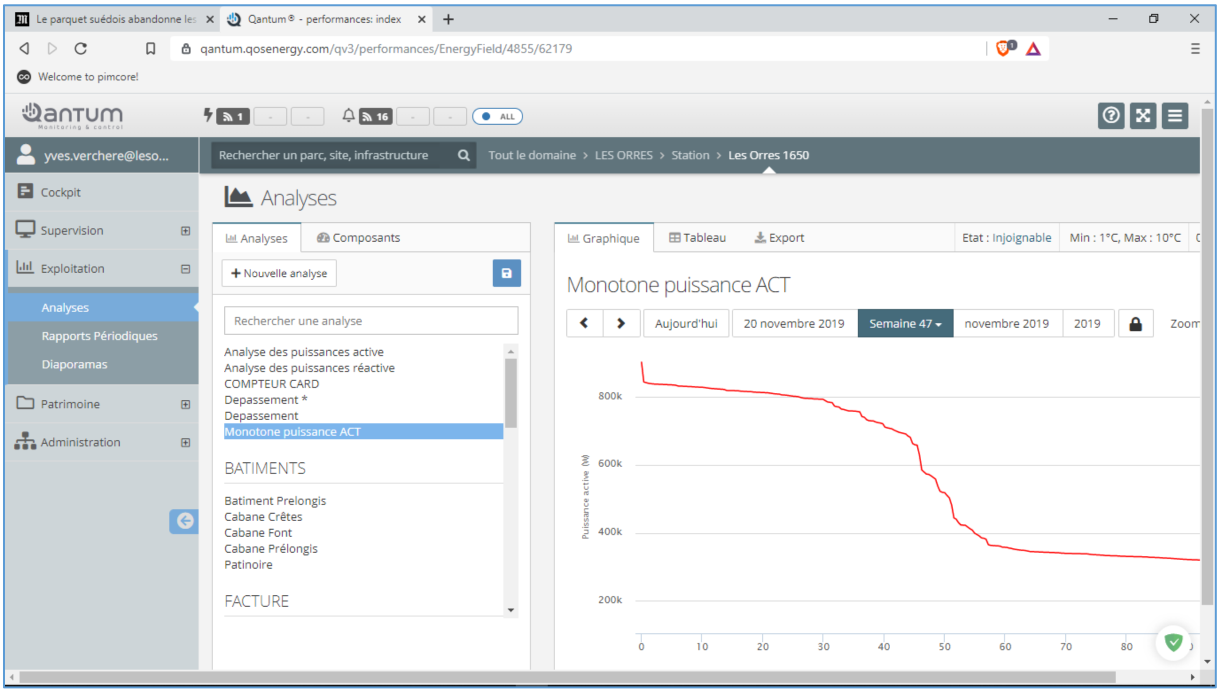

Figure 7– Power demand analysis (Qantum)

