Advanced Tools for Low carbon, high-value development of historic architecture in the Alpine Space.

D.T3.2.1 Methods for assessment and quantification of local renewable energy sources in the alpine space

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SO3.1 - Sustainably valorise Alpine Space cultural and natural heritage
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<th>T3 Toolkit for municipalities and regional planning strategies</th>
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<td>D.T3.2.1 Methods for assessment and quantification of local renewable energy sources in the alpine space</td>
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1 Introduction

This deliverable presents a summary of the work done in the Interreg alpine space project (ATLAS) in the tasks A.T3.2 (Methods for assessment and quantification of local renewable energy sources in the alpine space).

The deliverable gathers information and capitalize existing tools and strategies for potential assessment of renewables in the areas of the Alpine Space studied with focus on their impact on historic structures.

The final energy consumption in building sector has to be sustainably covered by local, renewable energy sources, RES. The report describes strategies and methodologies on different level of scale (from national, regional to local scale), which allows increasing the share of RES, also applicable for historic buildings and sites, exploiting the full potential with practical advice for model regions.

The document studies in deep the exploitation possibilities of most important renewable energy sources: Solar (photovoltaic and solar thermal), Wind, Hydroelectric, Hydrothermal, Geothermal and Biomass considering also specificities and new ways to exploit RES by overcoming technical and legal barriers while preserving authenticity of historic buildings and historical settlements to be protected. Direct examples of application in the different countries and regional areas of the Alpine arc that have participated, are shown in this deliverable and in the Annex.

The purpose of this Deliverable and of the work done in the information fact-sheets that cover broad regional areas of the Alpine arc -well documented in the Annex to this Deliverable- are to disseminate as widely as possible and capitalize on the best practical experiences on the topic studied, but also to engage as many stakeholders as possible. A focus target audience pre-identified by the project’s partners are local Municipalities, as relevant actors directly or indirectly involved in energy efficiency strategies to huge implement renewable energies in the territory.
2 Local RES in the Alpine Space

The European Union (EU) is at the forefront of the global energy transformation. Its steadfast commitment and long-term vision combined with today’s cost-effective renewable energy options has enabled the region to nearly double the share of renewable energy from 2005 to 2015. As a result, the EU is on track to meet its 2020 renewables target, and its 2030 target of a 27% share of renewable energy is well within reach. Although impressive progress has been achieved as a result of the ambition and vision of the EU to meet climate targets, more effort will be needed to meet long-term decarbonisation objectives. The EU could cost effectively double the renewable share in its energy mix, from 17% in 2015 to 34% in 2030, according to a new report conducted by the International Renewable Energy Agency (IRENA) [1]. IRENA also sees potential for the share of renewable energy in the power sector to rise to 50% by 2030. The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future that promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy. Strong cost savings is expected mostly in solar energies (solar photovoltaic and solar thermal in buildings), wind, hydropower and geothermal power (Figure 1).

Figure 1: Renewable energy options to exceed the EU 27% energy target for 2030 (Source: IRENA Report 2018)

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3. As part of the “Clean Energy for All Europeans” package of November 2016, the European Commission proposed a binding EU-wide target of 30% for energy efficiency by 2030 (European Commission, 2016a).

Figure 1: Renewable energy options to exceed the EU 27% energy target for 2030 (Source: IRENA Report 2018)
IRENA, has split the renewables potential into three categories: the first category comprises different forms of renewable power generation (wind, solar, hydro, geothermal) as well as solar thermal in buildings. The second category includes electrification of heat and transport by means of heat pumps and electric vehicles (in combination with renewable power generation), as well as biodiesel for transport, solar thermal in industry and geothermal in district heating systems. The third category comprises different forms of biomass use across sectors. The report also mentioned that the accelerated adoption of heat pumps and electric vehicles would result in a substantial increase in the use of electricity in end-use sectors. IRENA’s REmap programme determines the potential for countries, regions and the world to scale up renewables. REmap, global roadmap suggests that renewables can make up 60% or more of many countries’ total final energy consumption (TFEC). In the European Union (EU), the share could grow from about 17% to over 70% [2].

