WP T4 Replication and Knowledge Transfer

Activity A.T 4.2 Smart Altitude Roadmap: Promoting operational excellence in winter tourism territories

D.T4.2.1 Replication Roadmap

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Executive summary

This report describes the Smart Altitude Replication Roadmap (D.T4.2.1), designed as an overview of project key results and output and the steps recommended by Smart Altitude partners for effective replication and implementation of low-carbon solutions in the Alpine Region (AR) ski resorts. The report starts from the climate change scenarios for the Alpine Region and with the highlights of the policy and legislative context in which tourism locations will have to implement long-term adaptation and mitigation goals. Subsequently, the report gives an overview of the main lessons learnt and the tools developed within the Smart Altitude project which are relevant to and usable by different stakeholders in the AR. The report concludes with the overall steps and suggestions for the replication of the Smart Altitude experience across winter tourism regions.

1. 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. Smart Altitude demonstrates the efficiency of a decision support tool integrating all challenges into a step-by-step approach to energy transition.

This document is the first deliverable of the activity A.T.4.2 "Smart Altitude Roadmap: promoting operational excellence in winter tourism territories", paving the way for D.4.T2 "Recommendations on clean energy in winter territories" and D.4.T3 "Recommendations on supporting S3, entrepreneurship and innovation". It aims at providing a roadmap to the involved stakeholders with the following content: a general framework, a set of recommendations based on lessons learnt, and guidelines for the implementation of the Smart Altitude experience in the territories of the Alpine Space. The replication roadmap builds on the main results of WP T1 (Smart Altitude Dashboard: WebGIS, monitoring systems, KPIs), WP T2 (Living Labs) and WP T3 (Smart Altitude Toolkit, Territorial Implementation Plans, Stakeholder Engagement Plans). It defines the key steps to be followed for the replication of the Smart Altitude process in the relevant sites.

The overall objective of the activity is to facilitate the adoption and implementation of long-term low-carbon objectives by resort operators and decision-makers in winter tourism areas.

2. Scope, context and vision of the Roadmap

The Smart Altitude Replication Roadmap aims at giving an overview of the future scenarios for the Alpine Region in terms of impact of climate change on mountain territories as well as on the winter tourism sector to different types of stakeholders. For this reason, the roadmap deals with the current policy framework at the EU level and provides a concrete vision of measures to be implemented by local, regional and national stakeholders in order to promote a transition towards a low-carbon Alpine Region.

2.1 Climate change scenarios for alpine regions

Numerous winter tourism destinations and their resort operators have not yet quantified the importance of global warming and the way it will affect their business model. However, awareness is gradually growing due to many actions by mountain organizations as well as some pressure exerted by the population (i.e. criticisms of growing snow making energy consumption, water consumption etc.).

Climate change already impacts winter tourism regions negatively and this trend is predicted to further increase. Indeed, in its Special Report on the Ocean and Cryosphere (2019)[1], the Intergovernmental Panel on Climate Change (IPCC) observes that "in nearly all high mountain areas, the depth, extent and duration of snow cover have declined over recent decades, especially at lower elevation". Consequently, the report also observes that "tourism and recreation, including ski and glacier tourism, hiking, and mountaineering, have also been negatively impacted in many mountain regions". The report further predicts that "current snowmaking technologies are projected to be less effective in reducing risks to ski tourism in a warmer climate in most parts of Europe".

Based on regional climate predictions in the Alpine Space, a study by Bruno Abegg (2012) analysed the predicted evolution of naturally reliable ski resorts with different climate scenarios.[2] With a global temperature rise of 2°C compared to today, the study predicts a drastic decrease of 30-90% of the number of ski resorts with naturally reliable snow cover (100 days with at least 30cm of natural snow cover in 70% of the years) for the outskirts of the Alps. Although the highest-located ski resorts in the central Alps are predicted to be less impacted, the decrease of snow reliability is significant for a global temperature rise of above 2°C. The decrease in natural snow reliability therefore implies a strong increase of needs for artificial snowmaking by the 2050s.[3] An increase of artificial snow production however also comes with higher energy, financial and ecological costs.

It is therefore critical for winter tourism areas, especially for those at lower elevations to reduce their vulnerability to climate change by developing and implementing adaptation strategies along with measures for climate change mitigation that reduce their emissions of greenhouse gases.

2.2 Policy and Legislative context

With the adoption of the Sustainable Development Goals[4] and the Paris Agreement [5] in 2015, the United Nations have intensified their effort to tackle the threats of climate change by limiting the global temperature rise well below 2°C. They agreed upon translating this goal into action by developing legal frameworks and incentives that foster climate change adaptation and mitigation. Policies were and are being implemented at all levels: European, national, regional, local and personal. Existing and planned policies should compel and support winter tourism areas to take measures regarding climate change adaptation and mitigation. The legislative context and incentives are therefore crucial parameters that need to be considered by winter tourism areas when developing adaptation/mitigation strategies.

The Smart Altitude partners have performed a grid analysis of existing policies in relation to climate mitigation and adaptation that are implemented by countries in the Alpine Space geographical area, at regional and national levels. The results were detailed in chapter 4 of the *Report of Territorial Stakeholder Engagement* [6], chapter 4. In this report, they also analysed existing gaps and barriers to implementation of

[1] IPCC, 2019: *Summary for Policymakers*. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner et al.], https://www.ipcc.ch/srocc/chapter/summary-for-policymakers/

[2] Abegg (2012). *Natürliche und technische Schneesicherheit in einer wärmeren Zukunft.* Forum für Wissen 2012, Alpine Schnee- und Wasserressourcen gestern, heute, morgen, p. 29-35.

[3] Abegg et al. (2019). *A critical review of climate change risk for ski tourism.* Current Issues in Tourism, 22:11, 1343-1379, https://doi.org/10.1080/13683500.2017.1410110

[4] UN sustainability goals: https://sdgs.un.org/goals

[5] Paris Agreement: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[6] The *Report of Territorial Stakeholder Engagement* can be downloaded here: https://www.alpine-space.eu/projects/smart-altitude/en/project-results/smart-altitude-toolkit/territorial-stakeholder-engagement

those policies, specifically in relation to winter tourism areas. More information about gaps and is also reported by other projects, such as in the *Transnational Synthesis Report* on Climate Adaptation in the Alpine Space (Go Apply project).[7] Specific recommendations for the improvement and enhancement of existing policies, based on project experience, will be developed by Smart Altitude partners and disseminated at all levels, based on project experience.

For the scope of this Roadmap, the key initiatives at the European and transnational level are:

- **The EU Strategy for the Alpine Region (EUSALP)** [8], a joint initiative of Alpine states and regions to strengthen cooperation and to address common challenges in a more effective way. One of its objectives is the establishment of a multi-level governance framework and transnational policies to enhance climate mitigation and adaptation among the Region's countries.
- **The EU Adaptation Strategy to climate change, adopted by the European Commission on 24 February 2021**[9]. This strategy focuses on delivering an effective and coordinated approach in order to render the EU Member States more resilient to climate change, at all levels of governance. This is expected to be achieved by supporting EU states, regions and cities in the adoption of adaptation strategies; by promoting adaptation actions in specific and more vulnerable fields such as agriculture and infrastructures; and by enhancing communication and information about climate adaptation in the decision-making context.
- Regarding **climate mitigation**, the European Union set an ambitious target to become the first climate-neutral continent by 2050. The 2020 objectives have been achieved (-20% GHG emissions compared to 1990), while the 2030 objectives are being defined (at least -55% GHG emissions compared to 1990)[10] [11]: To pursue the aim of substantially reducing greenhouse gas emissions, investing in a sustainable and circular economy system, preserving the European environment and biodiversity, the main measures implemented are the **European Green Deal** with the **proposal of European Climate Law and European Climate Pact initiatives** [12].

The *Report of Territorial Stakeholder Engagement* also gives an overview of the national climate adaptation and mitigation strategies in the countries of the Alpine region [13] [14], which should be converted into regional action plans for more specific and effective implementation.

At the municipal level, the **Covenant of Mayors (CoM) is an important as a voluntary instrument for cities and local municipalities to commit to tackle climate change through mitigation and adaptation policies**[15]. By signing the covenant, public administrations commit themselves to develop a Sustainable Energy and Climate Action Plan (SECAP), targeting 2030, where a baseline emissions inventory and a vulnerability and risks assessment related to the specific plan need to be included as a baseline to identify mitigation and adaptation actions in their territory. Smart Altitude is also developing recommendations for the effective implementation of the Covenant in winter tourism municipalities.

[7] The *Transnational Synthesis Report* on Climate Adaptation in the Alpine Space can be downloaded here: https://www.alpine-space.eu/projects/goapply/results/results_revised/goapply_d.t1.2.1_d.t1.3.1_wp1_transntional-synthesis-report_foen-wsl_final.pdf
[8] EUSALP initiative: http://alpine-region.eu/
[9] EU Adaptation strategy: https://ec.europa.eu/clima/policies/adaptation/what_en
[10] https://ec.europa.eu/clima/policies/strategies_en
[11] https://ec.europa.eu/clima/policies/eu-climate-action_en
[12] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[13] National Energy and Climate Plans (NECPs): https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en
[14] National long-term strategies: https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en#strategies
[15] Convenant of Mayors (CoM) and Sustainable Energy and Climate Action Plans (SECAPs): https://www.covenantofmayors.eu/plans-and-actions/action-plans.html

As the existing policies, initiatives and plans often differ from one region to another and the examples listed in the above-mentioned report may not cover all specific targets and/or incentives existing at a regional and/or local level, winter tourism areas willing to uptake a low-carbon transition and replication of Smart Altitude approach, should always start with a review of the specific context and conditions in which they operate.

2.3 Smart Altitude vision for a carbon-free Alpine region

To paint a vision for a completely carbon-free Alpine region, let us start with a look at the European Strategy for the Alpine Region (EUSALP), as defined in the specific objectives of Working Group 9[16] (Energy Efficiency and Renewable Energies), which we summarise here:

- **Setting up two clusters**: **one for energy efficiency and one for renewable energies**. The aim is to establish cooperation in the innovative development of technical solutions, processes and products for energy efficiency and renewable energies adapted to the Alpine Region, with a special focus on the housing and mobility sectors.
- **Greening the Alpine infrastructure** - with a special focus on assessment tools for public authorities and the building sector.
- **Supporting the development, installation and sharing of local energy monitoring and control systems** for energy efficiency of installations.
- **Better use of local sources to move towards self-sufficiency.**

In its mission statement, EUSALP mentions that the action aims at supporting a significant reduction of energy consumption in the housing and mobility sector, as well as in small and medium enterprises. The Alpine Space presents a wide economic and social diversity of its constituent regions. However, its mountainous areas are characterised by a relatively low level of industrialisation and a particularly important weight of winter tourism, fed by the large regional, national, and international conurbations, in the balance of its local economy.

Smart Altitude meets the above vision by focusing specifically on winter tourism destinations, developing specific solutions for ski resorts and their direct environment, as a strong contribution to EUSALP aims and vision. It is important to consider this specific aspect of mountain resorts because it is the place where two major industrial sectors converge: the sports & leisure industry and the construction and equipment industry. We note that the specific needs and constraints of mountain resort operators are often little taken into account or misunderstood by political decision-makers. Smart Altitude aims to fill this gap by proposing an operational approach to the deployment of low-carbon and energy optimisation policies in ski resorts because of their economic relevance on a territorial scale and the possible driving effect they can have on their direct environment.

The vision driving this replication roadmap is thus to make the Smart Altitude approach, tools and models widely available to all ski areas of the Alpine Space, starting their replication outside the partnership during the last months of the project and further supporting it after its end. The project tools and approaches are able to support ski resorts to assess their current status in relation to energy consumption and production,

[16] http://alpine-region.eu/action-group-9

identify their gaps and opportunities, implementing the right low-carbon solutions, and engaging key stakeholders and policy makers towards a zero-carbon future.

