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Strategies and tools for potential assessment of Renewables (RES) in Alpine Space areas valid for historic buildings and sites

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Abstract. Within the framework of ATLAS research project (Interreg Alpine Space Programme 2014-2020. ID: ASP644) experts of different countries of the Alpine arc studied and compared the measures implemented in the various countries to strengthen and further promote the implementation of renewable energies at the local level. This study highlights those strategies and existing tools for potential assessment of renewables taking into account the applicability for historic buildings, pointing out similarities and differences as model reference between the different territorial areas. The work aims to disseminate and capitalize on the best practical experiences on the topic, and to engage as many stakeholders as possible for a wider implementation of renewable energies in the territory of the Alpine arc. Direct examples of implementation at regional and local level to exploit RES while preserving the authenticity of historic buildings and settlements to be protected in the different countries and regional areas of Alpine Region are shown exploiting their full potential with practical advice for model regions.

Keywords – Renewable Energy Sources (RES); building heritage; sustainable cities and communities; affordable and clean energy

1. Local renewable energies: Identification of the potential solutions in Alpine regions

Transition towards on-site energy production in buildings and districts to enhance the energy efficiency contribution for CO2 mitigation is becoming more realistic in European Union (EU) countries but even also Alpine Space trans-regional areas [1]. Furthermore, since 2015, the EU Strategy for the Alpine Regions (EUSALP, Action Group 9) [2] provide a framework for cooperation, coordination between and within states and regions, focusing on macro-regional strategies for greater regional cohesion and more coordinated implementation of European policies towards a model region for energy efficiency and renewable energy. Furthermore, the recent EU policies set a target for RES penetration to 32% by 2030, as stated in the recast Renewable Energy Directive [3] and to achieve energy and environmental targets, final energy consumption in building sector must be increasingly covered by renewable energy sources, RES [4]. In the retrofitting process for the energy improvement of historic buildings, one possibility is the local renewable energy sources exploitation. The combination of main factors such as protection constrains, energy efficiency, technical and economic feasibility, and end user usability must be carefully weighted and evaluated. It is equally important to weight other aspects to promote energy efficiency of entire districts (e.g., using district heating systems supplied by RES), above all if

considered in the historical city cores or small historical settlements (e.g. spaces suitable for infrastructures, interference with existing installations, compliance with regulations, etc.).

The traditional historic architecture in the Alps is a key enabler for sustainable development in the social, ecological and economic spheres. Over a quarter of the European building stock is classified as "historic" with vast majority of it concentrated in the rural areas [5]. In this context, improving the sustainability of the historic buildings can lead to several positive effects on the sustainability of the whole Alpine area. This is the aim of ATLAS project [6]. Which want not only to the increase the number of high value renovations –considering historic and energetic aspects, living comfort or ecological footprint of traditional buildings– but also, to promote the implementation of sustainable use of historic buildings in regional development strategies. Engaging municipalities and local stakeholders in the process of energy renovation of traditional historic buildings to preserve cultural assets are only possible with better-informed building owners and planners. Exploitation options of most important RES (solar, wind, hydroelectric, hydrothermal, geothermal and biomass), considering specificities of historic buildings and settlements to be protected, were studied in-depth in five regions of the Alpine Arc: Switzerland (Ticino); Germany (Bavaria); Austria (Vorarlberg) and Slovenia (Soča). Additional information was considered only partially for other areas, as for example Italy (Trento – South Tyrol). This paper describes strategies (topic 1), which allow increasing the share of RES (from national and regional to local level) and methodologies or tools (topic 2) for assess and quantity local RES. The information collected were summarized in fact-sheets for each country and regional area giving useful information to stakeholder involved, as tools of the ATLAS holistic decision-support (DS) methodology and toolkit, which is one of the most important outputs to be achieved [7]. In the fact-sheets (Figure 1), the RES studied are identified by a symbol and each country and regional area has collected the information and filled in the templates according to the main topics (1 and 2) and the application level, from to local scale (municipality level). Examples related RES implementation at regional or local level but also the application to Historic Buildings (HB), monuments or protected ensembles were gathered.