Already in 2018, total renewable energy capacity has grown at a constant rate compared to previous years (more than 26% at the end of 2018) and the number of countries that integrate high shares of variable renewable energy (VRE) continued to increase in recent years, according to the Renewables 2019 Global Status Report (GSR) published by the Renewable Energy Policy Network for the 21st Century (REN21) in June 2019 [3]. The report, states that the effective use of modern renewable energy for heating and cooling in buildings and industrial applications progressed slowly. In the energy efficiency sector, there is a fragmentation of investments of various kinds in different countries, incentives divided among end-users and challenges related to the management of the distribution network. In buildings, total energy demand has increased despite energy efficiency improvements, due primarily to increasing population and incomes. Global energy demand for cooling has grown more rapidly than any other end-use in buildings.

At local level, some cities are able to achieve more ambitious renewable energy targets than national and state or regional/provincial bodies, as they can tap into their direct responsibility for providing services for residents and ensuring day-to-day quality of life, their contractual relationships with energy providers and large-scale users, and their authority to create incentives that guide lifestyle and local development choices. Cities, which are at the forefront of the energy transition given the fact that accounts for around 65% of global energy demand, are taking a leading role in promoting renewable energy through their efforts to achieve a wide range of interconnected environmental, economic and social goals. Important objectives in reducing air pollution, creating local jobs, improving access to

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1 Modern renewable energy for heating and cooling includes bioenergy (excluding the traditional use of biomass), geothermal and solar thermal heat, as well as electricity generated from renewable sources when used in thermal applications.
energy and improve energy security and governance. Renewables have the potential to achieve all these goals and most cities and local communities pursue renewable energy for more than one of these reasons.

Since 2015, the EU Strategy for the Alpine Region (EUSALP) provide a framework for cooperation, coordination, and consultation between and within states and regions, focusing on macro-regional strategies for greater regional cohesion and more coordinated implementation of European sectoral policies. Within EUSALP, Action Group 9 has the mission "to make the territory a model region for energy efficiency and renewable energy", collects reliable energy data and information which are the basis for decision-makers to define, to implement, and to monitor the effectiveness of energy policies.

Regarding RES implantation in the alpine region, last data reported in the last EUSALP ENERGY SURVEY 2019 refers previous 2017 reports [4-5], which also estimated the renewable energy sources (RES) share in heating and electricity. The report pointed out for the EUSALP area a yearly energy consumption estimated at approximately 2.300 TWh (Figure 2, Figure 3), mainly related to heating needs (43% of total final energy consumption of which about 21% from RES, mainly from hydropower), then transport (32%) and electricity (25% of which about 40% from RES, mainly from biofuels and biomass).

![The energy mix in the Alpine macro-region](image)

*Figure 2: EUSALP energy consumption and share of RES (Source: EUSALP ENERGY SURVEY 2017)*
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This document collects information related to the Countries, regions and local areas of the partners participating in the ATLAS research project.

Partners of ATLAS project that has been participated in this activity are: SUPSI, Switzerland (Ticino); EIV, Austria (Vorarlberg); MUAS, Germany (Bavaria); PRC, Slovenia (Soča) and EURAC from Italy (South Tyrol). The main renewable energy sources studied are:

**Renewable Energy Systems (RES)**

<table>
<thead>
<tr>
<th></th>
<th>Renewable Energy System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solar (Photovoltaic &amp; Solar thermal)</td>
</tr>
<tr>
<td>2</td>
<td>Wind power</td>
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<tr>
<td>3</td>
<td>Hydroelectric</td>
</tr>
<tr>
<td>4</td>
<td>Hydrothermal (surface waters, groundwater, sewage)</td>
</tr>
<tr>
<td>5</td>
<td>Geothermal</td>
</tr>
<tr>
<td>6</td>
<td>Biomass</td>
</tr>
</tbody>
</table>

*Table 1 – RES, Renewable Energy Sources studied.*
For each renewable resource, the study considered to investigate two main topics:

- **Topic 1**: STRATEGIES which allows increasing the share of RES (National - Regional – Local Level) providing direct examples of implementation at regional and local level to exploit RES while preserving authenticity of historic buildings and historical settlements to be protected.

The strategies reported by the various countries and partners in many cases are common to all renewable energy sources with slight differences, for example in the types or incentive's methods to promote their widespread use. This is why in some cases they have been reported in a single template which collect all the information.

- **Topic 2**: METHODOLOGIES, existing tools for potential assessment of renewables (National - Regional – Local Level), taking into account the specific features for historic buildings.

It is important to consider that usually, the current methodologies available today in the different countries, for the assessment of renewable energies potentials are developed at a macro-scale level (national level) and thereafter implemented in contexts and areas at regional and local level.

