WP T4 Replication and Knowledge Transfer

Activity A.T 4.1 Recommendations for low carbon winter tourism regions

EUSALP Recommendations and contribution reports

D.T4.1.3.5 – Alpine strategies for Action Group 9 Smart Grids

Project acronym:	**Smart Altitude**
Project name:	**Alpine winter tourism territories demonstrating an integrated framework for a low-carbon, high-impact and resilient future**
Programme priority:	**Priority 2 - Low Carbon Alpine Space**
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1. Executive summary / Brief

Given the present and future challenges related to the impacts of climate change that the tourism sector operating in the Alpine Region will have to deal with, a stronger collaboration and effort on R&I actions is needed. Setting up an Alpine energy efficiency cluster and greening the Alpine infrastructures are two key specific objectives of EUSALP Action Group 9 (AG-9) directly related to implementing energy efficiency measures in the Alpine area. By its actions implemented in its four technical workpackages, the Smart Altitude Alpine Space project generated a detailed process to deploy energy efficiency measures within a network of 26 mountain resorts engaged in a common action toward sustainable mountain tourism and economic development.

Among the fields of action explored and the actions implemented in the four living labs, Les Orres was in charge of conducting a study with its partner EDF on the implementation of a mountain smart grid. In particular, the aim was to determine the interest of such an approach to mutualise and regulate the energy production and use of energy at the resort level. This report presents the technical and economic characteristics and the obstacles to the deployment of such systems.

By its actions and replication program, Smart Altitude has paved the way for future developments that could usefully serve the strategy developed in the framework of EUSALP, in particular AG-9's contribution to the implementation of the EU Energy Efficiency Directive in the Alpine area.

2. Introduction

Three short reports aim to assess the convergence and contributions of the Smart Altitude project to EUSALP Action Group 9 (AG-9) with regard to energy efficiency, Energy Management Systems (EMS) and the deployment of **smart grids** respectively. Firstly, in this introduction, the work of AG-9 on these different topics will be reviewed. This will be followed by a brief review of the state of the art, often referring to other deliverables of the Smart Altitude project, then by a review of the work carried out in Living Lab Les Orres, and a discussion on barriers to development. Finally, the relevance of the outcomes of Smart Altitude's work for AG-9 will be highlighted and a series of recommendations will be made.

This third report focuses on **the adaptation of the smart grid concepts to Alpine resorts.**

The mission of EUSALP AG-9 is, by focusing on the promotion of energy efficiency and the production and use of local renewable energy in the Alpine Region, especially in the public and private sectors, to support a significant reduction of energy consumption in the housing and mobility sector, as well as in small and medium enterprises, promoting energy management and monitoring systems at different levels. AG-9 lists five specific objectives: 1) Setting up an Alpine energy efficiency cluster; 2) Greening the Alpine infrastructure; 3) Setting up an Alpine renewable energy cluster; 4) **Support energy management systems** in the Alpine Region; 5) Support a better use of local resources and increase energy self-sufficiency while reducing impacts on climate and the environment.[1] Specific objective No. 4 **extends the notion of energy management system,** mentioning energy efficiency and **decentralised monitoring systems at the local leve**l, which falls under a **microgrid type** approach.

Smart altitude, for its side, aims at enabling and accelerating the implementation of low-carbon policies in winter tourism regions. It will demonstrate the efficiency of a decision support tool

[1] https://www.alpine-region.eu/action-group-9

integrating all challenges into a step-by-step approach to energy transition and 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 (snow processes, municipal infrastructure, renewables, buildings etc.) and **Energy Management Systems (EMS)** in mountain territories, to build a shared situational awareness and take impactful decisions. The approach is implemented in four real-field demonstrations and prepares for replication in at least 20 other Alpine Space territories.

The project targets policymakers, infrastructure operators, investors, tourism and entrepreneurship organisations. Its outputs are as follows: 1) Territorial diagnosis method; 2) Online Smart Altitude Toolkit; 3) Living Labs; 4) Planning model for adaptation strategy implementation; 5) Replication roadmap and network of low-carbon winter tourism regions. The partnership and activities ensure the approach suitability across the Alpine Space, promote new innovations and skills, and enable policymakers to plan and prioritize measures increasing the resilience of mountain areas.

Within workpackage T2 "Smart Altitude Living Labs" that includes four Alpine resorts—Krvavec (SI), Madonna di Campiglio (IT), Les Orres (F) and Verbier (CH)—,Les Orres and its partner EDF were asked to explore the conditions for building a microgrid at the level of the resort and the municipality that supports it.

3. Definition and State of the art

In its specific objectives, AG-9 mentions as main targets three priority sectors: building/housing, **energy management systems**, and mobility. Among these, this report focuses on **Smart girds,** and more specifically **on microgrids** that could be deployed in mountain resorts and areas.

Definitions

Smart grids are energy networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly. When coupled with smart metering systems, smart grids reach consumers and suppliers by providing information on real-time consumption.[2]

Microgrids are smart grids at local level. Microgrids have been identified as a key component of the smart grid in order to improve system energy efficiency and reliability and to provide the possibility of grid-independence to individual end-user sites. As defined by the Microgrid Exchange Group (MEG), "A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."[3]

In this report, Smart grid refers to a microgrid implementation using smart grid technologies.

Presentation of the Smart grid/microgrid approach

An exhaustive presentation of smart grids, including general considerations on the context, deployment and challenges and possible application to mountain resorts, is discussed in Smart Altitude deliverable D.T3.2.1. "Territorial Maximisation" report, section 5[4]. We refer the reader to

[2] European Commission – https://ec.europa.eu/energy/topics/markets-and-consumers/smart-grids-and-meters_en

[3] US Department of Energy, DOE Microgrid Workshop Report, 2011.