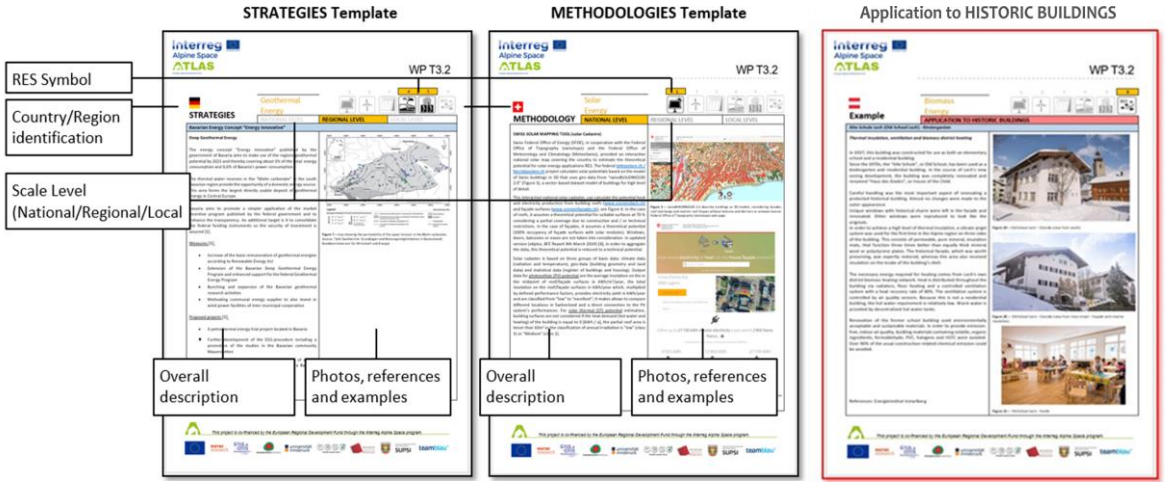

Figure 1. Template fact-sheet structure used for collecting information about RES. [8]

2. Strategies, methodologies and tools for RES assessment and implementation in Alpine EU countries

2.1. RES in Switzerland (Ticino Canton)

- Strategies

Switzerland is in line with the relevant EU regulations and the use of renewable energies and their expansion is granted the status of a national interest. Swiss Federal Council has drawn up the **Swiss Energy Strategy 2050** that foresees a massive increase in the share of renewable energy. Nowadays, it is in the final stages of a significant revision of **CO_2 Act** (**Energy Act 2050**), as key piece of climate change legislation – to be approved in 2021 – that includes a number of measures that may accelerate

greenhouse gas (GHG) emissions reduction. The most important ones, besides Swiss emissions trading scheme (ETS), are the introduction of a CO_2 levy, building standards and energy programs among others. In response to the COVID-19 crisis and the negative economic consequences due to the lockdown, the Federal Council recently approved spending packages of about CHF 60 billion, primarily targeting job preservation, with special provisions in place to protect the development of renewable energy projects. Strategies to promote the use of RES are set usually at national level (**Federal energy law, LEne**) [9] and subsequently implemented on regional and local scale [10]. At regional level, the **Cantonal Energy Plan (PEC)** [11] is the reference document of the cantonal energy and climate policy in the sectors of buildings, as well as the introduction of regulatory principles in accordance with the **2014 MoPEC model of cantonal energy regulations** [12]. In Ticino Canton, cantonal energy policy is supported by regional funds (FER, cantonal renewable energy fund) as well as through incentives. Local associations (i.e. TicinoEnergia or SvizzeraEnergia) put into act concrete measures through sensitization, information and training strategies. National handbooks [13][13] or cantonal guidelines [14] guide possibilities of intervention in historic buildings and protected areas.