The following sub-chapters a brief explanation is provided of how the information was collected in different templates (methodologies and strategies related RES implementation) and a summary by each Country / Region, that summarizes the most important aspects found for the two topics studied and the best-practice examples collected by each RES studied.

### 2.1 Template fact sheets to collect information

The results of the activity were structured in different template fact sheets, following the main topics studied (STRATEGIES / METHODOLOGIES). In the templates, the RES studied are identified by a symbol and a number according to Table 1. Each country and regional area has collected the information and filled in the forms according to the application level, at national, regional or local scale (municipality level) that are also identified in the description of the information documented in the template fact sheets.

How the information is structured and shown in the template fact sheet is shown in Figure 4 and Figure 5. The template fact sheets show the examples gathered related RES implementation at regional or local level but also the application to Historic Buildings (HB), monuments or protected ensembles and settlements (Figure 6).
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

Figure 4: Structure of the template fact sheet to gather the information regarding RES.

Figure 5: Example of templates Structure of the template fact sheet to gather the information regarding RES.
Figure 6: Examples collected related RES implementation at regional or local and the application to Historic Buildings (HB), monuments or protected sites.

All the template fact sheets collected by the different partners are presented in an Annex to this document, divided by country and regional area. At the beginning of the templates a brief summary of the main outcomes is reported, highlighting main findings regarding the application in historic buildings. These summaries also serve to explain the work carried out by each partner in this document. A comparison of the results obtained and the final conclusions are shown at the end of the Deliverable.
2.2 Summary table of information collected by country / region

The following table (Table 2) summarizes the documented information collected within this activity to quickly assess the results achieved. The table shows that there is not uniformity in the information that is available in the different macro-regions of the Alpine arc studied. In some cases, the missing information is not a matter of which it does not exist but which has not been documented because it is not relevant for the specific area studied. Full documentation has been provided by the following regional areas of which a complete study has been carried: 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).

<table>
<thead>
<tr>
<th>SUMMARY TABLE</th>
<th>Renewable Energies</th>
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<tbody>
<tr>
<td></td>
<td>Methodology</td>
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<td>Methodology</td>
</tr>
</tbody>
</table>

Table 2 – Summary table by country

At first glance it can be analyzed that in some countries, such as Switzerland (Ticino) and Germany (Bavaria), the methodologies and strategies used to promote the use of the different types of renewable energy studied have a greater impact and diffusion, finding examples also for all types of RES studied. In other cases, such as in Austria (Vorarlberg) and Slovenia (Soča region) the availability of information
is concentrated mainly on certain energy sources (Solar, Hydroelectric or Biomass mainly) depending on the greater availability and feasibility on use of this specific RES in these regional areas. These differences will be explained in detail in the next chapters.

3 Outcomes for RES implementation by countries and regional areas in Alpine arc

This chapter provides a review of the main results and conclusions, applicability and constraints in the use of the various renewable energy sources in the various countries, regional and local areas of the Alpine space studied. The purpose of this review is to summarize what is known about the different methodologies to quantify the potential of a given renewable source (Solar, Wind power, Hydroelectric, Hydrothermal, Geothermal and Biomass) and about the strategies for political and land planning implementation, financing methods, guidelines and local development models that are implemented in the various Alpine regions. In addition, particular attention was paid to highlighting the relationships and influences of these methodologies and strategies for RES implementation, related to historic buildings and protected settlements. This review can be used as a summary document that collects only the main points highlighted by the collection of detailed information, which is found in the respective template fact sheets of each country. This chapter gives a general vision of the impact of the different renewable energy sources in the territorial area analysis and addresses the topic of their use in the renovation of historic buildings, showing key examples in the various territorial areas studied that serve as model and practical advice for model regions.

As already indicated in previous chapters, the information concerns the following countries: Switzerland (Ticino); Germany (Bavaria); Austria (Vorarlberg) and Slovenia (Soča).