[4] https://www.alpine-space.eu/projects/smart-altitude/results/wpt3/d.t3.2.1.pdf .

this document for a full review. Below are some key considerations to help understand the implications of smart grid deployment.

The main benefit of setting up a Smart Grid is the massive integration of intermittent renewable energies. By modulating energy consumption according to the available power, Smart Grid technologies make it possible to maintain a reliable, durable and secure electricity supply. The setting up of a microgrid requires the implementation of a communication infrastructure between all the different electrical systems in a defined area, via smart meters collecting and transmitting energy production and consumption data in real time. Data analysis and processing platforms allow the real-time monitoring of the electrical status of the local electricity network. This computer supervision makes it possible to trigger automatic activation of production, consumption or storage flexibilities, upwards or downwards depending on their respective availability, in the search for an optimal balance between demand and supply of energy passing through the distribution network.

Figure 1 below presents the main components of the Nice Grid project[5] led by several players including Enedis, EDF, Saft, GE Grid Solutions.

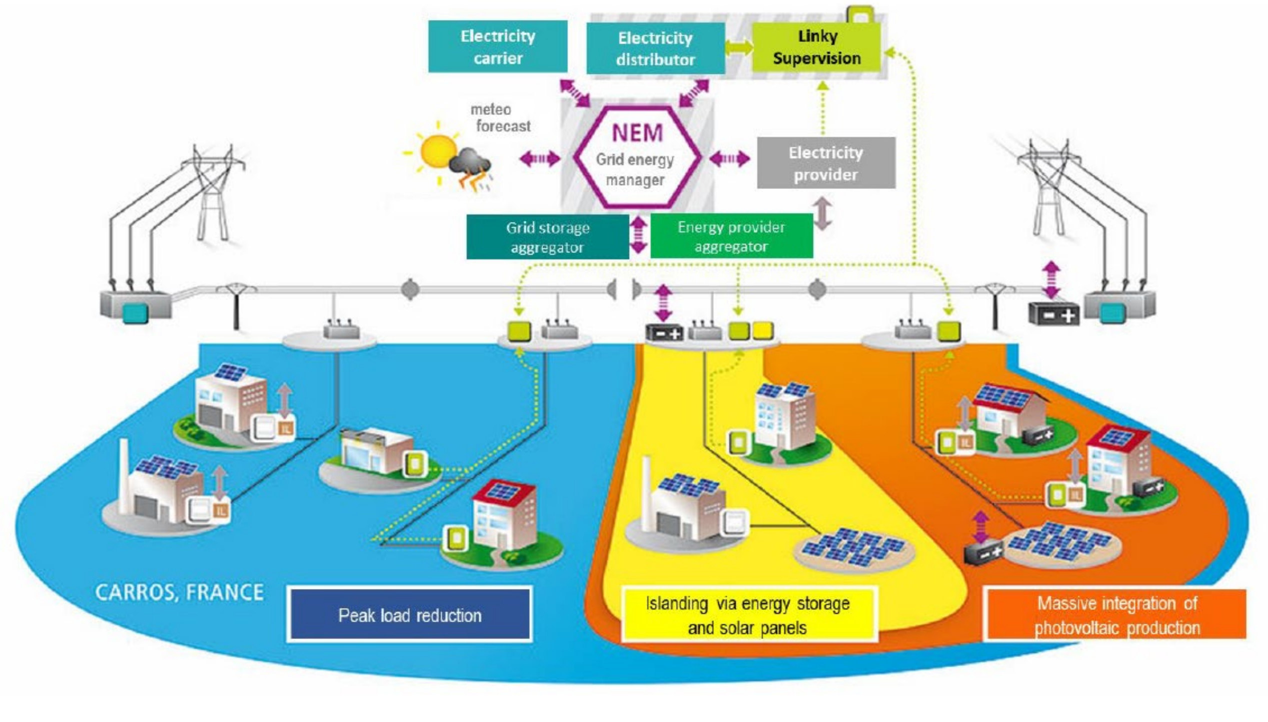

Figure 1–The “Nice Grid” Smart Grid -- Adapted from Thomas Drizard, ENEDIS

In its characteristics and dimension, the Nice grid experiments provides a useful model for a mountain grid: it involved 2,500 homes and businesses equipped with Linky smart meters, photovoltaic panels for a total production capacity of 2.5 MWh, storage capacities by batteries, distributed at different points on the electricity grid capable of storing 1 MW for 30 minutes. The Nice Grid project: included an islanding experiment consisting of running the grid in complete autonomy, for a given period of time, without any electricity input from the external grid.

[5] Guillaume Foggia, M. Muscholl, Jean-Christophe Passelergue, P. Gambier-Morel, Cyril Vuillecard, et al., The Nice Grid project: Using Distributed Energy Resources to Reduce Power Demand through Advanced Network Management. 2014 CIGRE Session, Aug 2014, Paris, France

The "NEM" (Network Energy Manager) makes it possible to solicit various aggregators, which optimise responses to the constraints observed on the network, depending on the time of day. These responses correspond to local flexibility offers made to participants. They encourage them to shift their consumption when solar production is high, and/or to reduce their consumption during cold peaks. For example, in the summer, in the event of overproduction of photovoltaic energy, they can take up the residential flexibility offers of the aggregator, which proposes "solar bonuses" (solar off-peak hours between 12 noon and 4 p.m.), remote activation of the water heater for voluntary customers, and storage of electricity in batteries. Conversely, in winter, during consumption peaks, the NEM can take up offers of lower heating via the Linky meter or proposals for battery discharge, from the grid battery aggregator.