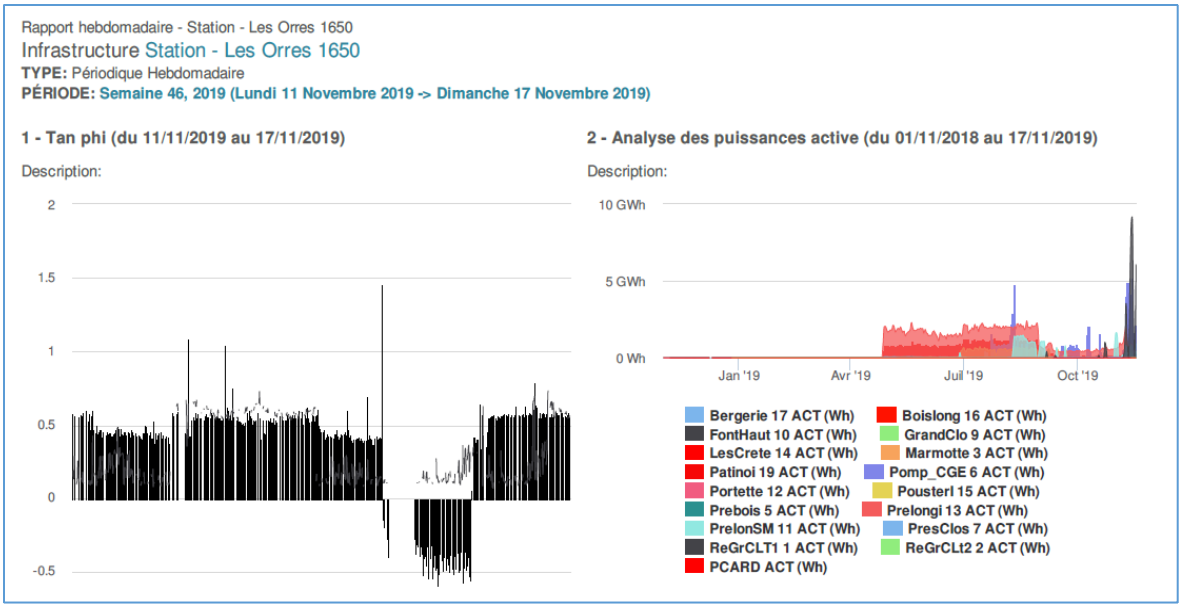

Figure 8– automatic weekly reporting (extract)

1.5. Summarizing IEMS requirement

In conclusion of this section, the main requirements for an efficient IEMS are the following:

- A detailed cartography of the energy network and a clear identification of all types of equipment connected to the electric grid
- The various types of energy sensors capable of metering the main electric values required to manage the system in real time and follow up the energy consumption over a period: tension, active and reactive power, energy, tangente phi, power demand)
- A network system including sub-metering modules, automata capable of data collection treatment and internal storage, with all requested gateways for control/command and data transfer over the network to a supervision platform.
- Connection to external sources of data such as meteorological, access control systems, fuel/gas consumption
- A cloud-based or local server-based supervision platform allowing instant synoptic visualization, with interfaces to define time-based and threshold-based load shedding rules, alerts, and giving control to operators for manual operations.

2. Energy production systems specifications

2.1. From a large range of energy production systems

The energy systems monitoring is different depending on the availability of the energy productions systems. So basically, it depends on each ski resort's energy mix.

If you can manage the energy production "on-demand", thanks to thermal or hydro production systems, the energy management system will be focused on the monitoring of energy production systems.

If the ski resort power generation is not flexible (renewable intermittent energies), the energy management system will be focused on the monitoring of energy consumption systems.

It is therefore necessary to study on the flexibility of each energy local mix to define a specific energy monitoring system.

From a ski resort to another, the energy mix can deeply change. It is closely linked to :

- Local & global energetic potential
- Economic & technical constraints
- Energy policies
- Past & future investment decisions