In addition to this information, which is described in greater detail in the following sub-chapters, specific data sheets have been added for the entire Alpine area in the Annex, for two interesting research projects carried out with the collaboration of different countries in the Alpine arc and related the promotion and greater use of renewable energy sources. The first, concerns an initiative based on a research project related to the development of an European database to collect examples, projects and best-practice that use renewable energy in all EU countries, the **REPOWERMAP project** [6], an interactive and digital map where all the detailed information of the projects that use every type of RES is located and where it is also possible to find examples of the use of renewable energy in historic buildings.
The second detail fact sheet for the Alpine area concerns the large-scale geothermal implementation methodology based in the GRETA Project [7]. GRETA project is an Interreg Alpine Space project aiming at fostering the diffusion of Ground Source Heat Pumps (GSHP) in the alpine area and promoting their structured inclusion in energy and strategic planning. GSHPs are used to exploit geothermal energy between the surface and 200 meters depth, the so-called NSGE (Near-surface Geothermal Resources), which represent an effective and sustainable technology for heating or cooling buildings without using natural gas or fossil fuels. This project was also implemented in particular in the area of Italy (South Tyrol) and the specific information and detail, for this territorial area, was collected in a corresponding template fact sheet for Italy.

3.1 Switzerland (Ticino)

The following table (Table 3) summarize the information collected in the template fact sheets presented in the Annex to this document.

<table>
<thead>
<tr>
<th>SWITZERLAND</th>
<th>Strategies</th>
<th>Methodologies</th>
<th>Application to HB - Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar (PV &amp; ST)</td>
<td>National - Regional – Local Level Solar swiss policy - Examples: “Sole per tutti” (Ticino) - Generoso purchasing group</td>
<td>National: Swiss Solar Cadastre Regional – Local Level Examples - BFAST research project - Ascona municipality (ISO5 village)</td>
<td>Application to HB: Methodologies: Specific Regulations Strategies: - Guidelines for HB and historic city centres - CARs and PILOT PROJECT (Carouge, GE CH) - LESO - OSV Quality Site Viability analysis tool</td>
</tr>
<tr>
<td>Wind power</td>
<td>National - Regional – Local Level Wind power swiss policy</td>
<td>National Level: Swiss wind map tool Local Level: Example: Getthard wind farm project (Ticino)</td>
<td>Application to HB: NO Examples</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>National - Regional – Local Level Hydroelectric swiss policy</td>
<td>National Level: Hydropower In Switzerland Regional Level: Alpine Waterworks Exploitation - Example: PORDAC project Local Level: - Example: Ritom power station</td>
<td>Application to HB: NO Examples</td>
</tr>
<tr>
<td>Hydrothermal (surface waters, groundwater, sewage)</td>
<td>National - Regional – Local Level Hydrothermal swiss policy</td>
<td>National Level: Swiss water maps Regional - Local Level (Ticino) - Example: Ascona Municipality (ISO5 village)</td>
<td>Application to HB: - Ascona Municipality (ISO5 of National Importance)</td>
</tr>
<tr>
<td>Geothermal</td>
<td>National - Regional – Local Level Geothermal swiss policy</td>
<td>National Level: Geothermal maps Regional, Local Level (Ticino) - Example: Ascona Municipality (ISO5 village)</td>
<td>Application to HB: - Ascona Municipality (ISO5 village) - GEO4CIVHC Project - Villa Carlotta, Orselina (TI)</td>
</tr>
<tr>
<td>Biomass</td>
<td>National - Regional – Local Level Biomass power swiss policy</td>
<td>National Level: Woody and non-woody biomass maps Regional Level, Example (Ticino) - Biomass exploitation (Municipalities)</td>
<td>Application to HB: - District heating Carona (ISO5 village) - Ascona Municipality (ISO5 village)</td>
</tr>
</tbody>
</table>

Table 3 – Information collected by SUPSI for Switzerland (Ticino).

Below a summary of what emerged from the collection of information for Switzerland is described.
3.1.1 STRATEGIES

Strategies to promote the use of renewable energies which allows increasing the share of RES are set usually at National level and subsequently implemented on regional and local scale.

Within the context of the energy transition the Swiss government foresees a massive increase in the share of renewable energy (e.g. wind, water, biomass, geothermal energy, solar, etc.). Federal Council has drawn up the **Swiss Energy Strategy 2050 (Energy Act 2050)** to remove gradually dependence on nuclear energy and nuclear power plants are to be decommissioned at the end of their safety-related operating period and not replaced. Furthermore, energy efficiency is to be increased and renewable energy sources such as solar energy expanded. Switzerland are in line with the relevant EU regulations.