As seen, in a Smart Grid, all local actors therefore play a role in ensuring this balance between production and consumption, according to predefined scenarios and priorities. Energy consumers are also called upon: they are invited to limit their energy consumption when energy production is low by deferring their electrical use to periods when availability is high.

4. Smart grid deployment modelling in Smart Altitude

Mountain Smart Grid

Energy consumption and production in mountain areas have a number of particularities with respect to the electricity network, which are outlined below:

1) A highly seasonal frequentation, and therefore of energy consumption, with a very specific winter evening/night consumption peak linked to snow production;
2) Low summer consumption (e.g., resort operations in Les Orres: energy demand of around 250 kW against a winter power peak up to 5 MW);
3) Widely varying conditions in the composition of the energy mix and renewable energy generation capacity depending on geographical location. In some locations, local hydroelectric generation capacity exceeds energy needs. Photovoltaic, geothermal and wind generation capacities can also vary considerably. In Les Orres, the production potential is mainly hydroelectric (23 GWh) and more marginally solar (423 MWh). Wind power does not seem relevant compared to other sites and resorts. Local biomass resources are also used for heating communal buildings, and gas heating for part of the heating installations in tourist accommodation buildings;
4) Seasonal imbalance between consumption needs and production capacity: needs are higher in winter when production capacity is low (low water flow, low photovoltaic production due to the short duration of sunshine and the greater prevalence of solar masks).

The mountain grid approach by Les Orres and EDF

Les Orres resort has been a pioneer in the implementation of an energy management system in the Alps within the framework of the ALPSTAR programme, over the period 2012-2014. On this occasion, Les Orres carried out a complete energy assessment of the station's operations and set up an energy management system with the contribution of two design offices: Eco-mesures[6] and Roquétude[7]. This action has made it possible to reduce energy consumption by 20%, greenhouse gas emissions by 100 t CO_2 and the station's energy bill by 25%.

[6] https://www.eco-mesures.fr/.
[7] http:/www.roquetude.com/

Since then, Les Orres has become the "Mountain resort of tomorrow" pilot of FLEXGRID, a programme for the deployment of smart grid solutions led by the Provence-Alpes-Côte d'Azur Region and operated by the Capenergies competitiveness cluster. The resort and the commune of Les Orres have continued their commitment to the deployment of responsible energy solutions, alongside their partners EDF and Enedis, and the commune of Les Orres has become the leader of the Alpine Space SMART ALTITUDE project to extend its EMS to model a smart mountain grid.

The diagram below shows the components of Les Orres smart grid with the central role that a local energy pilot would play, interacting with the resort's EMS, the public lighting supervisor and the various monitoring and control equipment that will be installed in public and private facilities and tourist accommodation buildings.

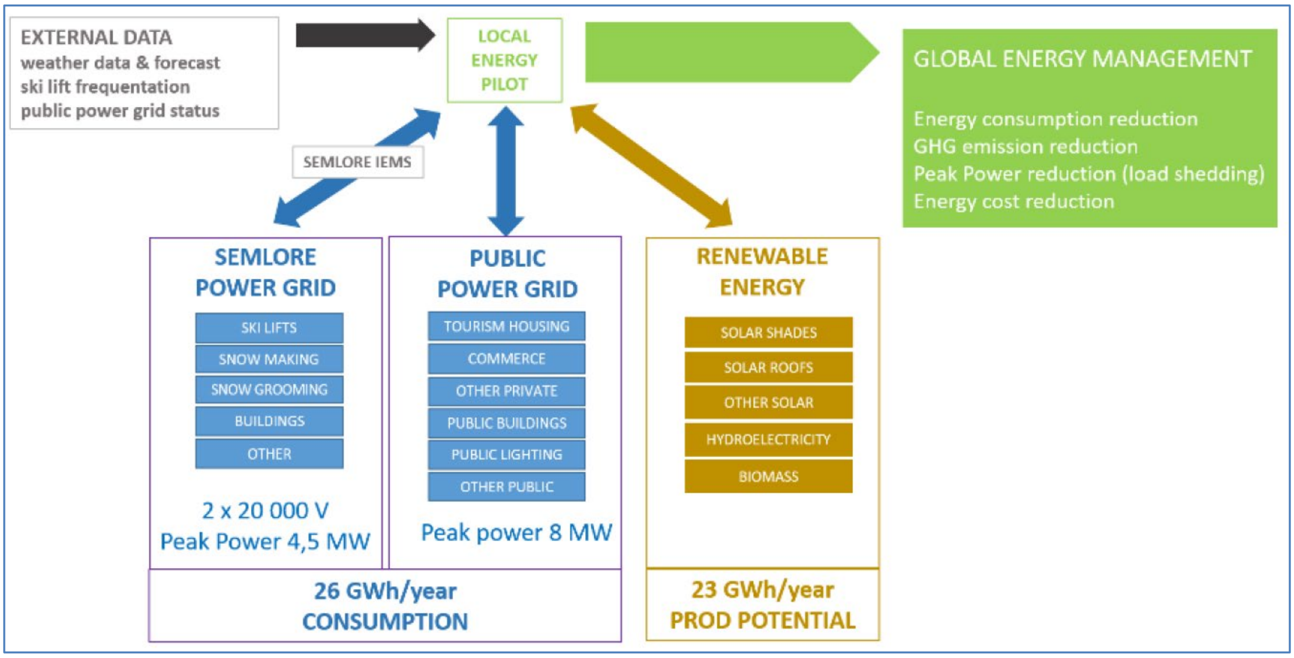

Figure 2—Principle of organization of Les Orres mountain grid

The resort of Les Orres has specific features that do not necessarily correspond to the conditions faced by all Alpine resorts:

1) In France, electricity is more decarbonated and less expensive than in most countries in the Alpine region;
2) Consequently, most of the heating in tourist accommodation is electric, which reinforces the interest in integrating this component into a smart grid approach because of the strong capacity to regulate and reduce energy demand that it represents.
3) The typology of actors can vary considerably from one country to another, and even within the same country. Les Orres has the advantage of having a semi-public operator with the municipality as main shareholder, which facilitates the integration between the public (municipality) and the semi-public (resort operator) in a common Smart Grid approach. However, the integration of the private part is complex to implement, due to the multitude of actors involved (multi-owner tourist accommodation).