3. Smart Altitude experience and lessons learnt

3.1 The Smart Altitude approach to low-carbon winter tourism regions

The mission of Smart Altitude is "to demonstrate the efficiency of a decision support tool that integrates 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 (snow processes, municipal infrastructure, renewables, buildings etc.) 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 four real-field demonstrations, i.e. Living Labs and prepares for replication in 20 other Alpine Space territories".

To achieve these objectives, Smart Altitude developed a toolkit offering an integrated approach to the energy transition of mountain resorts and territories, tested it across 4 project Living Labs, engaged other 20 ski resorts to replicate this approach outside the partnership and finally delivers a set of recommendations for policy improvement at different levels.

3.2 Supporting the transition: The Smart Altitude Toolkit

The Toolkit[17] developed by Smart Altitude is designed to provide a single low-carbon decision support system to two categories of ski resort stakeholders:

- **Ski resort operators**: supporting the definition of the low-carbon decision-making criteria and related tools, with the suggested steps for decarbonising a ski resort, including results monitoring and results communication.
- **Ski resort policy makers**: policy recommendations and roadmaps on how to promote a low-carbon ski resort and how to make good practices visible.

The Smart Altitude Toolkit comprises six tools, one for each step of the decision-making process for implementing low-carbon measures, thus providing a well described process for implementation. These tools are summarised in the figure and table below.

[17] https://smartaltitude.eu/tools/

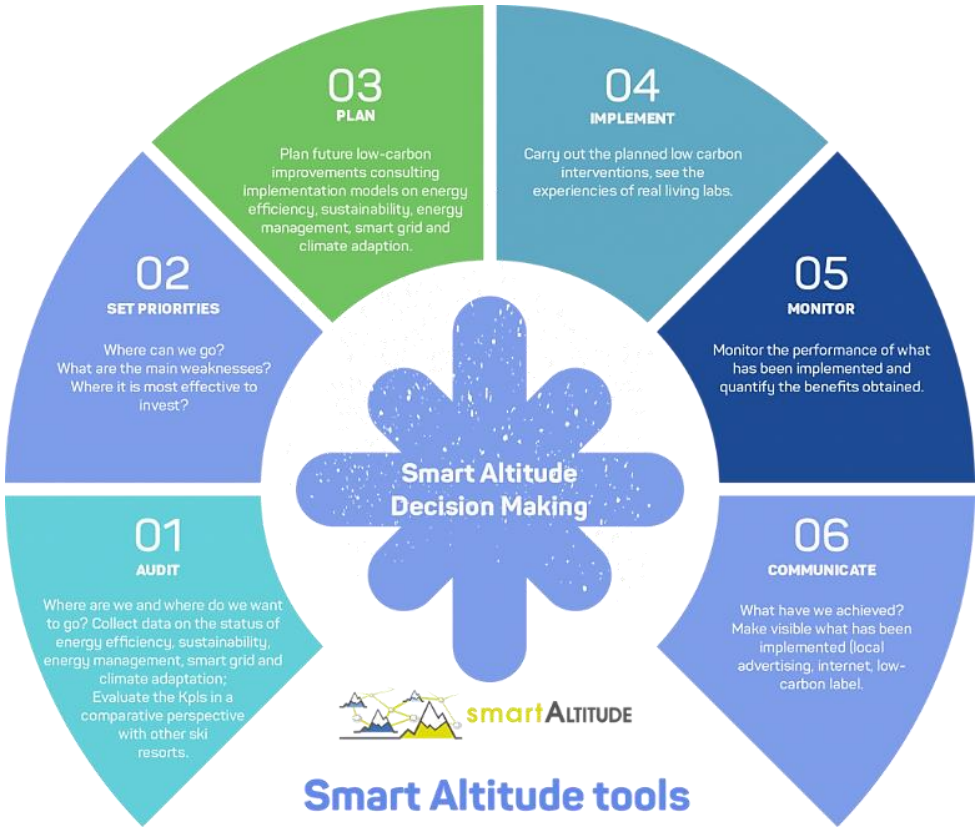

Figure 1: The Smart Altitude Toolkit and its steps

Table 1: Tools developed by the project and available for replication in other winter tourism regions

Implementation step	Tool	Goal
1. AUDIT	Wi-EMT	The Wi-EMT is an audit tool for the ski resort operators to evaluate the ecological, energetic and management status, identifying the priorities of intervention in a comparative perspective with other ski resorts. It relies on a self-audit questionnaire and is part of the replication process.
2. SET PRIORITIES	WebGIS	Web-based geographical information system on energy infrastructure, uses and energy potential. The WebGIS integrates data from the Smart Altitude Living Labs and replicators. It includes a set of KPIs to be implemented in the monitoring system and used by the WebGIS to optimize low-carbon policies in mountain resorts & territories.
3. PLAN	Implementation models	The Implementation Models are guidelines and best practices to design and implement measures on energy efficiency, sustainability (renewable energy and sustainable mobility), energy management, smart grid, climate adaptation, value creation through low- carbon innovation. 5 implementation models have been reported and made available: 1) Climate adaptation and mitigation; 2) Renewable energy and sustainable mobility; 3) Energy management systems; 4) Smart grid; 5) Value creation through low-carbon innovation.
4. IMPLEMENT	Living Lab examples	The four Smart Altitude Living Labs tested specific actions on the ground, at different levels of maturity and experience in energy management and smart solutions. Their experience and lessons learnt can be used by other ski resorts to follow the same or similar paths. More specifically: Krvavec on energy consumption reduction; Madonna di Campiglio on deploying an integrated energy

		management system (IEMS); Verbier on deploying an energy management system throughout the whole ski domain; Les Orres on the transition from a IEMS to smart grid.
5. MONITOR	Monitoring systems for live performance assessment and decision-making	Describing the specifications of monitoring systems allowing to supervise energy data from multiple sources (ski operations, snow making, tourism housing, public buildings & infrastructure…)
6. COMMUNICATE	Smart Altitude Websites, Social Media and WIKIAlps.	Websites and social media of the project, plus a wiki-style platform WIKIAlps, with more information on the WebGIS and the project, including extensive user guidance and help pages

In the Smart Altitude Toolkit, the tools for ski resort operators have been completed, while the recommendations for policy makers will be included in the coming months. The Smart Altitude Online Toolkit has been widely promoted through the News section on the Smart Altitude website[18], the Smart Altitude Newsletter of the first half of 2020, the project brochure, the project flyer for replicators and the Smart Altitude Webinar Series organized in June-July 2020.

3.2.1 Wi-EMT

Wi-EMT is an audit tool for the ski resort operators to evaluate the ecological, energetic and management status, in order to identify the priorities for intervention in a comparative perspective with other ski resorts. The input data are collected from a self-evaluation questionnaire completed by the ski resort operator.

The outputs are the following:

- **SKI RESORT ID**: main features that characterize the size, infrastructures and operation of the ski resort.
- **SKI RESORT KPIs**: measurable values that demonstrates how effectively the ski resort is achieving key business objectives.
- **EVALUATION REPORT**: a report that include the ski resort ID and the ski resort KPIs. It provides an overview of the level of energy efficiency, sustainability and management in the ski resort and compares its performance with an Alpine Space benchmark. Beside supervision and comparison of the performance, the report provides a value database for further measurements of energy improvement, able to strengthen competitiveness at international scale. The Evaluation Report is divided into 9 main sections (Energy Efficiency, Energy Economy, Sustainability, Energy Management, Smart Grid, Adaptation to Climate Change, Self-Evaluation, Future Outlook, Overall Result). In each main section the ski resort achieves a specific result.

The structure of the Wi-EMT approach is summarized below. A full description is available in the corresponding report and in the project website[19] and the questionnaire is downloadable from Smart Altitude Toolkit.

[18] (https://www.alpine-space.eu/projects/smartaltitude/en/news-events/news/news-overview)
[19] https://www.alpine-space.eu/projects/smart-altitude/results/smart-altitude_wi-emt_evaluation-report_final_xxx.pdf

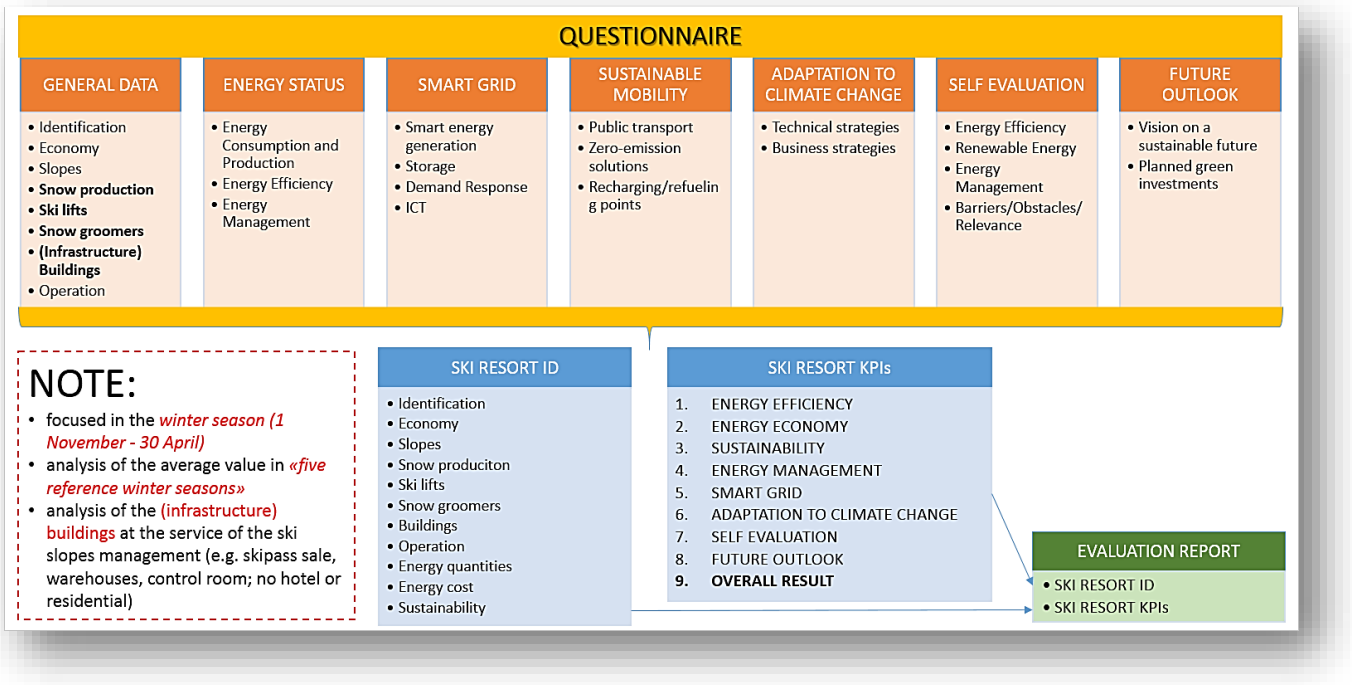

Figure 2: The Wi-EMT approach

3.2.2 WebGIS

In the Smart Altitude project, a web-based GIS application, the Smart Altitude WebGIS, has been developed to visualize existing data on renewable energy potential and infrastructure for sustainable mobility, as well as key performance indicators (KPIs) on eco-energy-management efficiency in ski resorts. It provides users the possibility to create their own maps, calculate their own indicators and compare their area with others across the Alpine Space. It is one of the tools in the Smart Altitude Toolkit that support the prioritization of low-carbon operations, targeting ski resort operators, policymakers, and other stakeholders.

The WebGIS has a spatial focus on the Alpine Space and the Smart Altitude Living Labs. Currently it presents the project specific KPIs for the Living abs. For the Alpine Space, data is included on ski resorts, and on the renewable energy potential and infrastructure for sustainable mobility using various renewable energy resource and mobility infrastructure datasets. Additionally, users can visualize datasets on land cover, protected areas, geo-political boundaries and elevation models in the WebGIS (see Figure). On the associated wiki-style platform WIKIAlps, more background information on the WebGIS and the project can be found, including extensive user guidance and help pages.

The Smart Altitude Toolkit, including the WebGIS and WIKIAlps enable the information exchange and knowledge transfer among the project partnership and the stakeholders, thereby supporting the replication of the Smart Altitude approach in winter tourism regions across the Alpine Region.