The use of renewable energies and their expansion is granted the status of a national interest. Within the context of the energy transition the Swiss government foresees a massive increase in the share of renewable energy (e.g. wind, water, biomass, geothermal energy, solar, etc.). Actually, 59% of Swiss overall electricity production comes from RES (PSI-BFE, 2017, update 2019) [8-9]:

- **Hydropower** dominates as the biggest contributor by far 95%
- **Wind power** generation currently covers 0.2%
- **Deep geothermal** power is zero and negligible, the potential is very high with uncertainties regarding costs and feasibility
- **Biomass**, can be turn into other energies: heat, electricity, biogas or liquid fuels, easily storable to compensate other intermittent RES
- **Solar PV** exhibits the largest potential for incoming years, from 3.4% to 20% by 2050
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
At national level, Swiss Confederation Energy Strategy 2050 are based in four pillars: energy efficiency, renewable energy, replacement/construction of new large-scale electricity production facilities (including nuclear power plants), and foreign energy policy. The first set of measures in Energy Strategy 2050 aims at increasing energy efficiency and promoting the development of renewable energies [10] with specific policies and regulations measures, as incentives, feed-in-tariff, tax relief options, that are implemented from national to regional and local scale. Cantons can define a maximum percentage of energy for heating and hot water that may originate from non-renewable sources for new buildings, according to the Energy Strategy 2050 and the CO2 Act [11]. The main measures considered are:

At regional level, the measures to increase the share of RES energies are integrated in specific regulations and energy planning strategies (e.g. Cantonal Energy Plan (PEC); Cantonal Energy Prescription Model (MuKEn/MoPEC); Land Use Planning (LPT), etc.) and through regional funds the energy policy is supported (e.g. in Ticino region, there is the FER, Fondo energie rinnovabili (FER) a Cantonal Fund, which is one of the important measures to achieve the objectives set at national level, to finance the construction of plants that produce electricity from renewable sources in Ticino, research projects primarily in the electricity sector and municipal activities in the field of efficiency and energy saving. Furthermore, the implementation of the cantonal energy policy, as well as through incentives and, must absolutely be operated through sensitization, information and specific training strategies for the energy sector to the final end-users. Local associations (as for example in Ticino, TicinoEnergia or at national level, SvizzeraEnergia) support the federal and cantonal energy policy with concrete measures to sensitisizes public opinion in Switzerland towards energy issues, promotes innovative projects and supports training and professional development.

At local level, there are many energy programs and tools available to municipalities, regarding all energy strategies in the building sector. Some of these energy programs and tools, as for example: City of Energy® Label; Region-Energy tool; Sustainable Neighborhoods, an online tool that consists of supporting decision-making and building sustainable neighborhoods; 2000 Watt Areas, an Energy City certificate; Prokilowatt program which supports projects that reduce electricity consumption; or the The KliK Foundation promotes various greenhouse gas reduction activities, are well-described in the template fact sheet in the Annex to this document. Besides, at the level of the municipalities, cities, areas and regions, there are techno-economic models to promote renewable energies. An example are the participatory models, applicable to collective projects like for example, share-purchasing groups and projects with a third-party investor involved, who invests, maintains and operates a RES installation (ad example a solar plant installed on a roof), offering a competitive price for the energy. Specific
examples of application are presented in the documented template fact sheet in the Annex. Furthermore, in Switzerland, there is a specific program for strategic “Flagship projects”, that are demonstrative pilot projects subsidized by the Swiss Federal Office of Energy (SFOE) to develop and demonstrate innovative energy solutions at real scale.

With regard the application to historic buildings and protected areas ISOS (federal Inventory of Swiss Heritage Sites) there are: Specific Regulations; National Handbooks (e.g. Energy and monument and Solarkultur / Cultura solare) or Regional Guidelines (e.g. cantonal guidelines) when consider the implementation and use of renewable energies. Examples are reported in the Annex, as for example, CarSol pilot project, for the global solar planning of the City of Carouge, Swiss heritage site ISOS of national significance in the Canton of Geneva, which has been the basis for a national handbook published by the Swiss Federal Office of Culture (OFC) on how to better join solar energy and construction culture in Switzerland, illustrating how the Municipalities can reconcile photovoltaic and quality constructions (Solarkultur / Cultura solare, [12]). The new approach to solar planning has shown that it is possible to achieve optimal use of solar energy - thermal and photovoltaic - while preserving the heritage and architectural quality of the site. An intelligent solar strategy must therefore set priorities that will vary according to the territory in order to reconcile two aspects that seem to be contradictory, modern solar plants on one side and settlements with high historical-cultural value on the other.