The following diagram is a simplified process flow proposal of the functional design of a mountain microgrid, adaptable to any configuration.

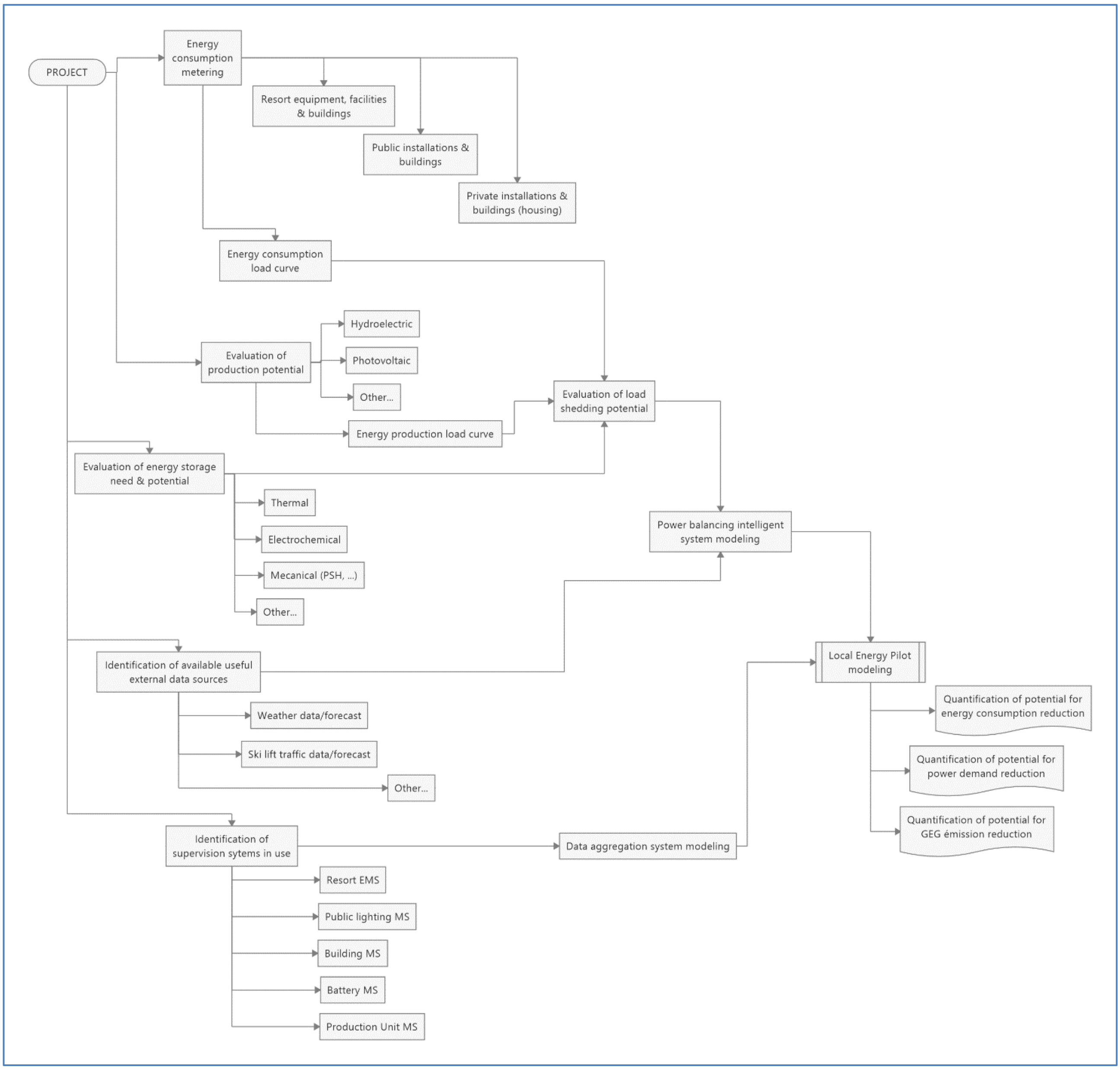

Figure 3—Simplified process flow of a mountain smart grid.

Real-time knowledge of the power available in the area concerned is an essential element in the operation of a smart grid. The total available power is the sum of the available power from several sources: 1) locally produced and self-consumed energy (e.g., a self-consumed photovoltaic system), and 2) the public electricity network, depending on the power subscribed by each consumer.

For each energy delivery point within the smart grid perimeter, it is important to have real-time access to the available power, i.e. the difference between the consumed power and the subscribed power at any given time. The power subscribed by the Les Orres ski lift operating company (SEMLORE) is approximately 5 MW, whereas the total cumulative power of all the resort's electrical equipment is 12.5 MW (see Figure 3). There can therefore be large differences in available power depending on the equipment in operation. SEMLORE's EMS allows the power consumed by its equipment to be displayed in real time.