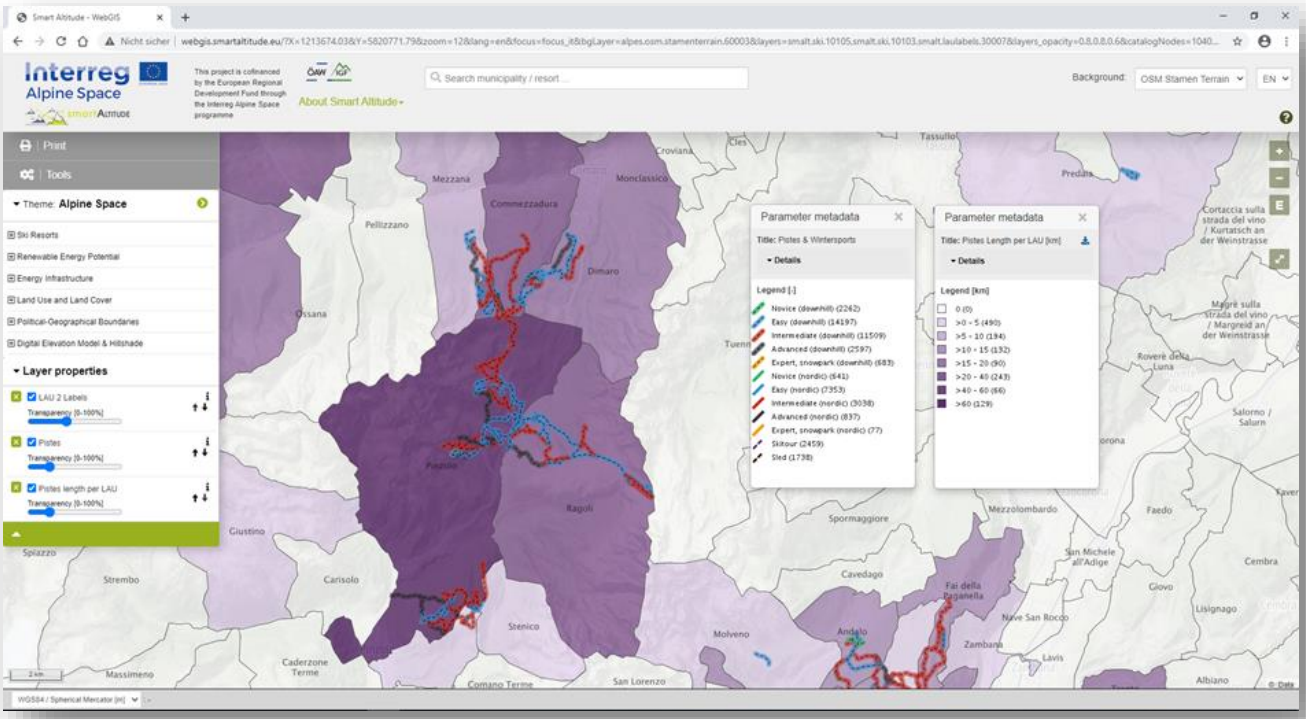

Figure 3: Screenshot Smart Altitude WebGIS

3.2.3 Implementation Models

The Implementation Models are guidelines and best practices which can be used to design and implement measures on energy efficiency, sustainability (renewable energy and sustainable mobility), energy management, smart grid, climate adaptation, value creation through low- carbon innovation. The Implementation models and their contents are briefly summarised below.

1) Climate adaptation and mitigation. With its strong reliance on specific climatic and natural conditions, the ski industry is regarded as the tourism market most directly and more rapidly affected by climate change. Mitigation and adaptation measures should be both integrated not only within ski resort's business plans but should also be taken into account by local, regional and national policies focusing on winter tourism. This approach could be achieved by involving of different stakeholders in the decision-making process of ski resorts, including policy makers and tourism associations, as suggested by the Smart Altitude's Decision-Making Tree.
2) Renewable energy and sustainable mobility. This implementation model is made of two sections. The first focuses on the possible renewable energy systems (RES) for ski resorts, the working conditions and configurations of solar (thermal and PV), wind, hydroelectric, geothermal and biomass, with some examples of "green" ski resorts using RES to meet their energy demand. Alternative methods to artificial snow production are also discussed, including the physical-biological characteristics of the hydrological

basins (artificial and natural), necessary for water supply of the snowmaking systems and alternative systems using RES to produce snow. The fundamental role of energy storage systems (ESS) in the integration between energy demand and renewable energy production closed the first part. In the second section, the optimising transport facilities, another crucial issue in the context of sustainability, are discussed, including: the different features of electric vehicles, from the operating mechanism to the charging and refuelling mode; the main differences between battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell electric vehicles (FCEVs); the use of these special vehicles in ski resorts, with some examples, such as the Austrian hydrogen powered snowmobile (Hysnowmobile) and snow groomer prototypes that are being developed.

3) Integrated energy monitoring system. In this implementation model, an integrated energy monitoring system (IEMS) suitable for a generic ski resort is described. A ski resort is characterized by considerable energy consumption and a multitude of electrical and thermal energy flows. Through an adequate IEMS it is possible to avoid energy waste by ensuring maximum operating efficiency. As result, costs are reduced due to lower energy and fuel consumption and emissions in terms of CO_2 are reduced. An IEMS is necessary to upgrade a more efficient and more sustainable ski resort. At first, the main components of a ski resort are identified. These mainly involve ski lifts, artificial snow production systems, snow groomers activities and indoor space heating of a generic ski resort. Their operating conditions and know-how are described, including a brief physical thermodynamic treatment of the different phenomena. Subsequently, the sensors and communication systems required for an adequate IEMS are described. Moreover, an application/technology matrix and monitoring systems is presented. This includes the units of the different types and technologies with the respective suitable sensors. By filling in this matrix it would be possible to define a status of the IEMS installed in the different Living Labs considered for the "Smart Altitude" project. Finally, the example of the IEMS implemented in the Living Lab in Madonna di Campiglio is provided.
4) Smart grid. This document presents a territorial implementation plan specific to Smart Grid technologies. It aims at presenting Smart Grid models for maximizing GHG reduction, economic impact and stakeholder benefits. The general characteristics of smart grids, presented in the first part, allow stakeholders to measure the economic and environmental impact of such technologies. A second part, more specific to the technique of a smart grid, with Nice Grid & Les Orres examples, allows to evaluate the measures to be taken for the implementation of a smart grid.
5) Value creation through low-carbon innovation. As any business, ski resorts need to innovate continuously in order to survive. This need is now becoming particularly pressing due to the challenges posed by physical impacts of climate change on the one hand and regulatory and legal obligations related to climate change mitigation on the other. Successful innovation management will ensure that ski resorts do not just survive but create value for their businesses and for their customers. This short guide to creating value from low-carbon innovation introduces the most important aspects and tools to consider when a ski resorts wants to innovate. Tools such as PESTEL and SWOT are presented in order to facilitate a sound understanding of the status quo of a ski resort and identification of its innovation needs.
In order to plan an innovation carefully, it is necessary to understand all implications on the supply-side and customer side. Value chain analysis can contribute to this, which will then help to crystallise the value proposition. The five forces of Porter1 help to fine-tune the innovation and its market entry. Green or sustainable procurement can also play a powerful role in fostering innovation. The most important aspects are summarised here. Through the examples of Smart Altitude pilots, this model illustrates which innovations are possible and appropriate in ski resorts, while also providing an understanding of the

barriers encountered and the various contextual factors that enable successful implementation of innovations.

3.3 Providing leadership: the experience of Smart Altitude Living Labs

3.3.1 Krvavec – implementation of energy efficiency measures

RTC Krvavec's first project goal was to reduce the use of energy in the resort's systems. Several setups have been deployed to achieve this goal.

1) Hotel energy consumption. A series of energy efficiency solutions were installed. In the hotel, thermostatic valves, controlled via a computer or mobile application, were installed on radiators. Through the program, each room is heated according to a pre-set temperature. If the room is not booked, the system itself switches off the room heating via the hotel program. In case of a reservation, the room starts to be heated an hour before the arrival of the guest. The SELTRON WDC20 system, which controls the temperature of the water that flows into the heating system depending on the outside temperature, has been installed in the boiler room. If the environmental temperature is low, the regulation system will deliver a higher temperature to the heating water. In the boiler room, the circulating pumps were also replaced for economy reasons. The Clausius application has been installed along with the GWD communication module. Receptionist, hotel management and maintenance staff can manage hotel heating entirely via the Clausius mobile application and/or as a web application. These changes have resulted in an approximate 20% reduction in oil/gas consumption, improved customer comfort and easier management of the heating system, leading to higher customer satisfaction and reduced staff working hours.
2) Snowmaking process (Figure 5). Krvavec ski resort has a complex system for snowmaking process. Geographic position, climate with rapid changes in temperatures, wind directions and weather conditions lead the necessity of snowmaking optimization. The ATASSplus software developed by TechnoAlpin is a product that best meets our expectations. The system itself manages snowmaking procedures using input data (outside temperature, humidity, wind, snow depth, snow gun condition, water flow, etc.) and is user friendly. Results: 30% less water needed to cover the slopes with technical snow; 40% less working hours, safe management (from the office); optimal snow depth on the slopes; less snow groomer hours; 30% electrical power reduction.