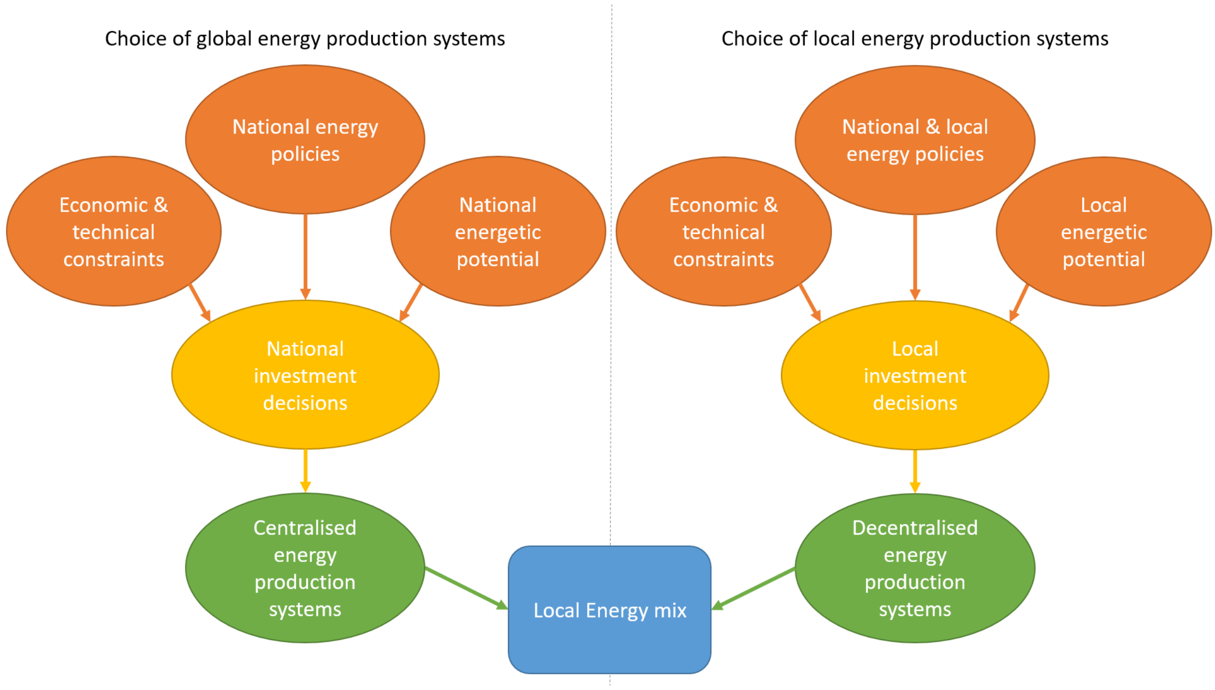

Figure 9– Impact of different criteria for a local energy mix definition

2.1.1. *Energetic potential*

The availability of natural energetic resources has obviously an impact on each local energy mix.

Firstly, a local energy mix depends on the national energy mix. After the first oil crisis in 1971, acquiring an energy autonomy has become one of the priorities in energy policies. Countries with significant fossil, hydro or renewable resources have therefore built their energy mix according to locally available resources. Today, the energy mix established in each country deeply depends on choices made during this period, conditioned by the availability of natural resources. Thus, the supply of electricity, thermal fuels and heat at each ski resort depends mainly on this global energy mix.

Secondly, the emergence of energy solutions based on self-consumption has changed the local energy mix over the past ten years. These decentralized energy production systems depend mainly on the on-site natural energy resources. Self-consumed energies can be based on hydro, wind, photovoltaic, geothermal, or biomass resources. The presence or absence of these self-consumption solutions changes the flexibility of the energy production. Thereby, it impacts the operation of the energy monitoring system to be defined.

2.1.2. *Economic & technical constraints*

Technical and economic constraints, inherent to the location of each ski resort, also impact the energy choices and therefore the local energy mix of the ski resort.

These constraints are mainly related to the issues of electrical/gas connection to the national grid. For instance, some ski resorts are not connected to the national gas network. Some others, which may have a potential for local renewable energy production, are limited in their energy policy because of technical and economic constraints related to the distance connection to the electrical local grid.

2.1.3. *Energy policies*

Energy policies, whether European, national, regional or local, necessarily impact the existing energy mix. It is indeed through the use of taxes, funding, obligations or standards that an energy policy can speed up or slow down one energy solution compared to another.

For instance, funding, investment aids, tax exemptions and power purchase agreements make the development of renewable energies possible.

Energy and climate goals have been set at the European level. By 2020, the objectives are:

- Reduce greenhouse gas emissions by 20% from 1990 levels;
- Increase the share of renewable energies to 20% in total final energy consumption;
- Improve energy efficiency by 20% compared to forecasts set in 2007 for 2020.

By 2030, these objectives are 40%, 32% and 32.5% respectively. It is the framework for climate and energy actions at the European Union level.