- Methodologies

At national, regional and local level, **interactive online WEB-GIS tools and maps** (https://map.geo.admin.ch/), which include national protected buildings and sites, provide comprehensive information on all renewable energies allowing private, companies and municipalities to gather information such as potential, regulations and case examples of each RES. There are hydropower or geothermal maps, a wind atlas and woody and non-woody biomass maps that show the high potential zones. Swiss solar cadaster is one of the most advanced tools, covering the country to estimate the theoretical potential for solar energy applications, on roofs and facades of buildings.

At present, 59% of Swiss overall electricity production comes from RES [15] with **hydropower** as the biggest contributor by far 95%. **Wind power** generation currently covers 0.2% of the production from RES. Regional and local hydroelectric / wind power exploitation depends on the measures of the Cantonal Energy Plan (PEC). Deep **geothermal power** rate is zero and negligible and although if the potential is very high there are uncertainties regarding costs and feasibility and for this reason remain in a research stage. Hydrothermal power instead has a potential in the exploitation of surface waters (mostly water from lakes), groundwater and sewage flows. **Biomass power** generation meets currently the 3.6% of Switzerland's energy demand, and is easily storable to compensate other intermittent RES. The largest potential for the future biomass-based electricity generation is from the mobilization woody biomass and manure resources and by redirecting to CHP systems (cogeneration). Realization of biomass potentials faces challenges in terms of logistics and costs; **Solar energy** is the fastest-growing energy source and solar photovoltaic (PV) exhibits the largest potential for incoming years, from 3.4% to 20% by 2050, but will depend on governmental incentives and appropriate regulation. Self-consumption is being promoted and the option of storage need to be investigated.

- Related to Historic Buildings and protected sites

Hydropower and wind power have not direct application in historic buildings. Cantons with the support of the Confederation (art. 11, LEne Energy Law), must develop a global renewable energy planning open to compromises, with negative planning spaces and buffer distances, to allow a targeted and efficient use in suitable sites ensuring not damage the integrity and appearance of that monuments and landscapes. The possibility of exploiting hydrothermal renewable sources for the thermal conditioning of historic buildings is limited to the availability of the distribution infrastructure network in the relevant area. District heating systems can be produced from different sources; mostly these are renewable energy vectors, as for example wind energy, hydroelectric, or biomass (firewood). Depending on local availability, connection to the district heating network can also represent a good solution for monuments and sites. Feasibility studies in Ticino for Ascona municipality and Carona village (Swiss Heritage Sites, ISOS) investigated several options to exploit different RES [16]. In the examples documented, geothermal and solar potential can be exploited directly in historic buildings, in some cases in combination. As example, an historical villa in Orselina (Ticino), Swiss solar prize award 2019 [17]. Nevertheless, the practical application on using geothermal energy in Historic Buildings is still being investigated (e.g. [18]).

2.2. RES in Germany (Bavaria)

- Strategies

The German Government aims to develop an energy system, which is entirely based on RES as per the **National Energy Concept 2050** [19]. **This is reflected in the Bavarian "Energy innovative" concept** [20]. that aims at the systematic enhancement of regional and municipal energy use plans, restructuring construction planning law, annual reviews and equal treatment of all renewable energies in relation to trade tax **"Südostoberbayern" Program**, taking into consideration regional compatibility and all affected interests such as nature and landscape or settlement development [21].