In Les Orres, the EMS was limited to the equipment of the ski lift operating company (SEMLORE). In the implementation of a smart grid, many other consumers can be involved in the process. The integration of new actors allows for a more efficient operation of energy scenarios, with a much greater capacity for load shedding and power/demand balancing. These can include:

- Tourist accommodation (heating systems, hot water production, 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 systems, hot water production);
- Offices (heating, hot water production), etc.

Power production/demand balancing

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

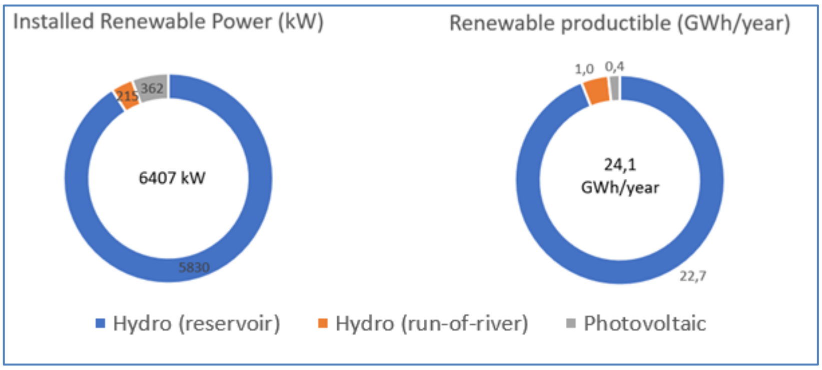

Figure 5—Les Orres potential for installed power and annual energy production

By extending the scope of the smart grid to the entire Les Orres ski resort, and in particular by including tourist accommodation, electricity consumption is much higher (26 GWh/year). At first sight, 92% of the ski resort's electricity needs could be covered by local renewable energy. However, the imbalance between the RE production capacity due to seasonal climatic conditions and the peak consumption induced by the variation in tourist numbers does not allow to fully cover the needs by local RE production, in the absence of high-capacity storage solutions to compensate for such imbalances. This does not prevent the optimisation of consumption from being modelled in a local grid vision by using the flexibility capacities offered by the multiplicity of players and uses (load management) and the mix between RE and energy supplied by the public grid, which has a high level of decarbonisation in France.

To model the integration of tourist accommodation and public energy consumption in the mountain smart grid, we used studies carried out on 3 types of tourist accommodation and the pilot deployment of an energy control solution on the UCPA building (social tourism accommodation centre), along with the public lighting control solution of Les Orres.[8]

With the integration of public lighting and the UCPA centre into the scope of the Mountain Smart Grid, the total load management capacity of the Smart Grid is distributed as follows:

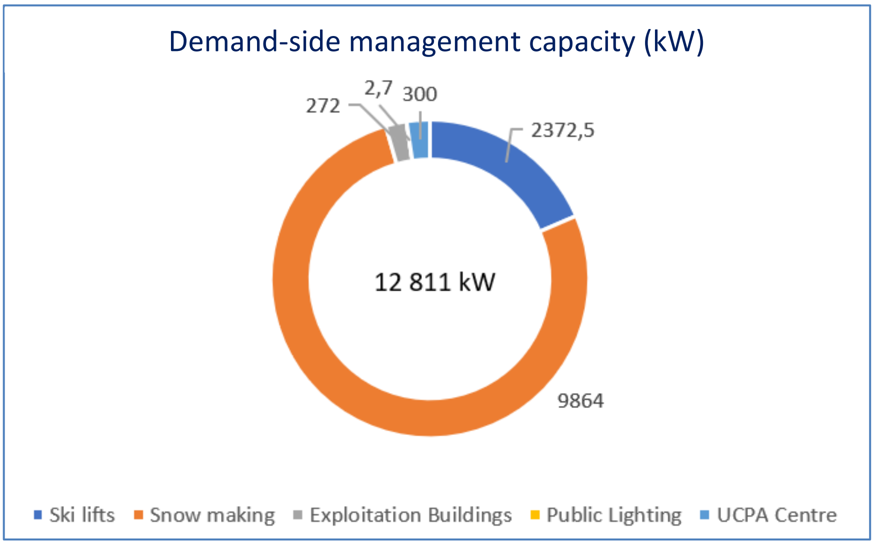

Figure 6— Demand-side load management potential in Les Orres

The total installed power at SEMLORE (ski lifts, snowmaking system, operating buildings) is around 12.5 MW whereas the subscribed power is only 5 MW. There is therefore a high reduction rate between the total installed power and the maximum power demand. This is due, on the one hand, to the time lag between the periods of use of the different types of equipment and, on the other hand, to the flexibility and optimization capacities of the power demand offered by the EMS.

In addition to this installed power are public lighting (2.7 kW) and the UCPA Centre (300 kW). Theoretically, if all the residential buildings (17,000 beds) in the resort were equipped with a solution similar to the one implemented in the UCPA centre, the total peak shaving capacity related to tourist accommodation would be around 21 MW (assuming electric heating and hot water production systems similar to those of the UCPA centre). The theoretical shedding capacity of tourist accommodation (21 MW) is therefore much higher than that of the ski lifts (2.3 MW) and snowmaking systems (9.8 MW). However, it is important to take into account that for comfort reasons, load management is usually carried out by switching off the heating systems sequentially in groups of systems over periods of 10 minutes.