On a national level, these objectives were reset by every country of to define energy-climate national plans. Goals from one country to another are therefore quite different.

Similarly, climate and energy national objectives are reset regionally and locally. Thus, depending on elected representatives, local energy policies are for instance more or less based on renewable energies despite common objectives at the European level.

2.1.4. *Past and future investment decisions*

Investment decisions are made on a local scale. These decisions mainly concern investment in decentralized / self-consumed energy production systems.

Several criteria must be considered in these investment decisions among which:

- Economic and financial criteria such as investment costs, operating costs and breakeven point are essential elements to be taken into account in any investment decision.
- Environmental criteria also impact investment decisions such as renewable energy rate or greenhouse gas emissions of the ski resort. The environmental criteria can also have an impact on the attractiveness of the ski resort and thus modify its economic balance.

There is no magic formula concerning the respective weight of each of these criteria in the decision or not to invest in decentralized means of energy production. It is up to each local operator to place the cursor between profitability and environmental commitment.

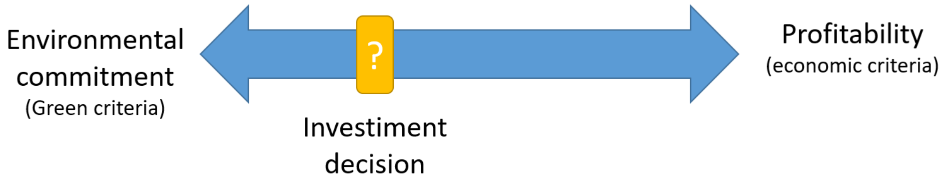

Figure 10– Weight of environmental & economic criteria in an investment decision

2.1.5. *Energy mix analysis*

It should be first noticed that the following energy data presented are national data. Locally, energy consumption and production data may vary according to the local energy choices but also according to the resort activities.

For example, if we focus on the operation of the Les Orres ski resort (excluding tourist housing), the total final energy consumption is mainly 69% electric (ski lifts, snow making and buildings exploitation). The consumption of fossil products (mainly oil products) corresponds to 31% of the energy mix. Therefore, Les Orres energy mix (Figure 11) is not representative of the French energy mix (Figure 12).

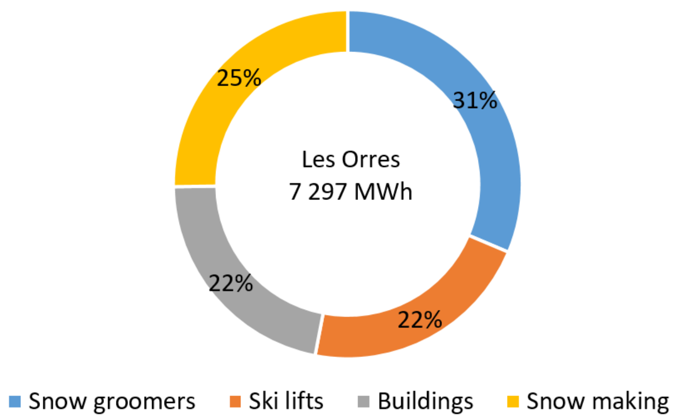

Figure 11– Total final energy consumption in Les Orres (France) in winter 2016-2017. Source: Les Orres energy report.

On the other hand, the total final energy consumption of the whole station of Les Orres (including tourist habitat) is much closer to the French global energy mix (Figure 12).

Subsequently, in order to overcome the specific aspects of each ski resort in terms of local energy production, and for reproducibility issues for the other Alpine ski resorts, we will focus more on the global energy mix by country than on each local energy mix (Figure 12, Figure 13, Figure 14).

Only data from the 3 countries corresponding to the 3 living-labs of the Smart Altitude project are presented below: Slovenia, France, Italy.