3.1.2 METHODOLOGIES

At national, regional and local level, interactive WEB-GIS tools and maps (Figure 9) provides comprehensive information on all renewable energies, the online platform provides interactive maps allowing private individuals, companies and municipalities to gather information such as potential, regulations and case examples of each renewable energy. Digital geodata are developed by the Federal Office of Topography swisstopo, geo.admin.ch is the geographical information platform of the Swiss Confederation within the Federal Administration. In these multilayered tools, several information from all public institution are integrated and national protected buildings and sites are considered. The Swiss Federal Inventory of Heritage Sites ISOS database is also available.

The Web-GIS maps offer detailed information of each element (Figure 10).
3.1.2.1 Solar Energy vector

The potential for additional electricity generation from PV in Switzerland is the largest among all renewables, even if only roof-top PV modules are considered. Solar power has enormous potential: by 2050 it would be possible to meet around 20 percent of the current level of electricity demand in Switzerland through the use of photovoltaic systems. In 2018, about 270 MW of PV systems were installed in Switzerland, increasing the total capacity to 2.2 GW [14]. In 2018, PV power generated 1.9 TWh or 3.4% of the Swiss electricity demand. Since PV faces much less opposition than other renewables in Switzerland, realizing this potential seems to be more realistic. However, since electricity from PV in Switzerland is still expensive, implementation within the next years will depend on...
governmental incentives and appropriate regulation. In addition, decentralized and small-scale intermittent PV generation might be a challenge for the electricity grid from a system perspective, and self-consumption is being promoted. New ways of integration considering the option of storage need to be investigated. The federal government promotes the generation of electricity from renewable energies and operators of new photovoltaic plants of at least 100kWp can profit from the feed-in remuneration. For the installation of solar photovoltaic systems, a cantonal building permit must be obtained. The Spatial Planning Act (SPA) regulates the authorization of solar systems in construction and agricultural areas. According to Article 18 bis of the SPA, for solar systems that are carefully integrated into the roof or facade of a building, a notification to the competent authorities is sufficient instead of a building permit. Monuments and historic buildings of cantonal or national importance remain subject to the authorization requirement.

Solar energy can also be utilised very effectively in solar thermal power plants, but this is not a feasible option in Switzerland like in other parts of the earth. Although the proportion of solar heat to overall consumption in Switzerland is still relatively low, its potential is considerable. If all existing buildings were to be optimally improved in terms of energy efficiency, it would be possible to meet the heating requirements of all Switzerland's households through the use of solar collectors (source: Swiss Federal Office of Energy SFOE, [15]).

Swiss solar cadaster is an interactive web-based map covering the country to estimate the theoretical potential for solar energy applications RES. This tool that can calculate the potential heat and electricity production from building roofs (www.sonnendach.ch) and façade surfaces (www.sonnenfassade.ch) and calculates solar potentials based on the model of Swiss buildings in 3D that uses geo data for high level of detail. Swiss solar cadaster is based on three groups of basic data: climate data (radiation and temperature), geo-data (building geometry and land data) and statistical data (register of buildings and housing). It is a very advanced tool and one of the few solar cadasters that contemplates the calculation of the solar potential of the façades. This solar cadaster is also used at regional and local level, through the OASI (Swiss Italian Environmental Observatory) web platform since 2012 and connected to the national system since 2018. Examples of application at local level and specific research project in Ticino to better implemented the calculation model to assess solar potential for building façades considering typological features are shown (e.g. bFAST research project, [16]). At local level, the tool is also useful for municipalities to estimate the potential of solar energy and solar heat (considering the solar thermal potential, photovoltaic or a mix of both carriers), in order to attract attention and raise awareness citizens regarding the potential exploitable of solar energy, in the entire municipal area.
- **Related to Historic Buildings and protected sites**

  - Swiss solar mapping tool takes into account types of objects (historical buildings and protected areas (ISOS))
  - For data aggregation, surfaces of façades whose distance from a Swiss settlement of national importance is less than a minimum value (ISOS criteria) are not considered;
  - Solar systems are one of the RES sources that could be more easily integrated into historic buildings.

Furthermore, in Switzerland, the acceptability of solar solutions when integrated in historical contexts has been further investigated by LESO (*Laboratoire d'énergie solaire et physique du bâtiment*) at EPFL (*Ecole polytechnique fédérale de Lausanne*), in collaboration with architects and authorities, to develop the LESO-QSV Architectural integration tool (Quality Site Visibility analysis tool) [17]. This tool defines a new approach for promoting solar energy while preserving urban and historical contexts. Detailed information is shown in the specific fact sheet, in the Annex.