[8] Please refer to D.T2.3.1. Report available on https://www.alpine-space.eu/projects/smart-altitude/en/project-results/smart-altitude-living-labs/les-orres

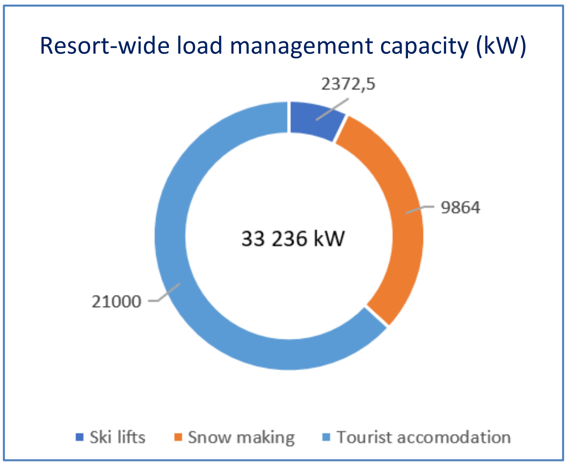

Figure 7—Theoretical total load management capacity

5. Review of possible obstacles to deployment

Technical issues

No mention has been made here of the development of the Local Energy Pilot of the smart grid. There is certainly a great deal of development to be done, particularly in terms of interconnection between the production and consumption systems of renewable energy sources in order to achieve the best possible supply/demand balance and peak load shedding, which is one of the major interests of the approach. For more information, please refer to figure 1 in which the NEM (Grid Energy Manager) is the equivalent of the Local Energy Pilot envisaged for Les Orres, and to the extensive literature on EMS, SCADA and interoperability issues (for example a technical review[9]).

The main problem encountered is the communication of the energy driver with local IT systems, i.e. interoperability problems. Locally deployed systems do not always use standard protocols (e.g. Modbus), which requires bridges between proprietary protocols and processing platforms. For example, in the case of tourist accommodation, the integration between the consumption control system and the reservation platforms.

However, it appears that the main challenges are economic and inter-relational rather than technological.

[9] Lee Cardwell and Annie Shebanow, The efficacy and challenges of SCADA and smart grid Integration, *Journal of Cyber Security and Information Systems, **1**:3, 2016.* Full article available on: https://www.csiac.org/journal-article/the-efficacy-and-challenges-of-scada-and-smart-grid-integration/.

Regulatory issues: Local energy community: an opportunity for grid deployment?

Article 22 of the revised EU Renewable Energy Directive (EU) 2018/2001[10] states the following about local renewable energy communities:

1. Member States shall ensure that final customers, in particular household customers, are entitled to participate in a renewable energy community while maintaining their rights or obligations as final customers, and without being subject to unjustified or discriminatory conditions or procedures that would prevent their participation in a renewable energy community, provided that for private undertakings, their participation does not constitute their primary commercial or professional activity.
2. Member States shall ensure that renewable energy communities are entitled to:
    a. produce, consume, store and sell renewable energy, including through renewables power purchase agreements;
    b. share, within the renewable energy community, renewable energy that is produced by the production units owned by that renewable energy community, subject to the other requirements laid down in this Article and to maintaining the rights and obligations of the renewable energy community members as customers;
    c. access all suitable energy markets both directly or through aggregation in a non-discriminatory manner.
3. Member States shall carry out an assessment of the existing barriers and potential of development of renewable energy communities in their territories.

The Electricity Directive leaves it to Member States to decide whether or not to allow citizens' energy communities to own or operate electricity networks. This freedom left to Member States has important potential consequences.

We can see that there is now a framework that obliges Member States to facilitate the establishment of local energy communities, building on existing network infrastructure, but allowing them to implement the energy exchanges required within a smart grid. Until now, particularly in France, the energy exchange arrangements in the context of collective self-consumption were much more restricted and not adapted to the effective implementation of a mountain microgrid.

However, there may still be regulatory obstacles to the deployment of a smart grid in a mountain resort such as Les Orres, where one of the players (Semlore) operates a private network. Below is presented a summary of the analysis of Article 22 by the French National Energy Regulatory Commission (CRE) and how the cohabitation between local energy communities and the national electricity system is envisaged.[11] We underline (bold) in the text below the point raised by CRE that could be discussed.

"It is difficult to envisage situations in which consumers and producers would do without public electricity distribution and transmission networks altogether. On the contrary, the deployment of renewable energies in a much more diffuse way than in the centralised model prevailing until now requires a more proactive and intelligent management of the networks. Even with the changes underway, the nature of the networks gives them a decisive advantage over a multitude of closed systems, making it possible to pool resources and increase production as well as consumption. Thus, it is important to remember that the deployment of collective self-consumption and more broadly the mobilisation of citizens and communities within energy communities should mean a more intelligent use of these networks rather than an alternative to them.

Energy communities have been thought of and should thus be seen as facilitators of the deployment of renewable energy production sources and as means of access to electricity markets, not as alternatives to public networks. **Thus, the law of 8 November 2019 on energy and climate has specified that renewable energy communities, but also citizen energy communities (with reference to the recast of the Renewable Energy Directive to date) cannot own or operate a grid."**

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN.

[11] https://www.smartgrids-cre.fr/encyclopedie/les-communautes-energetiques-locales/communautes-energetiques-et-systeme-electrique-national-quelle-cohabitation

In the case of Les Orres, the smart grid would result on the interconnection between the private grid of Semlore (itself connected to the public grid) and the public grid to which public and private consumers (municipality, tourism housing owners and co-owners, …) and/or renewable energy producers (municipality, other public or private producers) are connected. The question remains to be asked.

Economic issues: evaluating the value of load management

in order to guarantee a national balance between production and consumption, and to integrate increasingly intermittent renewable energies, load management capacities—meaning balancing electricity supply by reducing load demand rather than increasing electricity generation—must be increased. 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. From an environmental viewpoint, load management allows to avoid having to run additional energy production resources that are generally highly GHG emitters, such as coal or gas power plants.