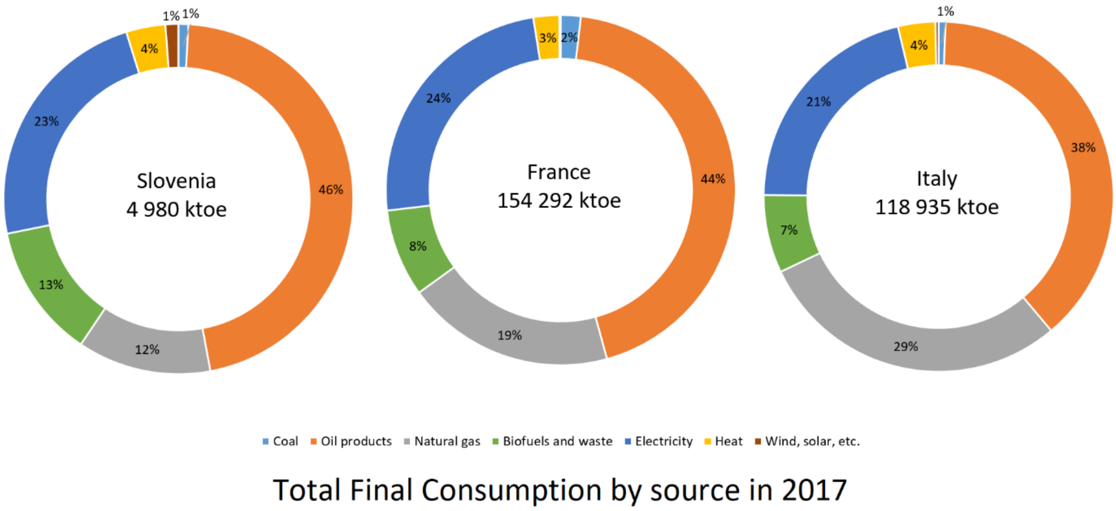

Figure 12– Comparison of total final energy consumption by source in Slovenia, France and Italy in 2017. Source: IEA.

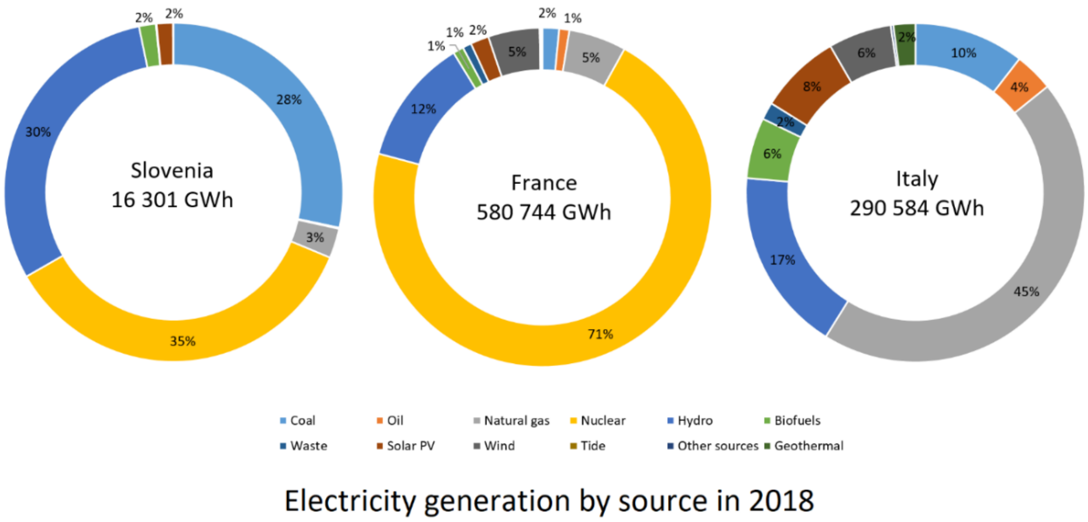

Figure 13– Comparison of electricity generation by source in Slovenia, France and Italy in 2018. Source: IEA.