- Methodologies

German national and **regional interactive WEB-GIS maps** provide comprehensive information on all renewable energies. The tool includes different layers and takes into account references to inventories (Historic Buildings and protected areas). Most important planning instrument on the regional level in Bavaria is the web portal Energie-Atlas Bayern (https://www.energieatlas.bayern.de/), developed by the Bavarian Government. On a local level, the Energy Use Plan (Energienutzungsplan = ENP) [22] is a common strategical planning instrument that provides a comprehensive overview of a municipality's current and future energy demand and supply situation. The ENP is not mandatory for communities but receives government support in case of development. **Hydroelectric energies,** in Bavaria, are already widely used and the Government aims to extend the exploitation in the years to come. The Bavarian Government created online platforms with access to comprehensive information on waters in Bavaria such as the Catalog of stream and river basins in Bavaria (www.umweltatlas.bayern.de, www.energieatlas.bayern.de); Bavaria aim to increase the applicability and use of **wind energies**. Due to geographic and topographic circumstances and partially low acceptance of wind turbines, only a small share of the gross electricity generation in Bavaria is based on wind power. In Bavaria, shallow-ground **geothermal energy** is conditionally exploited [23] and although, **hydrothermal energy** has been already widely used for energetic purposes and an even higher energy yield is expected in the coming years (Bayerisches Energiekonzept "Energie innovativ", 2011). To promote the use of geothermal energies, the Bavarian State created the Geothermal Atlas Bayern, which comprises comprehensive information referring to local conditions and expected values [24]. **Biomass energy** is already widely used for energetic purposes and an even higher and more sustainable energy yield is expected in the coming years as contemplated in the National energy concept 2050 (Energiekonzept 2050, 2010). **Solar energy** is already widely used for energetic purposes and the Government aims to extend its exploitation. In order to make solar energy more accessible to wider public, the government promotes development of innovative technologies as well as further development of existing technologies. Respective tender procedures were introduced in order to enable appropriate funding for the use of solar energies [25].

- Related to Historic Buildings and protected sites

In Germany, monumental protection and climate protection pursue equal interests. The use of waste water and heat recovery, hydrothermal or geothermal energy could be considered to develop energy efficient options for urban development, taking the listed building stock into account. The feasibility is demonstrated in the research project "eCO2centric" conducted by the University of Biberach. The utilization of biogas energy is no more bound directly to a building structure. Biogas plants in the immediate proximity of an architectural or art monument require an individual approval procedure according to article 6 and 7, of the Bavarian heritage protection Law (DSchG) [26] . On the other hand, hydroelectric power plants can be monuments of a technical nature. Good example is the Danube power plant Jochenstein, in Untergriesbach, at the German-Austrian border that is joint monument of technology of Austria and Bavaria and is listed in both states. Other interesting applications of hydropower RES energy in historic buildings (e.g. Thannberg historic hydroelectric power plant built in 1896), or closed to historical city areas, were documented in Bavaria alpine region. Due to the fact, that solar energy systems often affect the protected authentic appearance of historic buildings, it is mandatory by law, [27] to obtain a construction permit from the licensing authority. This applies to architectural monuments and ensembles, as well as, to immediate surroundings of monuments. Each decision is decided on a case-by-case basis. In many cases, a solar energy plant can be installed in a way that the requirements of monumental protection can be fulfilled and the permission can be granted. The

conflict between heritage protection and use of solar energy can be resolved by being sufficiently flexible regarding the design and the choice of location of a solar plant as in the case of the historic Maximilianeum in Munich, which houses the Bavarian Parliament.

2.3. RES in Austria (Vorarlberg)

- Strategies

The long-term energy policy goal of Vorarlberg is energy autonomy in 2050, in which the use of renewable energy sources plays a central role. As part of the 2018/19 energy promotion programme, the State of Vorarlberg supports with an **Energy Subsidies Program** [28] the purchase of thermal solar systems, wood-fired heating systems, heat pumps and ventilation systems with heat recovery in residential buildings. Independent of income, heating with renewable energies is promoted. In Vorarlberg, Austria, anyone who thermally improves components such as exterior walls, ceilings, windows or renews the heating system in his or her home can benefit from a low-interest loan. When consider the implementation and use of renewable energies in historic buildings, the BDA-brochure of the monument office for energy efficiency is guideline, intended as a strategy and methodology that comprises the principles of the Federal Monuments Office with regard to energetic refurbishment of architectural monuments. This document constitutes a guide to the assessment of those measures, which are connected to a monument within the framework of the energetic renovation.