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 demand adjustment to be carried out. The associated financial remuneration therefore depends on this reaction time and the capacities involved. Two different financial valuations are then possible:

In power on a half-hourly step: 9 €/MW
In energy: 50 €/MWh

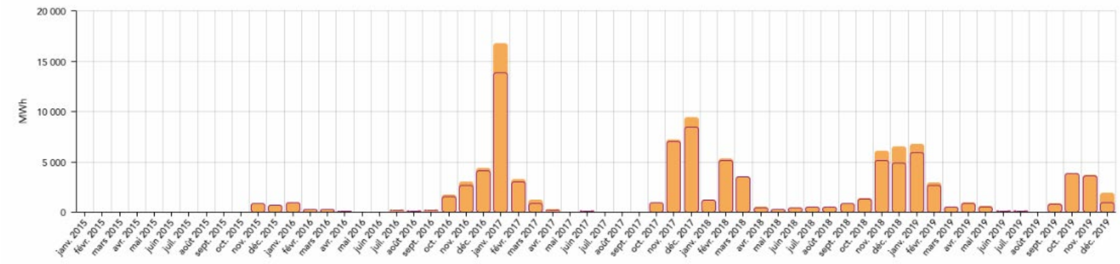

Figure 8—Monthly load demand reduction volumes declared on the load management market

Hourly, daily and seasonal variations are observed on the load management market. It can be noted that the need for load demand reduction mainly coincides with the winter period. In a ski resorts, the ski lifts, the snowmaking system and the tourist accommodation should therefore theoretically present a real value in terms of demand-side management and peak shaving capacity. However, as mentioned before, there is no additional capacity to play with the resort operations’ energy consumption (ski lifts, snow making and heating) than what is currently done with the EMS. Therefore, we could only consider the theoretical total of 21 MW offered by the tourist accommodation.

in order to make peak shaving and energy demand management capacities profitable, it is necessary to have a good knowledge: 1) of daily operations so as not to disrupt the priorities and imperatives of the categories of use as well as the comfort needs of the users, the smooth running of the resort's operations remaining an absolute priority; 2) of the tariff incentives offered by the energy suppliers; 3) of the financial remuneration offered by licensed load demand aggregators.

As for this last case, dynamic demand management generally involves energy demand reduction of about 77% (percent of heating and water heating in housing) for periods not exceeding 10 mn over one hour. It is very likely that the consumption reduction induced by tourism energy management systems (> 20%) added to the flexibility induced by the microgrid with regard to tariff incentives and max power subscribed would be much more interesting. A complete study should be performed for financial optimization, with some elements discussed in the D.T2.3.1[12].

Stakeholder engagement and governance issues

Implementing a microgrid at the resort level requires the involvement of several categories of stakeholders with very different interests and concerns. The main actors are as follows:

- **The municipality**. It manages a number of energy consuming facilities (public buildings, swimming pool, rescue centre...); it invests in the deployment of renewable energies (photovoltaic, hydroelectricity); its financial capacities are limited: it must optimise its investments and operating costs, and the current models of collective self-consumption are not favourable to the optimisation of the use of local public finances.
- **The resort operator.** It must minimise his costs and maximise his revenues. His primary concern is to make profitable productive investments and to optimise his operations. Setting up or joining a microgrid management organisation, such as a local energy community, involves more risks: mobilising part of its staff, non-productive investments, in a structure with shared governance, and with a high degree of uncertainty about the final profitability of the operation. Finally, it already has an energy management system that satisfies most of its needs, even though being part of the operation would allow it to optimise its energy consumption costs.
- **Collective tourist housing operators (hotels, etc.)**. They have the capacity to make management decisions. It is in their interest to minimise their energy costs. Having an energy management system is of great interest. Joining a microgrid type management structure may appear to be of marginal interest with high risks in relation to the local system in place or to be deployed.
- **Co-owners of condominiums**. It is difficult to mobilise them on operations of common interest. They see their own direct interest first and foremost and participating in an operation that does not guarantee them an immediate benefit is not very attractive to them. Thetwo benefits they can expect is 1) a guarantee of stability of the electricity price over a long period (as in a collective self-consumption operation), and 2) an increase in the asset value of their flat.The financial aspects of the operation, more specifically the cost benefit/risk balance, must be studied very carefully for the enrolment of stakeholders to be successful. It is very likely that co-owners will not be part of the operation.

[12] Op. cit. Please refer to note 8.

6. AG9 specific objectives vs. Smart Altitude achievements

The table below presents the relation that can be drawn between the 5 specific objectives of AG9 and the Smart Altitude project's actions and achievements. **Grey cells indicate AG9 specific objectives and related Smart Altitude actions not examined in the present report**.