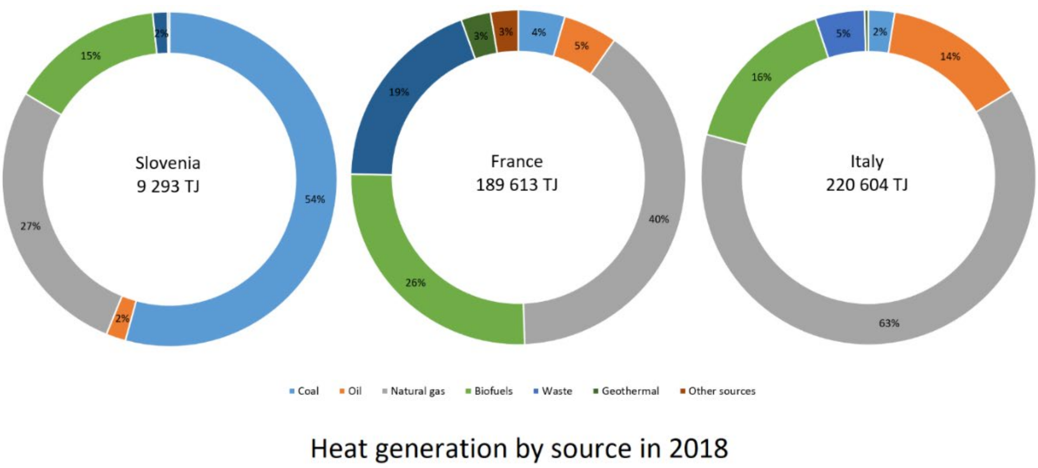

Figure 14– Comparison of heat generation by source in Slovenia, France and Italy in 2018. Source: IEA.

Without taking the national energy volumes (production or consumption) into account, we can firstly notice that the total final energy consumption by source is similar from one country to another

(Slovenia, France, Italy). Differences in natural gas consumption (29% of final consumption in Italy, against 12% in Slovenia) are offset by a complementary share of oil and biomass products. The share of fuels (natural gas, oil products, biomass and waste) is thus almost constant from one country to another (71% for Slovenia and France - 74% for Italy). It is also important to notice that the share of heat and electricity in the total final energy consumption of each of these countries is comparable (differences under 3%).

On the other hand, if we focus on the way this electricity and heat is produced in each of the three countries, big differences are observed.

Electricity generation (Figure 13) is mainly nuclear in France (71%), natural gas in Italy (45%), and equitably distributed between nuclear power, hydroelectricity and coal in Slovenia. Fossil and hydraulic production systems are more flexible than nuclear power plants. Therefore, it is more relevant to use the electricity network to meet a specific on-site energy demand in Italy or Slovenia than in France. Nevertheless, issues related to the carbon footprint can be taken into account with regard to the solicitation of fossil production systems to meet a specific on-site energy demand. All these factors should therefore be considered when setting up an energy management system.

Regarding heat generation (Figure14), differences are quite remarkable from one country to another. Heat from fossil fuels (natural gas, coal, petroleum products) account for 83%, 49% and 79% of heat generation respectively in Slovenia, France and Italy. Other means of producing heat to complete the energy mix (biomass and geothermal) are as flexible as conventional fossil production systems. The share of non-flexible or intermittent production systems such as solar thermal remains anecdotal in the heat generation of these countries. Producing heat to meet a specific on-site demand is therefore not a problem in each of these countries. However, the associated carbon footprint is very different from one country to another (Figure 15). Thus, it needs to be considered in the choice of both heat generation and heat consumption.