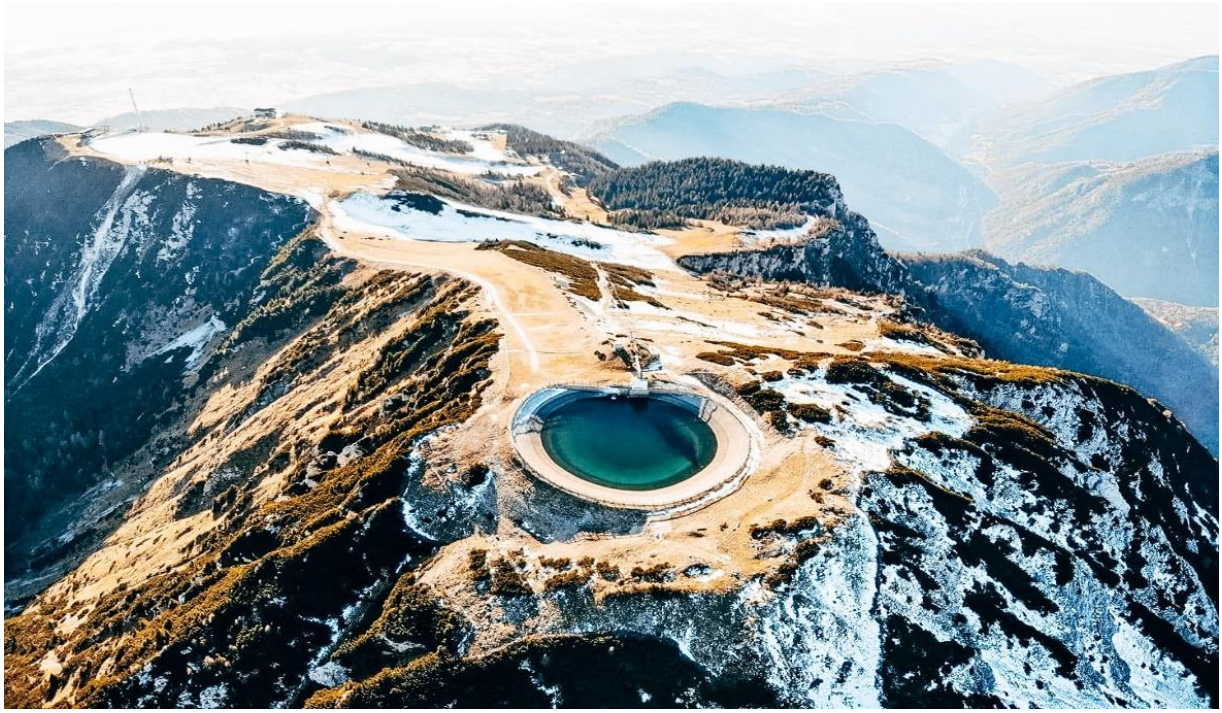

Figure 4: ©RTC Krvavec d.o.o.- ZVOH

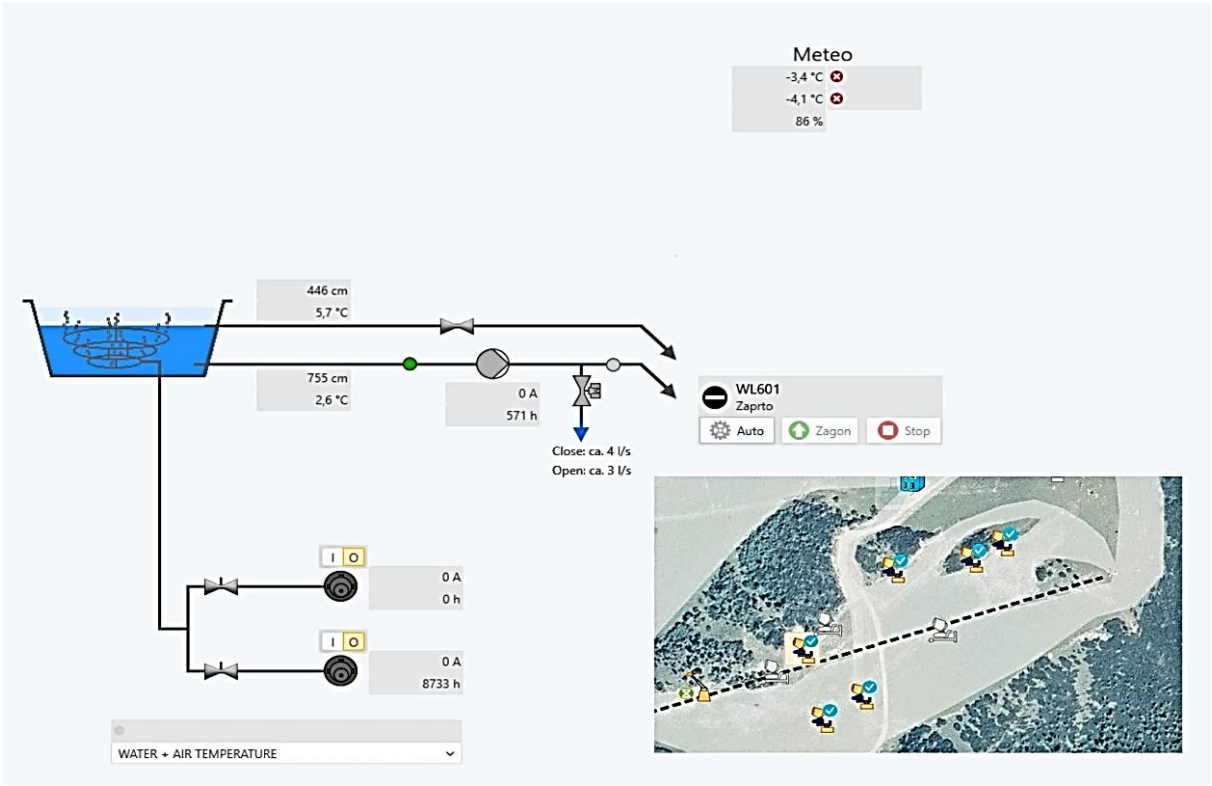

Figure 5: © RTC Krvavec - Snowmaking monitoring system

3.3.2 Madonna di Campiglio – implementation of integrated energy management system

The Madonna di Campiglio is the Italian Living Lab of the European project Smart Altitude. We are testing an Integrated Energy Management System (IEMS) to improve energy efficiency, optimize the use of water, integrate renewable energy sources and reduce CO_2 emissions in the ski area. Our mission is to achieve zero CO_2 emissions by 2026, the year of the XXV Winter Olympic Games hosted in Italy.
With the IEMS, we are monitoring plants' operations and consumption of energy and water to support sustainable decisions. The IEMS integrates data from both existing and new Smart Altitude monitoring systems, the latter including: monitoring of Lake Montagnoli (the main basin for snowmaking), monitoring of four ski lifts (Telecabina 5 Laghi, Seggiovia Grostè, Seggiovia Nube d'Oro, Telecabina Fortini-Pradalago), monitoring of two snow groomers warehouses (Grostè, Patascoss) and photovoltaic potential at the top station of a new ski lift (Fortini-Pradalago).

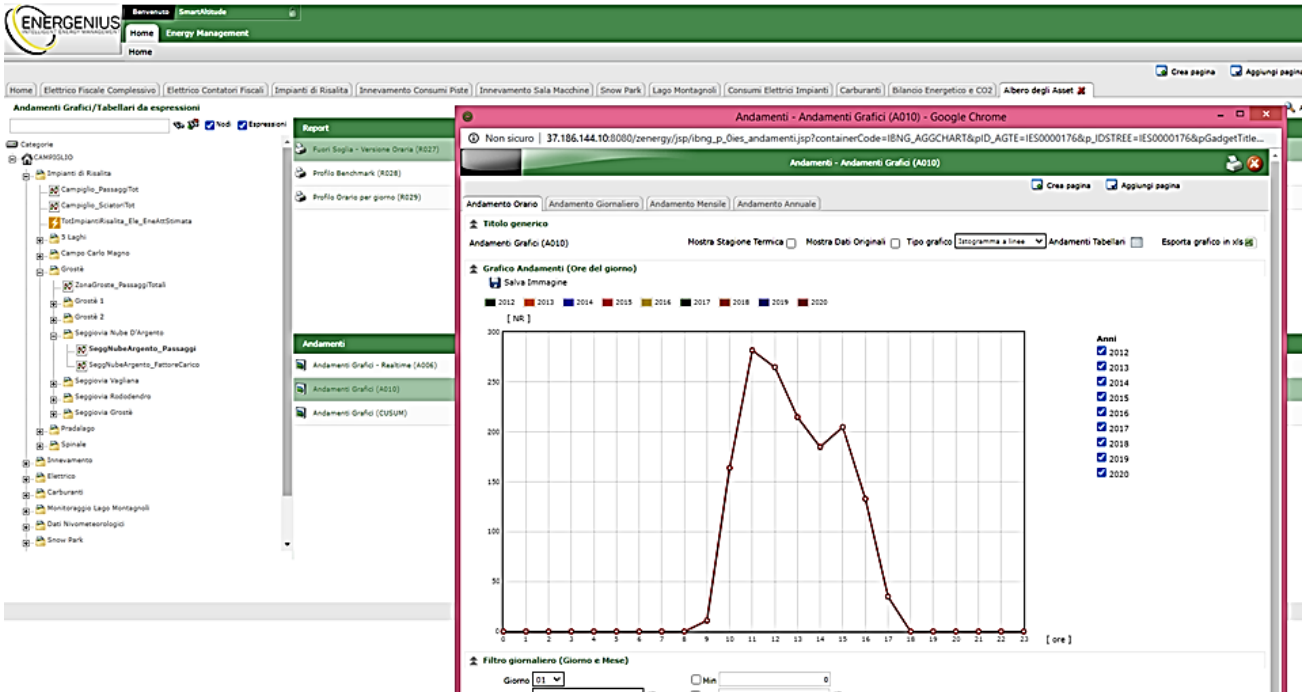

Figure 6: ©Funivie Madonna di Campiglio – The integrated energy management system

The Integrated Energy Management System (IEMS) is a digital platform for monitoring the mountain environment and the overall ski infrastructure. It collects data from multiple monitoring systems, organizes them in folders, allows them to be viewed in graphs, processes specific KPIs and produces monthly and seasonal reports. The main objective is to facilitate data management, through a single platform, and to support ski managers in taking sustainable decisions. Active since November 2019, it monitors and integrates data coming from ten different sources:

1. Weather forecasting: snowfall and air temperature in some locations of the ski area;
2. PV potential: at the top station of a ski lift;
3. Snow thickness: on all the slopes of the ski area;
4. Skier data: data on the skier days;
5. Ski lifts: data on electricity consumption and number of entrances;
6. Snow production: data on the quantity of water, compressed air and electricity consumption;
7. Snow grooming: operational data (km, hours) and diesel consumption;

8. Operational buildings: electricity consumption for heating two snow groomers warehouses;
9. Electric grid: data on electricity consumption from the medium voltage grid;
10. Lake Montagnoli: data on water temperatures at different depths, water surface level and weather conditions.

Lake Montagnoli is an artificial reservoir supporting the snow production of the Madonna di Campiglio ski area. Placed at an altitude of 1775 m.a.s.l., it has a maximum depth of 11.7 m and a capacity of approximately 200 000 m^3. The capacity of the lake allows the whole ski area to be covered with snow in 80-100 hours.
In general, the use foresees:

- a replenishment from August to September after emptying for maintenance;
- a first use of the water when the external temperatures are suitable for the production of artificial snow (November);
- subsequent filling and emptying during the winter season.

Depending on the seasonal trend, it may happen that the summer water stored in the basin is overheated and not compatible with the production of artificial snow.

In the new Smart Altitude monitoring system of Lake Montagnoli, we are analysing the thermal behaviour of the lake to improve the use of water in the snow making process. It is a set of hi-tech sensors that gathers data on water temperature at different depths, water surface and meteorological conditions, providing data to study the possibility to optimize the artificial snow production process through energy and water savings and heat recovery.
The monitoring was possible thanks to the installation of two floating buoys, in the north and in the south, capable of detecting water levels and water temperatures from the bottom to the surface.
In the 2019/2020 winter season, monitoring began on 26/9/2019 and ended on 26/11/2019 (the lake was starting to freeze, putting the monitoring equipment at risk). The monitoring was also repeated in the 2020/2021 winter season, between 1/9/2020 and 30/11/2020. The data collected, included in the IEMS, are in the analysis phase studying the impact of these parameters: atmospheric temperature, solar radiation, use of water, water intake, and boulage. The aim is to identify guidelines both for the management of snow-making artificial basins and for their design.

Figure 7: ©Funivie Madonna di Campiglio - Lago Montagnoli

3.3.3 Les Orres – moving from IEMS to Smart Grid

Les Orres implemented a comprehensive diagnosis of energy consumption in ski operations and an integrated energy management system (IEMS) in 2012-2014, as part of the ALPSTAR Alpine Space Project. In 2014, measurements showed that the system had resulted in a 20% reduction in energy consumption, a 100 teqCO_2 reduction in GHG emissions, and a 25% reduction in energy costs. Since then, Les Orres has continued to develop and improve its IEMS. With the SMART ALTITUDE project, Les Orres has worked on several axes towards a mountain smart grid: 1) integrating the production of renewable energy into the system; 2) monitoring and controlling the energy consumption in tourist accommodation; 3) setting up supervision systems for public buildings and infrastructures (public lighting, emergency and health centres, etc.). Ultimately, the aim will be to move towards a self-sufficient mountain area with monitoring and control of energy consumption and production.