- Methodologies

In Austria, and also in the state of Vorarlberg, there are also **interactive tools** to support RES implementation. There are online tools for solar potential calculation and visualization (e.g. VoGIS tool, Vorarlberger Geographisches Informationssystem) or tools which provides the electrical energy balance (e.g. SUSI tool) of a building or for comparison of heating systems (e.g. Heizrechner tool). In the state of Vorarlberg mainly three different renewable energy sources are used and are supported with strategies and methodologies to promote their implementation. These are the energy sources: solar (solar thermal and photovoltaics), geothermal (with heat pumps, not with power plants) and biomass (district heating systems and heating systems in houses). **Hydroelectric energy** vector is not relevant for municipalities in Vorarlberg (everything is organized and managed by the national energy provider, owned by State of Vorarlberg). **Wind power** in not present and there is also no political will to change it; There are no **geothermal power** plants (only geothermal uses are heat pumps which are very often not possible in historic building due to the need of high temperature for heating system) and no **hydrothermal** sources in Vorarlberg. **Biomass energy** is commonly used as single heating system or district heating and is supported by subsidies; Solar energy (thermal solar energy and photovoltaic PV systems) is widely used, but no so often in historic buildings.

- Related to Historic Buildings and protected sites

Biomass energy could be used for Historic buildings as single heating system or thanks to a district heating network. Examples of application in the State of Vorarlberg have been documented. In the three examples, mainly public buildings (School Building in Lauterach; Old School Lech, kindergarden and Town Hall of Zwischenwasser) have been energetically upgraded while maintaining their existing qualities for a contemporary use. The necessary energy required for heating comes from the district biomass-heating network powered by the municipal biomass power plant, in some cases together with solar energy (e.g. a photovoltaic system beside the Town Hall Zwischenwasser). Thermal solar energy and PV systems are used widely, but no so often in historic buildings. Despite this, interesting examples are been found in Vorarlberg. Private traditional rural houses in Hittisau (House Breuer) and in the region of Montafon (House Nenning) show that the electricity demand and the hot water and heating demand can be produced locally respecting the historical character of the buildings.

2.4. RES in Slovenia (Soča region)

- Strategies

In the **National Renewable Energy Action Plan 2010-2020 (NREAP)**, Slovenia has a goal set forth, namely by 2020 achieve 25% share of RES in gross final energy consumption. All Slovenian strategic documents related to energy production, renewable energy sources and efficient use of energy are

covering the national level. The plan was updated in 2017 also with a vision towards 2030. As Slovenia does not have a regional administration, also the majority of grant/subsidy systems; [47] are based on the national level [29]; [30] (e.g. Ekosklad, National Environmental Funding Scheme, [31]).

- Methodologies

In 2017, the share of RES in gross final energy consumption in Slovenia amounted to 21.5%. The majority of RES is produced in hydropower plants. Planning of new production facilities is many times in conflict with environmental issues, especially when planning hydropower plants and wind turbines. The planning is in hands of potential investors. RES that are mostly used in Soča valley now and still show potential are: **Solar** (many small production sites, national approach of subsidies; **Hydroelectric** (a combination of large and small plants); **Biomass** (individual and district heating systems).

- Related to Historic Buildings and protected sites

In the past (2007-2013), Slovenia had a special supporting mechanism as part of the Rural development funding (so called measures 322 and 323) that was dedicated to refurbishment of listed buildings however the energy efficiency was not a criterion for funding. Currently, the most used public funding offers a variety of grants and loans for different measures. There is no special treatment of historical buildings, so the investors can apply to the common calls that are opened for all buildings. The mechanism covers total or partial refurbishments. All existing methods and tools are general and do not specifically address historical buildings when it comes to RES. There are however, some guidelines and manuals and we also mention one case in the document, as for example the Slovenian guideline for energy retrofitting of historical buildings [49]. The majority of RES in Slovenia and in the area of Soča valley is produced in hydropower plants. Two best practice examples were documented in Slovenia at regional level (i.e. a methodology to plan and crosscheck different water uses in the Soča catchment) and at local level (i.e. Trenta hydropower plant, built and owned by a cooperative of inhabitants taking into account economic, social and environmental aspects).