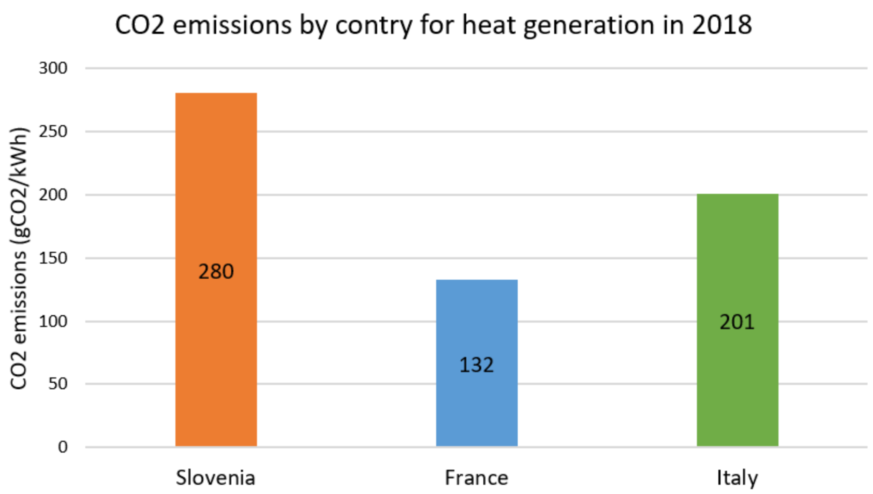

Figure 15 – Comparison of CO_2 emissions for heat generation in Slovenia, France and Italy in 2018. Source: IEA.

In overall, it is therefore relevant to focus on the flexibility and carbon emissions of energy production systems. The knowledge of these two dimensions will make the definition of a management system adapted to each situation possible.

2.2. Conclusion: toward a global system specification

Although energy production differs widely from one site to another, it is possible to define some common rules concerning the energy production data to be collected in order to define an energy management system.

In overall, the necessary data to characterize an energy monitoring system to be implemented are the following:

- Electricity supply by the grid;
- Natural gas supply by the network;
- Other fuels supply by tank (oil, gas, wood, gasoline, etc.);
- Local energy production.

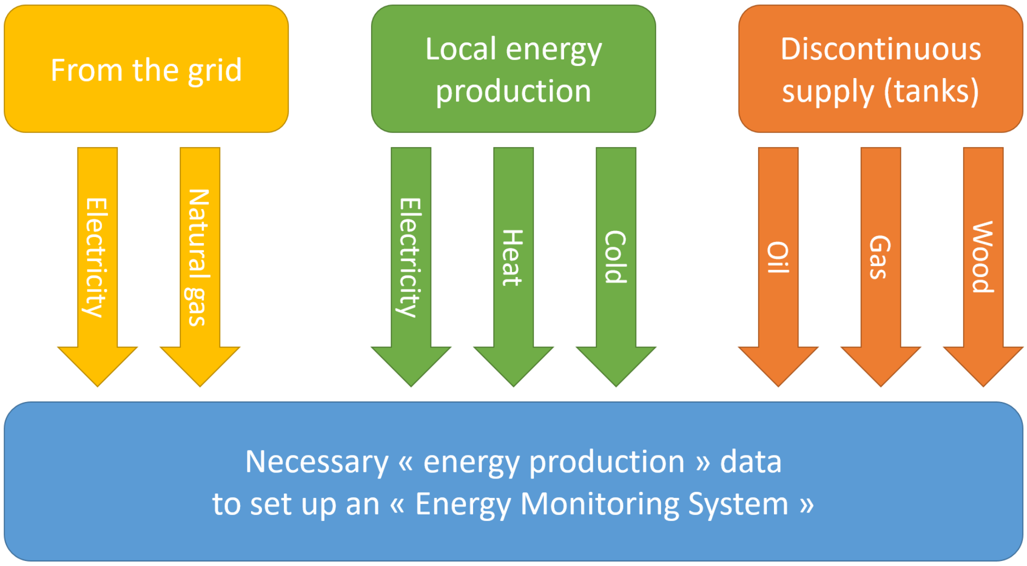

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Figure 16– Energy production data to set up an energy monitoring system.