AG9 Specific objective	Smart Altitude action
Setting up an Alpine energy efficiency cluster. *This cluster should serve as a forum for cooperation and innovation, bring technical solutions for the specific energy needs of the Alpine Region, and develop* ***energy efficiency processes and products*** *particularly adapted to the Alpine Region, especially in the housing and mobility sectors.*	**Setting up a Replication roadmap and a Network of low-carbon winter tourism regions.** *This action has resulted in the* ***creation of a network of 26 Alpine resorts involved in a common approach to reducing energy consumption and GHG emissions****, and links with other network initiatives (WikiAlps). The project has established* ***close links with the different categories of stakeholders****, i.e. local, regional and European (EUSALP) decision-makers, in order to draw up* ***a body of recommendations based on its studies and feedback on the scale of the Alpine*** *space.*
Greening the Alpine infrastructure: *focusing on* ***energy efficiency in the building sector*** *and promote harmonised, affordable and operational assessment tools to be used by public authorities in order to boost sustainable and low-carbon buildings in the Alpine Region.*	**Demonstrating the efficiency of a decision support tool integrating all challenges into a step-by-step approach to energy transition.** *Several initiatives have been deployed in Smart Altitude Living labs for* ***tourism housing energy efficiency****, especially in Krvavec (Hotel) and Les Orres (Youth Centre). In additions,* ***operational and public buildings have also been integrated in EMS solutions*** *(Kvavec, Madonna di Campiglio, Les Orres, Verbier). All these approaches are documented and made available.*
Setting up an Alpine renewable energy cluster while taking into account ecological, economical and land use issues and considering societal trade-offs	**Creation of a Network of low-carbon winter tourism regions supporting the attractiveness of sustainable winter tourism.** *It provides recommendations suited for regional, national, Alpine and European levels while developing guidance on the adoption of Sustainable Energy Action Plans (SEAPs) at local level. The integration of renewable energies in the sustainable development model is part of the smart grid approach developed in Les Orres, including hydroelectricity and photovoltaic energy. The Smart Altitude dashboard develops KPIs and platforms (WebGIS) including the renewable energy potential of winter tourism areas.*
Support energy management systems in the Alpine Region *by developing, sharing and installing energy efficiency and decentralised monitoring systems at the local level and by promoting regional energy monitoring.*	**Monitoring system for live performance assessment and decision-making.** *This activity specifies the monitoring system on energy usage and production for the Living Labs. The* ***integrated monitoring system*** *agglomerates energy data from multiple sources (snow processes, buildings, renewables, municipal infrastructure) and performance indicators. It is developed for implementation in the three Living Labs to prioritize low-carbon operations.*
Support a better use of local resources and increase energy self-sufficiency while reducing impacts on climate and the environment.	**Visualizing clean energy potential against economic and governance factors:** *setting up the Smart Altitude WebGIS: Web-based GIS application development on energy infrastructure, uses and renewable potential.*

	« Smart Mountain Grid" Living Lab (Les Orres): *Test of a* ***demand and production balancing system****, based on user involvement with an 'energy management service' (B2B and B2C) and a self-production/consumption approach optimizing local renewables.*

Table 1—Evidence of relations between AG9 specific objectives and Smart Altitude actions

7. Recommendations

To maximise the deployment and impact of the Smart Altitude approach with regard to implementing energy efficiency measures in the Alpine area, the project recommends AG-9 to (most relevant recommendations for **smart grid deployment** in bold):

- Apply the Smart Altitude approach to sustainable mobility at 3 levels (intrastation, station/valley, and station/conurbation), and cooperating in technical solutions, processes and products for energy efficiency with a special focus on the housing and mobility sectors.
- **Provide support for local energy management systems by expanding the deployment of energy consumption supervision systems to the municipality or valley area (integrated energy management system, smart grid, sensors, cloud infrastructures, sub-metering modules, PLCs, supervision platform, …)**
- **Support mountain resorts in their implementation of energy efficiency and self-sufficiency solutions by further developing the toolbox and support platform for replicators beyond the Smart Altitude project.**
- **Invest in the recruitment of experts within the EUSALP structures to ensure the management and coordination of the network of European actors in the field of energy transition in resorts in order to organise the sharing of good practices, data, training and the visibility of initiatives in this field.**
- **Facilitate cooperation between energy innovation clusters with their R&I organizations and alpine areas.**
- Facilitate cooperation between professional organizations for alpine sports and tourism and energy innovation clusters with their R&I organizations.
- Facilitate the citizens' involvement in energy policy: **building on the concept of energy communities introduced by the Clean energy for all Europeans package, it could be desirable to define a model adapted to the energy specific characteristics of the Alpine space (seasonal consumption, geographical constraints, presence of big operators and individual consumers, …).** Such framework would make it easier for citizens, together with other market players, to team up and jointly invest in energy projects. The network of these Alpine energy communities could be facilitated by EUSALP to ensure sharing of synergies and feedback about projects involving civil societies.
- **Promote a labelling logic specially designed for mountain resorts based on the data monitored by the observatory for the energy transition in the Alpine space:** It would enable resorts to promote their efforts in terms of a low-carbon strategy to enhance their attractiveness and to mobilise internal stakeholders around good practices and a proven transformation model. Thus, the work carried out in the framework of Smart Altitude could contribute directly to the effort undertaken in the framework of EUSALP to build a Charter

for Sustainable Resorts by informing on the best practices identified and on the conditions of their transferability. While the environmental dimension of sustainable tourism drives the various analyses and actions, it seems absolutely necessary to develop a concrete and operational contribution to mobilise as much as possible the alpine tourist destinations and resorts in the elaboration of their sustainable development strategies. Smart Altitude therefore has a key operational role to play on the theme of labelling and certification.

Conclusion

Through its concerted action, based on the systematic exploration of the state of the art of energy efficiency technologies and their deployment in 4 pilot sites representative of the diversity of the Alpine space, the Smart Altitude project has demonstrated the interest and feasibility of reducing the carbon footprint and energy consumption in mountain resorts. This work has resulted in the development of reliable common criteria and indicators to measure the efforts undertaken, the implementation of a detailed process to achieve the objectives, a collection of feedback from the 4 living labs and the organisation of a replication programme to which 26 Alpine resorts have already subscribed.

Reports have been written to develop recommendations for regional, national and European policy makers to facilitate the energy transition of mountain resorts in the Alpine region. Of these, five were specifically aimed at the EUSALP Action Groups, including three reports for AG 9, whose activity is dedicated to energy efficiency and renewable energies.

The present report, focusing on Smart Grid approaches, by exploring the characteristics of microgrids and discussing their deployment conditions, issues and current limitations in mountain resorts, lays the foundations for future advances in efficient energy management in mountain territories.