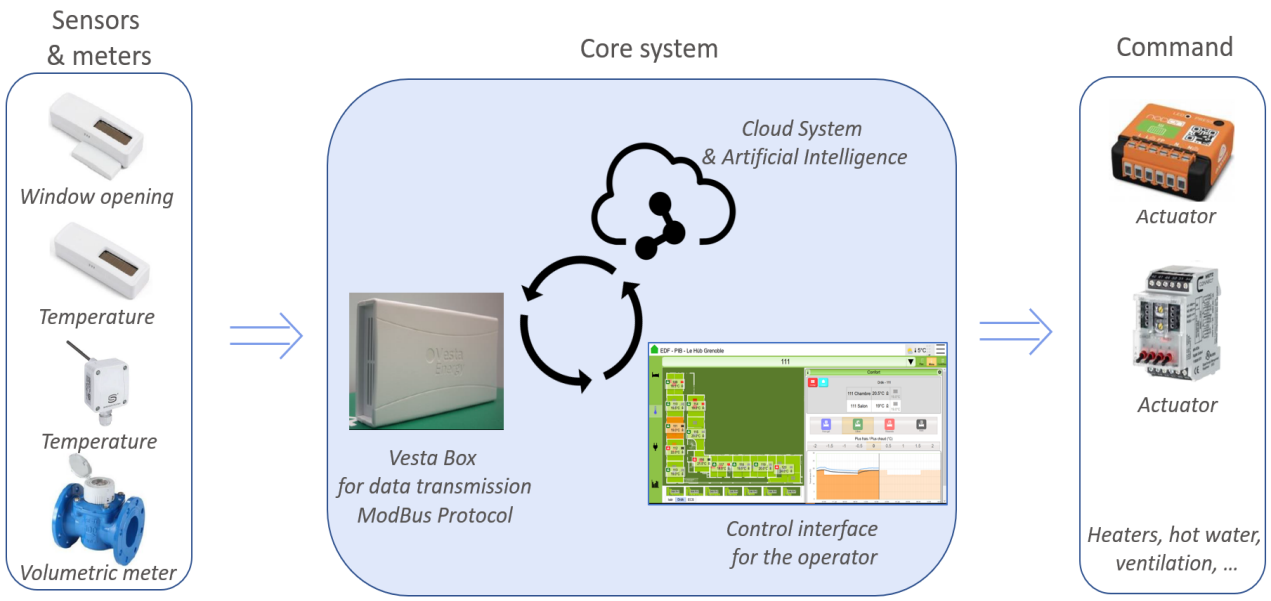

Figure 8: Intelligent Building Control Architecture

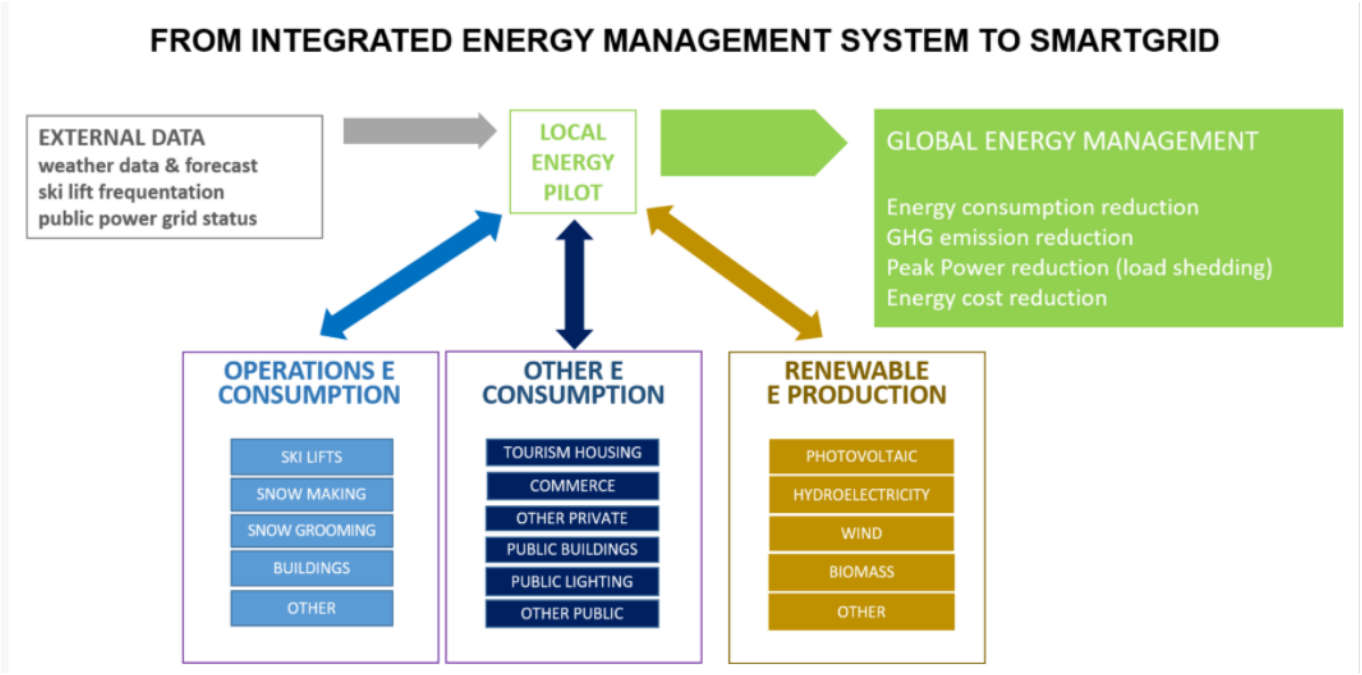

Figure 9: From IEMS to Smart Grid in Les Orres

3.3.4 Verbier – Toward ISO 50'001 Energy Management and "Cité de l'énergie" gold label

Téléverbier, the operator of Verbier ski resort, with the support of the CREM, has set an ambitious roadmap to bring efficient energy management at the territory level. Televerbier has defined important steps towards a low-carbon economy, to increase energy efficiency and renewable energy. Since 2016 Televerbier started to introduce an energy monitoring platform called "OBSERV". This tool, constantly updated and improved, identifies issues, supports decisions on energy efficiency measures and helps to promote the use of renewable energy. Lift speed regulations, snow groomers motor optimization, introduction of renewable solutions and sustainable public transportations are some examples of the energy actions levers taken by Téléverbier so far. With the Smart Altitude project Verbier aimed to identify and implement relevant action levers in term of energy efficiency and GHG emission reduction. Over time, Téléverbier energy strategy will be aligned with that of the Commune of Val de Bagnes with a view to obtaining the Energy City gold label. Furthermore, Téléverbier will move toward the ISO 50001 certification offering a framework to become a performing and sustainable ski resort, through an iterative process:

- Commitment to action – energy policy commitment: definition of objectives related to energy efficiency, reduction of greenhouse gas emissions;
- Planning – action plan and objectives: definition of the measures to achieve the set of objectives;
- Implementation: Realisation of the measures defined;
- Verification – monitoring analysis and performance evaluation: monitoring the impacts related to the implemented measures, and if necessary, partially redefine the strategy.

Energy and climate state of Téléverbier has been realised to identify precisely relevant actions levers and now actions plan is being implemented. The action plan in 4 different fields is being defined:

- Ski lifts: speed variator, speed function of passage, low consumption energy motor;
- Snow making: low energy consumption snow cannon, pumping station;
- Snow grooming: radar, motor optimisation, replacement by hybrid technology;
- Building: replacement of fossil fuel heating by renewable energy, insulation and window replacement, room temperature regulation, heat release from ski lift engines valorisation.

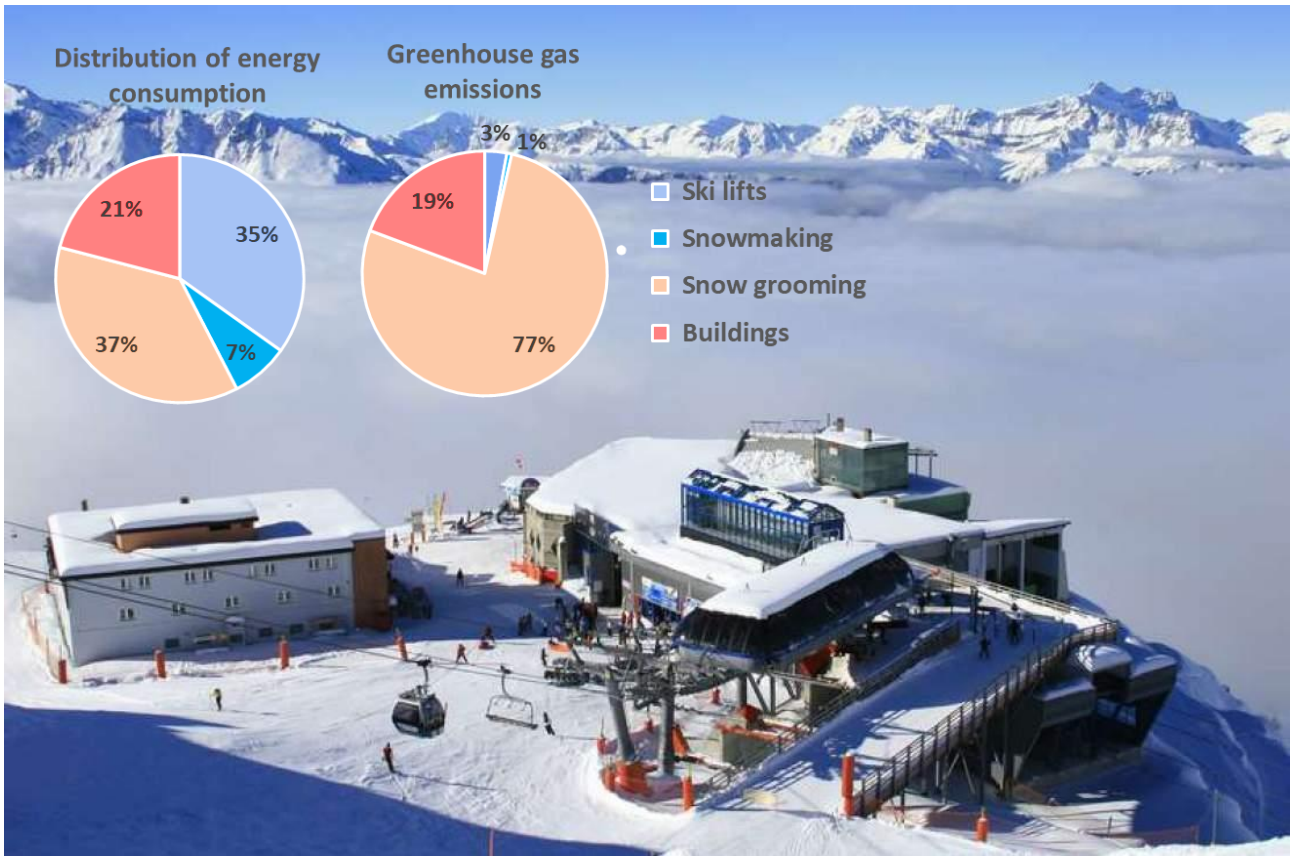

Figure 10: Energy consumption and Greenhouse gas emissions distribution – image ©4Vallees

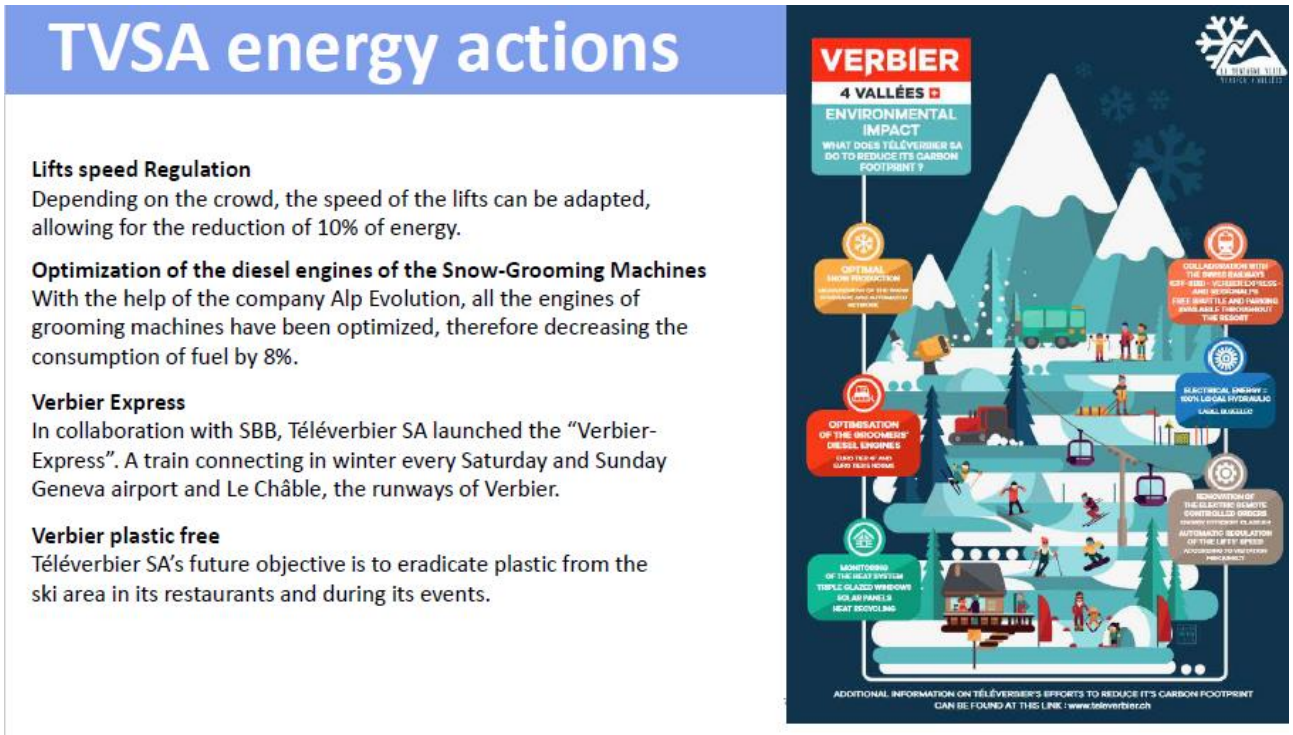

Figure 11: Example of energy actions undertaken by Téléverbier – image ©Téléverbier SA

4. Key Stakeholders

Smart Altitude project partners conducted a Stakeholders analysis to identify and prioritize the key stakeholders to be engaged along the process with several aims: to define a network of contacts to be used for communication and engagement in each region and also to formulate recommendations for SH engagement that can be useful for similar projects and initiatives or by Smart Altitude replicating sites.