All the data to be collected are listed below:

Fuel	Fuel tank	Volume available	m3
		Energy price	€/kWh
		Instant energy supplied	kWh
Natural Gas	Natural Gas grid	Contract subscription price	€/year
		Energy price	€/kWh
		Pressure	mbar
		Instant energy supplied	kWh
	Liquefied Gas tank	Volume available	m3
		Pressure	bar
		Energy price	€/kWh
		Instant energy supplied	kWh
Electricity	Electricity from grid	Power subscribed	MW
		Contract subscription price	€/year
		Energy price	€/kWh
		Over power price	€/kW
		Instant power supplied	MW
		Voltage	V
		Intensity	A
	Electrical local storage	Storage energy capacity	kWh
		Available energy capacity	kWh
		Installed power	kW
		Instant power supplied	kW
		Energy price	€/kWh
		Rated voltage	V
		Intensity	A
		Deep max load admitted	%
	Local Electricity production for self-consumption (for each kind of power generation - PV, wind, hydro, etc.)	Installed power	kW
		Instant power supplied	kW
		Energy price	€/kWh
		Voltage	V
		Intensity	A
Heat	Local Heat production for self-consumption (for each kind of heat generation - geothermal, thermal solar, biofuels, waste, etc.)	Installed power	kW
		Instant power supplied	kW
		Energy price	€/kWh
		Voltage	V
		Intensity	A
	Thermal local storage	Storage energy capacity	kWh
		Available energy capacity	kWh
		Installed power	kW
		Instant power supplied	kW
		Energy price	€/kWh
		Voltage	V
		Intensity	A

Table 3– Necessary energy production data to set up a local Energy Management System.

That kind of data are then to be completed by the on-site energy consumption data. As soon as all these data (production, consumption, storage) are collected in real time, energy management scenarios can be set up to guarantee the local balance between energy production and energy consumption. Energy availability and erasure flexibility are the main technical criteria for defining these scenarios. However, economic and environmental criteria have also to be considered when defining real-time management scenarios.

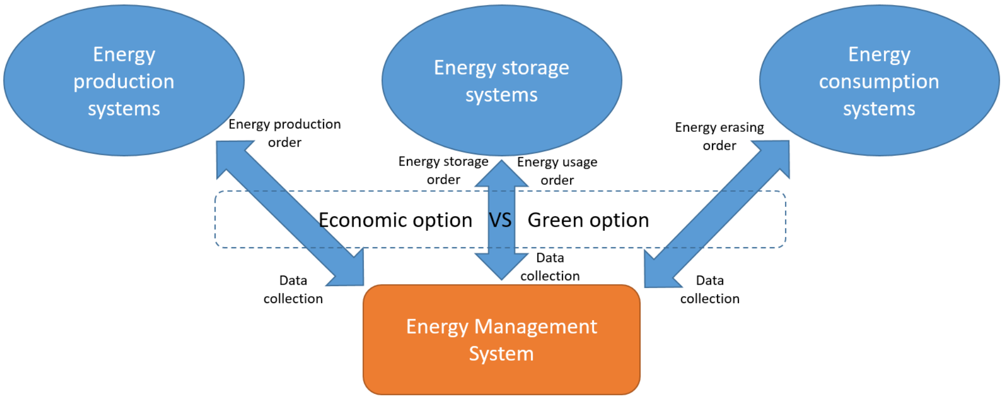

Figure 17 – Global design of a local energy management system.

Conclusion

The A.T.1.2. activity allowed to identify and describe the functional specifications of global real-time monitoring system which will be implemented at various levels in the 3 living labs and associated pilot ski resort of Verbier (WP2). Then, the WP2 living lab return on experience will serve to develop a more detailed approach that will be reported in the D.T2.1.1, D.T2.1.2 & D.T2.1.3 reports. Access to real time metering in Madonna di Campiglio and Les Orres by various categories of stakeholders will be made available via the A.T3.1 activity. All this work will be one of the main triggers to get replicator sites (other ski resorts in the Alpine Space area) onboard, one of the key objectives of the project.

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