3. Conclusions

This paper presents the exploitation possibilities of most important renewable energy sources in countries of the EUSALP region. Solar (photovoltaic and solar thermal), Wind, Hydroelectric, Hydrothermal, Geothermal and Biomass RES have been studied in depth in Switzerland (Ticino), Germany (Bavaria), Austria (Vorarlberg) and Slovenia (Soča) considering specificities to overcome technical and legal barriers when implemented in historic buildings or historical settlements.

Information about strategies, methodologies and tools for potential assessment and increase the share of the main RES were collected and structured in templates. The research conducted highlighted that there are methodologies and specific tools to quantify the potential of a given renewable source, which are usually specific for each country and take into account inventories (historic buildings and protected areas). Strategies to increase the share of RES energies are implemented in all Alpine areas, by means of energy programs, action investments, regional and action plans (at municipal level). Even if all the countries have a common legislative framework and similar energy objectives, fragmented approaches and not homogeneous development to the issue, both at the regional and local level are shown. This work make evidence the best practices as model for other regions. . Besides, these policies should be operated by decision makers through sensitization, information and training activities useful for a good and coordinated final implementation. Furthermore, when considering the implementation of renewable energy sources in buildings and especially in historical buildings, as expression of a recognized cultural and historical value of a specific area each "Project Role Profile" is important. Specific manuals, handbooks and guidelines support the process (examples are documented for Switzerland, Austria and Slovenia areas of study). At local level, cities and municipalities are engaged in achieving the ambitious renewable energy targets set at national and regional level and implemented by state, regional or provincial bodies. They have the responsibility and the authority to create energy strategies and incentives that guide lifestyle and local development choices in order to provide services that ensure day-to-day quality of life for citizens. Strategies for political and land planning implementation, financing methods, guidelines and local development and techno-economic models are all potential solutions that allow the exploitation of renewable sources in a specific area. With regard RES exploitation in historic building and protected sites main findings are:

- **Wind and Hydroelectric** energy, are mainly exploited at regional level depending on its feasibility in the specific Alpine area (e.g. the Gotthard wind park in Switzerland). However, listed small Hydropower stations, reactivated, protected or new plants in historical contexts, have been documented, as important examples of local ancient industries from the past (e.g. in Germany) or traditional installations in Slovenia (Soča Valley).
- **Geothermal** energy, still remains in a research stage (e.g. GEO4CIVHIC project) with few examples in Historic Buildings (e.g. Villa Carlotta, Ticino, Switzerland).
- **Hydrothermal** potential (surface waters, groundwater, sewage), are not widely exploited till now, but there are promising studies for its implementation al local level (e.g. in Switzerland, Ascona municipality or eCO2centric Biberach project, in Germany).
- **Solar and Biomass**, are the only RES energies implemented and documented in Historical Buildings (HB) in Switzerland, Germany and Austria showing their potential future development in Alpine areas. Nevertheless, it is preferred installing plants on adjoining structures or not visible surfaces.
- **Biomass,** exploited mainly in rural regions, can be turn into other energies as heat, electricity, biogas or liquid fuels, easily storable to compensate other intermittent RES. Furthermore, provides high delivery temperatures ideal for old buildings poorly insulated or with ancient heating systems (radiators). District heating network, represent a good solution for monuments and can be produced from different RES (e.g. wind energy, hydroelectric, or biomass). Examples are shown in Switzerland (Carona/Ascona ISOS municipalities), Austria (e.g. Lech, Lauterach, Zwischenwasser), and Germany (e.g. Biberach, Lupburg and Bad Alexandersbad).

This works refers the period before COVID-19 crisis and some of the energy policies and strategies changed recently at European level and in the different countries. Nevertheless, the work done has shown remarkable application opportunities for the use of renewable energy sources (RES) in different Alpine Space countries considering the application to Historic Buildings (HB), monuments or protected ensembles and settlements. It gives a general vision of the impact of the different renewable energy sources in the territorial area of analysis and addresses the topic of their use in the renovation of historic buildings, showing key examples as model and practical advice for model regions.

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