Full results can be found in the already mentioned Report of Territorial Stakeholder Engagement published on the project website.

In the context of this roadmap the key results of the analysis are summarised in the table below (Table 2).

Table 2: key stakeholders identified and engaged in Smart Altitude

Stakeholder	Role	Engagement strategy
Ski resort managers and Ski infrastructure operators,	Key role in implementing Smart Altitude actions, and any similar initiatives. Ski resort manager and Ski infrastructure operators can be considered as key stakeholders because they are the key users of Smart Altitude tools	Manage closely in order to understand their priorities and to find the most effective way to communicate the multi-dimensional benefits in terms of economic, social and environmental sustainability for the ski area and the surrounding territory. These stakeholders received high attention since the beginning of Smart Altitude, and where they are not involved as partners or observers, they are the target of continuous dialogue and cooperation.
Local and regional authorities	Municipalities are key stakeholders because usually Mayors or political representatives facilitate the engagement of ski areas and the stakeholder dialogue.	
Energy companies, Research institutes, Business Support Organizations	Business Support Organization and Energy companies may have a crucial role in project development, depending on priorities, while Research institutes may provide the needed technical and scientific advice.	
Citizens and residents of winter tourism areas	Potential opposition to particular energy projects, especially if they do not understand the benefits and the positive feedback loops on the local economy and job opportunities, and because their support could create synergies across sectors, especially in relation to a coherent tourism marketing of the ski area	Keep informed and understand needs. In Smart Altitude Living Labs the engagement of citizens and resident in winter tourism areas was delivered with different degrees of involvement, based on local context and actions delivered by the Labs.

Involving stakeholders and building a dedicated communication channel with local communities need to be planned carefully, as this represents the first step towards citizens' participation and accountability. Regularly informing the public about the project progress and results and highlighting clearly the benefits achieved help to increase awareness and change behaviour, but also to generate support among local communities and stakeholders, promote a coherent marketing message across all economic operators, reduce potential oppositions and increase the potential for a long-term sustainability of project results.

Higher visibility to sustainable practices that enhance natural, economic, and social capital and at the same time attract users and tourists should be given, targeting all stakeholders. Networking with other ski resorts

and their stakeholders to spread best practices and the benefits achieved from sustainable models is also necessary, in order to share knowledge, discuss results, ask for feedbacks and influence policies. It is important to create synergies and collaborations between public and private organizations, citizens, and mountain associations, developing multi-level governance projects and initiatives to achieve the low-carbon transition at quicker and larger scale.

A comprehensive SH analysis is always recommended at the beginning of each project, so that the needs and opportunities in a specific region can be identified and an effective engagement and communication plan can be designed and implemented. More guidelines on this can be found in the Smart Altitude Report of Territorial Stakeholder Engagement.

5. Replication conditions and limits

Numerous studies have pointed out the diversity among mountain resort development policies in terms of management methods, governance structure as well as implementation modalities, both within a single country and between the various countries of the Alpine Space. Moreover, there is also considerable diversity in terms of topology (altitude), geophysics (availability of renewable energy resources), economics (importance of the resort and the ski area, frequentation, links with surrounding conurbations, local, regional and national support for tourism development and investment in infrastructure). Consequently, it seems inadequate to propose a single operational deployment model for energy optimisation and reduction of the energy consumption and emissions would appear inadequate.

For this reason, the Smart Altitude project has based its actions on the diversity of its actors. The work on the development of tools, the validation of their effectiveness within the Living Labs, the setting up of a deployment support platform aims precisely at providing a toolbox from which everyone can draw on good technical and economic practices according to their own situation, while adopting a common implementation approach (process). The role of the Smart Altitude Toolkit is to ensure the best possible transfer of such good practices to the sites involved in the replication process.

In addition, when starting the replication process some other factors should be considered, which we have highlighted below. In the Annex a checklist is provided, which can further help in assessing the initial situation of replicators and in identifying the existing favourable conditions to build on.

The socio-economic drivers are of major relevance, together with closely related aspects, like the existing infrastructure for e.g. mobility, the evolution of tourists' expectations for low-carbon measures, the availability of competences and useful data for the transition to a low-carbon model. All these drivers are prone to significant variations from one region or ski resort to another, therefore calling for individual low-carbon solutions are needed.

The following aspects are derived from a case study on drivers and barriers for innovation in the Smart Altitude Living Labs. The study was conducted as a survey among the Living Labs during the development of the Smart Altitude Toolkit.[20]

[20] Territorial Implementation Plan for Value creation through low-carbon innovation: https://smartaltitude.eu/wp-content/uploads/2020/08/2020_07_09_Smart-Altitude_IM_Value-creation.pdf

- **Economic and financial aspects**

Financial barriers and solutions

Sustainability and low-carbon innovations are important issues for the ski resort, but even though energy costs can be high, they usually represent a small part in the overall expenses of the ski resort. Therefore, energy savings are often a secondary priority. However, systems which have the potential to save up to 25% of the energy bill can be set up in a reasonable timeframe (1-2 year), with a very good Return on Investment (ROI) (< 3 years).

Furthermore, typical financial barriers for low-carbon innovation are the lack of budget, time, and qualified personnel for identifying specific technological eco-solutions. Once these barriers have been overcome, the often-high costs of low-carbon technology act as a major barrier for investment. Existing subsidies and other financial assistance can help to overcome these difficulties. Also, specific regional or national aids could be set up to help the most economically fragile resorts to acquire the necessary equipment and engage into a global energy saving plan.

Competition and collaboration within the economic framework

Competition (territorial, economic) with other ski resorts and other businesses either hamper or foster the development of a winter tourism territory. On the other hand, the collaboration with businesses and other actors within the regional economic framework can help to remove barriers, find synergies, accelerate transformation processes and therefore reduce costs and/or increase benefits.

- **Social aspects**

Mountain communities can be highly dependent on tourism activity, which brings financial resources and seasonal employment. However, it is of the most importance to protect the local permanent population from the economic risks of a decrease in resort activity due to climate change. This threat is also an opportunity to reconsider the economic model of mountain areas, i.e. to favour the decoupling of financial flows from tourism by developing full-time jobs and year-round activities, e.g. through environmentally friendly summer activities, local green-energy initiatives, short cycle farming and new services for the local population. The future resides in helping the local populations to manage and take charge of the sustainable development of their community and territory. To obtain the support and commitment of the local community in the action programmes, it is necessary to set up effective communication campaigns to raise awareness of the fact that the future of the resort, of their living environment and of their territory depends to a large extent on their individual and collective commitment.

- **Marketing aspects**

Gradually, winter sports consumers become more aware of the unsustainable aspects of skiing and the impacts of global warming, and “green” resorts will more and more become a criterion for choosing a winter tourism destination. However, the green policies implemented by a ski resort have still little impact on the tourist population, unless promoted via targeted communication means, such as recreational and educational entertainment activities. Therefore, a specific approach must be developed to integrate low-carbon actions into the global visitor experience, which requires an innovative approach using advanced communication means such as augmented reality, digital animations, etc in addition to more traditional means, such as social media, etc.

- **Infrastructural aspects: Mobility and transportation infrastructure**

Implementation of low-carbon measures is hampered in some important fields of sustainable development, such as green mobility, both by individual and societal barriers, though transport if often a critical issue in skiing resorts. Globally, individuals remain very attached to private cars rather than public transportation systems, especially in maybe after the COVID pandemic. The transportation infrastructure is in most cases dependent on regional or national decisions. Mountain resorts are mass tourism destinations. Therefore, organizing a low-carbon transportation infrastructure and promoting low-carbon solutions such as public transportation and electric vehicles is a crucial lever towards a low-carbon model. Connecting big agglomerations and mountain valleys and resorts must be thought through all levels.

- **Available knowledge and know-how on low-carbon innovation**

Specific competences and knowledge are needed throughout the whole planning and implementation process of low-carbon measures. There is indeed some lack of knowledge on the real cost of implementing an IEMS and other measures for energy consumption reduction. Therefore, there is a need to advocate energy saving measures and deliver thorough financial as well as technical information on such systems. Moreover, when for example setting up an energy saving system such as an IEMS, there is a need for organizational changes. The system needs to be controlled and monitored, thus recruiting or internally training an energy manager is necessary as well as training all operational and administrative staff (snow groomer drivers, ski lift operators, administrative and technical staff occupying building and premises) to energy saving quality procedures.

- **Organisational aspects**

Innovative solutions can be complex – for example it is far easier to replace an old oil burner by a new one with the same power than to investigate an alternative, which would have to be planned well in advance. Time to implement an innovative technology is often very short, often the company has only a few months outside skiing season (normally during summer) to realise the work in order to be operational in the coming season. Furthermore, it is often difficult for ski resort operators to find the qualified personnel for identifying specific technological eco-solutions

The planning and organisation of low-carbon solution implementation can therefore be challenging.

6. Smart Altitude replicators

As of mid-February 2021, 20 ski resorts in total formally signed a Memorandum of Understanding to become project replicators, these are shown in the map below together with the 4 project Living Labs.

Figure 12: Map of Smart Altitude replicators

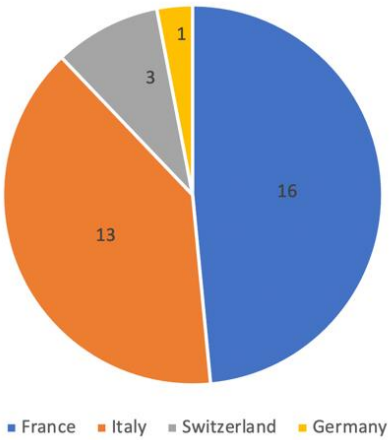

Figure 13: Distribution of participants to the replicator workshops as of mid-February 2021

Further to these, other resorts have participated to the Replicators' workshops, are in touch with the partnership and interested to replicate the project solutions in various ways, either applying the project tools or participating in the Smart Altitude Network. The overall distribution across countries of participants to the replicators' workshops organised until February 2021 is shown in Figure 13. A final update before the end of the project will be provided in Output 4.1 Replication Roadmap.

11 of the 20 ski resorts involved in the Smart Altitude project and all the 4 Smart Altitude Living Labs, that become project replicators, have carried on an energy audit, based on different KPI, in order to measure energy consumption, energy costs, C02 emissions. The project replicators that have done the energy audit are listed below:

- France: Arâches (Les Carroz), Châtel, Les Belleveille (Les Menuires, Val Thorens), Les Orres (Smart Altitude Living Lab), Oz Vaujany, Val Cenis;
- Italy: Bardonecchia Ski, Folgaria – Marilleva, Madonna di Campiglio (Smart Altitude Living Lab), Monte Bondone, Paganella, Pinzolo, Valle Bianca;
- Switzerland: Verbier (Smart Altitude Living Lab);
- Slovenia: Krvacec (Smart Altitude Living Lab).

7. Replication pathway and roadmap

Smart Altitude has already started the replication process during its duration with the aim to engage 20 replication sites before the project end.

Replicators were recruited after an intensive communication campaign based mainly on a series of webinars, followed by specific "replication" workshops and the exchange of information on the project and its various tools. The objective is to create a first core of a community of actors engaged at various levels of the same process. This is fully in line with the objectives of EUSALP Working Group 9 already mentioned. Taking into account the diversity of the replicators' backgrounds and their level of technical and economic competence, we wanted to simplify the membership process as much as possible so as not to discourage the willingness to join by an excessively high level of requirements.

Below the key steps for replicators engagement are summarised:

1. **Information, communication and scouting:** This step started in June-July 2020. Five online webinars were held explaining the objectives and work plans of the Smart Altitude project. The webinars were directed to two categories of stakeholders: decision makers and project observers on the one hand, potential replicators on the other hand. 110 actors of the mountain territories attended at least one webinar of the series, and several potential replicators were identified among the attendees; mainly from Italy and France for which it was easier to set up a good database of resort contacts possibly interested in the replication process. Starting from there and from existing partners' contacts and stakeholders involved throughout the project a first list of potential replicators was identified.
2. **Enrolment:** the full list of potential replicators was approached by email with Smart Altitude key web references and available materials, inviting them to a specific workshop organised to explain the opportunities and advantage of becoming a replicator. Other levers were used, for example information through the ANMSM (association of French mayors of ski resort municipalities). Some partners were already in touch with ski resorts willing to engage in the process, in this case bilateral discussions and communications took place.
   Specific Replicators' workshops were held online in local languages and in English; Smart Altitude partners and Living Lab representatives were there to present their experience from the project and answering all questions by other ski resorts.
   As a formal establishment of the first bunch of replicators, sites interested in engaging as project replicators were asked to sign a Memorandum of Understanding (MoU). Each replicator was then given the option to engage in the full energy audit through the Wi-EMT or simply reviewing the project

deliverables and outcomes and gain support for replicating the implementation models in their areas. As of February 2021, 20 replicators signed the MoU and about 7 are currently in the process of carrying out the audit part of the Smart Altitude toolkit.

3. **Implementation:** During the process, replicators were provided support by project partners in compiling the audit. The process continues till the end of the project. At this time, the main contributors are Italy and France, with perspective to add some more Swiss and German resorts in the short term. Two actions are taken: firstly by organizing additional online meetings to help replicators understand the process and enter the first phases (audit), as describe on the Wi-EMT / replicator website, secondly by setting up an interactive exchange platform by which a dedicated Smart Altitude expert resource can bring technical-economic answers to replicators in need of support and opening threads of discussion for exchanges between peers.
4. **Expansion: creating an enabling environment ensuring sustainability of results and further replication after the project**: besides the actual implementation of replication during the project, Smart Altitude partners worked towards the set-up of enabling conditions that can support the continuation of the efforts towards sustainable and attractive winter tourism regions also after the project. This include the development of policy recommendations at all levels and the establishment of a network of winter tourism regions and stakeholders supporting this transition. Also, the establishment of an interactive platform for project replicators goes towards the objective of generating a long-term community of resorts and mountain territories exchanging information on the practical implementation of low-carbon solutions and energy optimization. Contacts are also made with EUSALP in order to continue the actions beyond the closure of the Smart Altitude project and disseminate the replication process throughout the Alpine Space.

The full process delivered during the project is summarised in the timeline below.

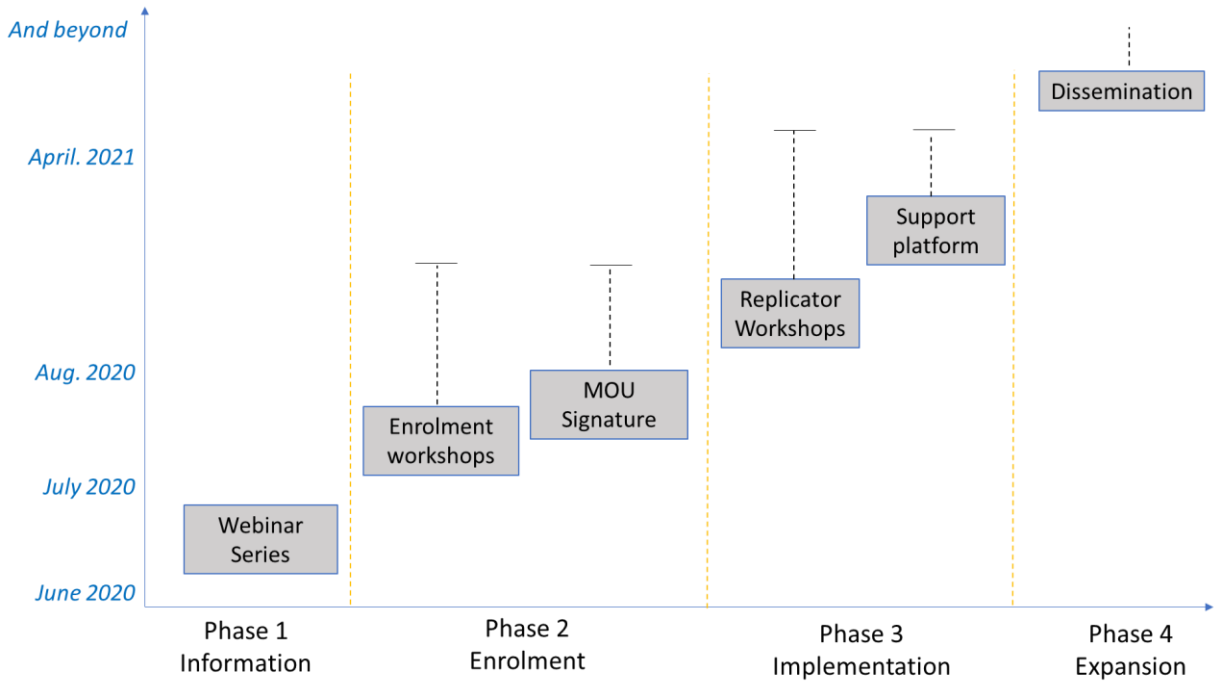

Figure 14: Replication steps

In relation to the "Expansion" phase, Smart Altitude has prepared the ground for continuation and sustainability of replication after its end. This is mainly ensured by:

- **The establishment of a Network of winter tourism regions and stakeholders:** the project has created a network of regions and stakeholders dedicated to the development of resilient Alpine winter tourism territories, which includes all relevant SHs of winter tourism regions, including local, regional and national SHs, policy and decision makers, who are in charge of policies and support to winter areas, business support organisations, SMEs, research organisations and all stakeholders that came in direct contact with the project. The network includes besides project partners and observers: project replicators, stakeholders and partners of the 4 Living Labs and additionally further entities who provided support to the project by signing a specific Letter of Support to Smart Altitude and its overall objectives.

- **The development of policy recommendations at all levels:** the products of the last part of the project will be several recommendation papers addressing all levels of governance from the local up to the EUSALP level, in order to enhance policy support, along the operational, economic and governance axis, to the transition of winter tourism regions towards attractive low-carbon and resilient destinations.

  Dissemination activities: all deliverables and outputs of the project are published on the project website and will be widely disseminated by the partners through the last project event planned in April 2021. Besides this dissemination of project results will continue thanks to the Network, the websites set up by the project and follow up activities by the consortium.

- **The set-up of a dedicated platform for replicators:** besides the project website and the Toolkit website, Smart Altitude is setting up a dedicated platform for project replicators, which will be maintained after the project by the Lead Partner to continue supporting replicators in their effort towards low-carbon ski resorts.

The picture below summarises the full Replication Roadmap during and after the project, with its key steps and milestones.

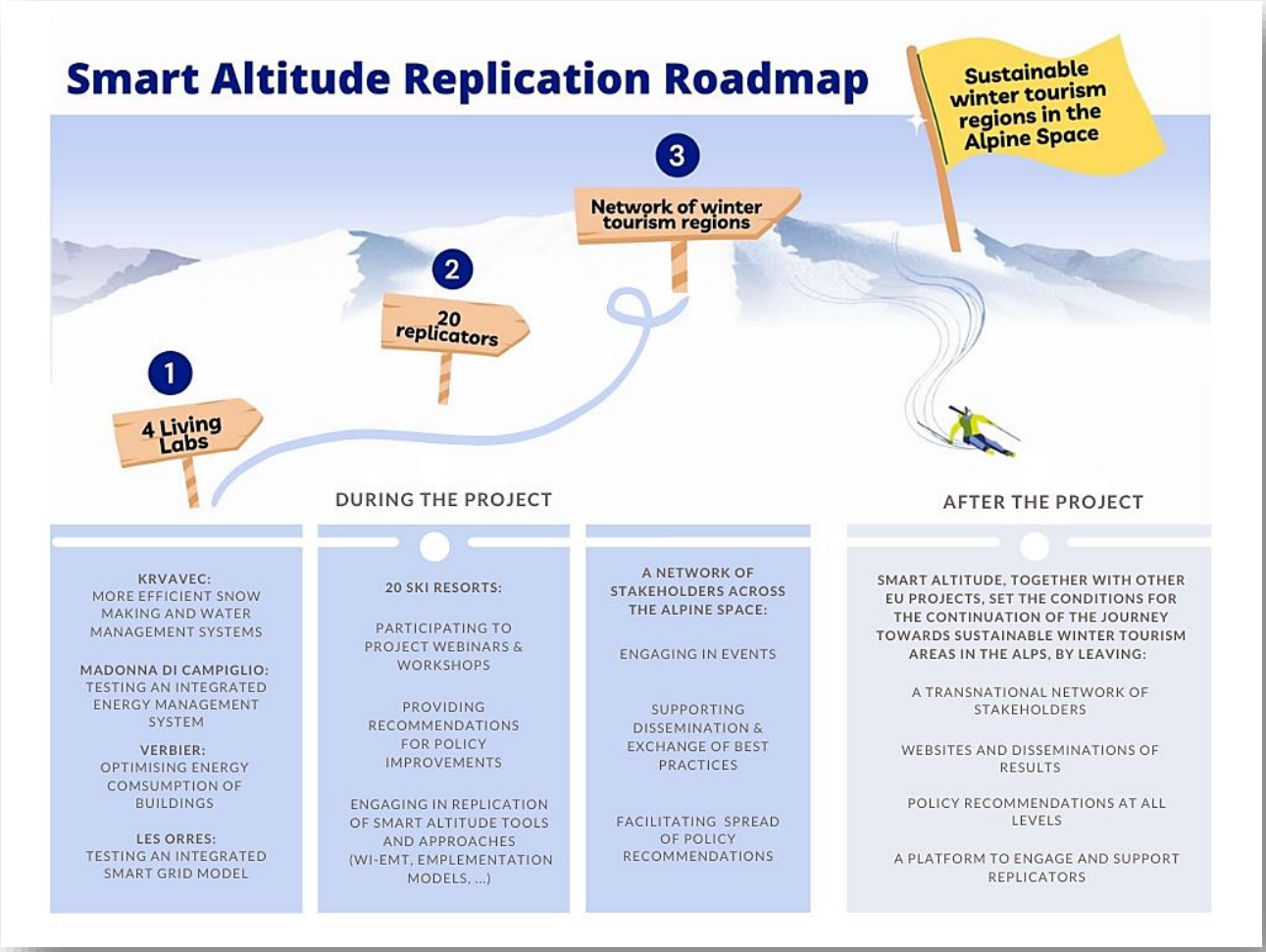

Figure 15: Smart Altitude Replication Roadmap: key steps

8. Monitoring progress for continuous improvement

The integrated project dashboard for energy transition in Alpine mountain areas includes the Smart Altitude WebGIS, KPIs that are calculated as part of the Wi-EMT audit, and a monitoring system for live performance assessment. The main objective of this package is to monitor progress for continuous improvement of the energy use in winter tourism areas. The monitoring takes place at two levels, namely at the level of the Alpine Space and at the level of the ski resort itself. The KPIs, the macro indicators related to the ecological, energetic and management performance of a ski resort, can be visualized in the WebGIS and provide a way to compare the energy performance of ski resorts within the Alpine Space. The Wi-EMT audit of three Living Labs has been completed (Madonna di Campiglio, Les Orres, Krvavec). Currently the Wi-EMT audit is underway for Verbier and for about 7 of the 20 ski resorts and their KPIs will subsequently be integrated into the WebGIS. Other indicators calculated as part of the WI-EMT audit are relevant for the daily "low-carbon" operation of a ski resort. A selection of KPIs can also be used in an integrated energy management system.

This brings us to the second level, the performance monitoring within the ski resort itself by means of an integrated monitoring system on energy usage, storage and production. A real-time integrated monitoring system collects energy data from multiple sources (energy supply from various sources including renewables, energy storage, and energy consumption by snow making, snow grooming, ski lifts, buildings and other operation infrastructure) and performance indicators. Real-time monitoring systems have been implemented at various levels in the four Living Labs. Based on the collected real-time data (production, consumption, storage) energy management scenarios can be set up to, ultimately, guarantee a local balance between energy production and energy consumption. The main steps components of a real-time integrated energy management system are described in the table below. For more complete information, please refer to D.T1.2 deliverable.

Table 3: Performance monitoring

Component	Function
Detailed cartography of the electric grid with of all pieces of equipment connected.	Detailed and exhaustive description of the electric grid and connected equipment.
Energy sensors capable of real time measurement of energy consumption tension, active and reactive power, energy, power demand.	Energy consumption metering by category of equipment and type of use (Snow making, ski lifts, heating…)
A network system including sub-metering modules, automata and gateways	Electric data collection, treatment, and transfer to the IEMS supervision platform.
Data flows from external sources: ski lift frequentation, weather data and forecast, fuel/gas consumption (grooming), heating	Other data collection, treatment for interoperability and transfer to the IEMS supervision platform.
Cloud-based or local server-based supervision platform with interfaces to define time-based and threshold-based load shedding rules.	Instant synoptic and visualization for automatic control actions or manual adjustments by operators upon alerts, and the elaboration of mid- long-term plans to lower energy consumption.
Multi-site historicised energy consumption and local production integration platform at the territory level	Collecting all historicised energy data at the territory level (resort operations, tourism housing, municipality public lighting, buildings, and facilities, etc.) for the elaboration of mid- long-term plans toward territorial energy self-sufficiency
WebGIS	Integration into WebGIS of main KPIs for decision making and contribution to regional/Alpine Space strategy.

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. Achieving a detailed understanding of the energy processes within a ski resort through an integrated monitoring system leads to a more durable and efficient energy production and consumption. The experiences of the Living Labs and lessons learnt in terms of monitoring systems is shared with the Smart Altitude replicators in order to support and stimulate a broader energy transition among ski resort in the Alpine Space.

9. Final conclusions and recommendations

Support of the Smart Altitude Project to strategic EUSALP Objectives

The overall solutions presented within this report are aimed at giving a procedural overview to policy makers as well as ski resorts operators interested in the transition towards a low-carbon approach for their location. The main policy framework which could help fast-track the adoption of these solutions within the Alpine region consists of the EUSALP strategy and specifically the work carried out within the Action Group 1 – Research & Innovation, Action Group 2 – Economic Development and Action Group 9 – Energy Efficiency.

This work has been initiated within the framework of the Interreg Alpine Space AlpGov II project where the Action Groups defined five strategic policy areas on which to focus their work on. Within the "Innovation Hub for Green Business Models" policy priority, which sees the contribution of AG2, AG1, AG3, AG5, AG6 and AG9 the Region Auvergne Rhône Alps is dealing with the topic of sustainable tourism. The overall aim is to promote and support the diversification of the touristic offer as well as the creation of a network of mountain resorts interested in implementing long term objectives.

The Smart Altitude project could help reaching different EUSALP objectives, summed up in the table below (Table 3).

Table 4. How does Smart Altitude address these different specific objectives, and what should be implemented in future projects to fully cover the need?

Objectives	Smart Altitude	Additional points to be covered or further developed
Energy efficiency & renewable energies clusters.	Living Labs & replication process for energy efficiency **operations** and tourism **housing**, renewable energy development	- Applying the Smart Altitude approach to sustainable **mobility at 3 levels: intrastation, station/valley and station/conurbation** - Cooperation in technical solutions, processes and products for energy efficiency with a special focus on the **housing** and **mobility** sectors.
Greening the alpine infrastructure	Recommendations to regional, national and EUSALP authorities & decision makers	- Facilitating cooperation between alpine sports & tourism professional bodies and energy innovation clusters with their R&I organizations.

Supporting local energy management systems	- Living labs (Madonna di Campiglio, Verbier, Les Orres, Krvave)) - Replicator toolkit & support platform	- Expanding the deployment of energy consumption supervision systems to the municipality or to the valley area
Better use of local renewable energy resources	- Living abs (Madonna di Campiglio, Verbier, Les Orres), WebGIS	- Facilitating cooperation between energy innovation clusters with their R&I organizations and alpine areas.
Supporting mountain resorts in their implementation of energy efficiency & self-sufficiency solutions	All components of Smart altitude project	- Further development of the toolbox and support platform for replicators beyond the Smart Altitude project.

Recommendations for Replication

The following table provides an overview of the main recommendations divided by key stakeholder groups (Table 4).

Table 5. Recommendations for Replication

Stakeholder Group	Recommendations
Policy makers at the local, regional and national level	1. Fast-track the adoption of energy efficiency & renewable self-sufficiency solutions in mountain resorts by overcoming specific policy barriers and by supporting the transition through technical personnel. 2. Establish regional and trans-regional working groups involving ski resorts. 3. Promote the establishment of local working groups in order to involve different stakeholders in the development of a long-term transition vision for the Alpine Region. 4. Promote the adoption of long-term climate adaptation plans through the Covenant of Mayors. 5. Promote the collaboration between business organisations, research centres and Public Authorities through specific measures and the identification of tourism as a regional S3 priority.
Ski Resorts Operators	1. Implement the Smart Altitude Toolkit in the ski resort operations: this will allow to conduct the first energy audit and to set both short-term as well as long-term adaptation goals. 2. Invest in qualified personnel able to assess the long-term goals and to prepare a place-based adaptation plan. 3. Involve different stakeholders in the definition of the future roadmap.
Local Stakeholders	1. Promote the establishment of a local/regional working table on winter tourism. 2. Promote and facilitate the adoption of low-carbon measures in your region.

Annex I – Assessment of local context and conditions as additional and complementary to the Smart Altitude Toolkit, to identify existing barriers or enabling conditions for replicating the project approach and solutions.

Financial barriers and solutions	Examples of answers
Are there any existing policies in your country/region regarding for example CO_2 emissions, energy efficiency, environmental protection? Are these targets expected to evolve? In which timeframe?	
Are there any other types of incentives which are specific to your country/region?	**Eco-labels, energy ratings, consulting services offered by regional/local public agencies, …**
Which gaps and barriers for the implementation of adaptation and mitigation measures can you identify in your country/region?	Implementation of climate and energy action plans, lack of support from institutional organisations
Which local and regional public institutions need to be included during the planning process for an adaptation/mitigation strategy in your resort?	**Municipalities, nature reserves, regional councils, …**
How large is the part of the energy expenses in your budget?	
Which are the financial barriers to the implementation of low-carbon solutions to your ski resort?	Implementation costs, investment costs for renewable energies and energy efficient equipment, costs for qualified personnel, …
Are there any existing or planned public subsidies from regional/local agencies and/or institutions dedicated to the implementation of low-carbon solutions?	
What financial benefits do you expect from the energy efficiency / low-carbon measures?	Operational costs savings, higher attractivity of the ski resort due to improved image/visitor experience, …

Competition and collaboration within the economic framework	Examples of answers
How strong is your collaboration/relationship with businesses related to the ski resort activity? How can/must they be included in the planning and implementation processes of low-carbon measures?	Maintenance companies, hotels, bars & restaurants, service providers, shops, …
Are there other businesses/actors that support or interfere with the resort activities?	Agriculture, no-ski activities e.g. in summer, …

Is there a potential for developing synergies with all these actors and businesses?	Shared workforce, common use of renewable energies, use by ski resort of hydrogen produced by local industries, common use of infrastructure (charging stations for electric vehicles, …)
Which products, services and competences are available within the regional/local economic framework regarding low-carbon solutions?	
Which (local) companies, SMEs and start-ups is it possible to collaborate with in order to plan, develop and implement the solutions? Do you already have any partnerships with companies, SMEs, start-ups that promote low-carbon solutions?	
How is the competition with other ski resorts at the local/regional level? At the national/international level?	
What are the specificities of your ski resort that give you a competitive advantage with respect to others? Are these compatible with a low-carbon policy? Can these advantages be sustained in the future?	Family-friendly, accommodation quality, snow quality and reliability, good transport connections, …

Social aspects	Examples of answers
How strongly is the local population involved in the ski resort activities? If not, how can it be involved?	Seasonal/all-year workforce, involved in decisions, …
What are the current benefits of the local population from the ski resort activities?	Employment, financial benefits, infrastructure, shops, services, …
What would be the benefits of a low-carbon transition for the local population?	Increased attractivity of ski resort as an employer for young people, reduction of nuisances from car traffic/air pollution, …
Is there any current criticism from the population concerning the ski resort activities?	Water and energy consumption, nuisances from touristic activities, …
Are there any social barriers that could impede the transition to a low-carbon model?	Low acceptance of changes, potential nuisances from renewable energy sources (noise of wind turbines, landscape change, etc.), …
Are there some citizen communities that need to be involved in the planning and implementation processes of low-carbon solutions?	NGOs, associations, other citizen organizations, …

Tourism trends and vision	Examples of answers
Where are the tourists in your ski resort coming from?	Regional, national, international
Which type of vacations are your visitors seeking for?	Groups, families, individuals, business tourism,
Is the demand for low-carbon ski resorts growing among your public?	
What do you expect for your ski resort from a low-carbon transition?	Improved image, better visitor experience, …

Infrastructures and mobility	Examples of answers
Is it possible to reach the ski resort using public transportation? Which are the existing public transportation types?	Bus, train, cable car, …
How large are the existing capacities of these transport types?	
What are the barriers for developing public transportation types and capacities?	Unattractive to public (long transportation times, many changes, lack of comfort, etc.), lack of infrastructure, lack of political will, …
How could public transportation and green mobility be promoted among tourists?	Development of offer, advertising campaigns from ski resorts/municipality, …
Are there any facilities for charging electric vehicles on the ski resort area? Are hydrogen refuelling stations planned?	

Other types of infrastructure	Examples of answers
How well is the ski resort connected to the electrical grid?	
Are there any existing renewable energy production facilities?	Hydroelectric dams, wind turbines, solar panels, …
Is it legally/technically possible to develop energy production facilities on the territory/in the surroundings?	

Available knowledge and know-how on low-carbon innovation	Examples of answers

Are you already working with personnel qualified for implementing/using low-carbon solutions or equipment?	
Are you already participating in networks where the knowledge for planning and implementing low-carbon measures exists and can be exchanged?	Interaction with other ski resorts, partners, open days, clusters, …
Do you have collaborations with (regional/local) agencies, research organizations, universities that are specialised in low-carbon solutions? If not, what are the possibilities for engaging collaboration?	
Which specific datasets are needed for a transition toward a low-carbon model in your ski resort?	

Organisational aspects	Examples of answers
Can or does the personal motivation of influential personalities drive the transition process towards low-carbon solutions?	Ski resort operator, mayors, …
At which time of the year is it possible to implement low-carbon solutions in your ski resort?	