### 3.1.2.2 Wind Energy vector

Approximately 59% of Switzerland’s overall electricity production comes from renewable sources, with hydropower as the biggest contributor by far (95%). Wind power generation currently covers 0.2% of the Swiss electricity consumption. The Confederation's energy strategy predicts that wind energy will cover around 7% of Switzerland's electricity consumption by 2050. New wind turbines or wind farms are in the national interest if they have an expected average annual production of at least 20 GWh. This makes it more difficult to oppose power plants when referring to the protection of nature and heritage, but of course, the protection of nature, the environment and fauna is not underestimated. The Suisse Eole Association, partner of SvizzeraEnergia, supports the cantons and investors in planning wind energy projects in order to encourage and improve the acceptance of wind generators by the population. It also created a network of collaborations between electricity companies, authorities, engineering firms, investors and environmental associations to implement a sustainable energy policy.

Wind renewable energy vector are part of the 2050 Energy Strategy measures in Switzerland contemplated at a national level scale. In Switzerland, 2015, there were 34 wind farms in Switzerland with a total production of approx. 100-gigawatt hour (GWh) of electricity per year. Thanks to it, it is possible to meet the electricity consumption of around 28 000 households. The interactive on-line tool "Wind power plants", document current wind farms in Switzerland, based solely on information released by the operators of the plants, however, wind power in Switzerland still has great development potential.

For the country there are wind maps to show wind speed ([Wind Atlas of Switzerland](http://www.windatlas.ch)), the high potential
zones, and the restricted zones. Cantons with the most wind-power potential are Vaud, Bern, Neuchâtel, Jura, Fribourg and St. Gallen. Regions particularly well suited to wind power include the crests of Jura, Gros-de-Vaud, Vaud and Fribourg Prealps regions, Bern’s Seeland region, the region around Lake Constance, and the Rhine valley in Graubunden. There will be a regional distribution of wind energy plants across the country as function of the best capacity and potentialities of the area.

Regional and local hydroelectric / wind power exploitation depends on the measures of the Cantonal Energy Plan (PEC). In Ticino Canton, is now under construction a big wind plant in the Gotthard area with a total capacity of 11.75 MW and an estimated annual production of about 20 GWh to cover the needs of about 5,000 households [18]. There are specific limitations to build turbines close to residential areas, and should not be built within at least 300m of homes. This is to limit noise nuisance. Densely packed turbine parks are preferred than to small numbers of turbines across a large area. In historical monuments and buildings where it is not possible to carry out an energy retrofit intervention in the building envelope, to improve energy performance, such as insulation, or only to a limited extent, modern heating systems allow to compensate the high heat requirement through the use of renewable energies.

- Related Historic Buildings and protected sites

In enhancing the exploitation of wind energy, the cultural values which constitute the identity of the cultural landscape must be safeguarded. Cultural landscapes and valuable historical settlements must be kept clear of these plants and equipped with buffer zones with minimum distances to be respected, given that the environment surrounding the object to be protected or protected contributes significantly to its value [19]. The cantons, with the support of the Confederation (article 11, LEnE Energy Law), must develop a renewable energy development project with a planning that offers a global vision and open to compromises which entails, in certain circumstances, that the territories are to be excluded from exploitation for large wind / water systems (negative planning and buffer distances). This aims to allow a targeted and efficient use of the potential represented by wind and hydraulic energy in suitable sites. In this way it is possible to ensure that the national monuments and objects of the federal inventories of the Swiss settlements to be protected (ISOS) and that Landscapes and Natural Monuments of National Importance (ILNM) are not damaged in their integrity and appearance.

The exploitation of hydroelectric and wind energy mainly depends on the possibility of having large plants at regional level due to the availability of these resources in that specific alpine area in order to exploit this resource (hydrographic potential, availability of suitable wind conditions etc.). The energy generated is distributed in the local network through energy managers, local and regional agencies. District heating systems can be produced from different energy 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.

3.1.2.3 Hydroelectric energy vector

In Switzerland, hydropower contributes a little more than half the electricity produced Switzerland with a share about 60% to the national production of electricity (Swiss Confederation Press Release, Bern, 02.09.2019). The maintenance and further development of this renewable energy source is therefore a declared objective of the Energy Strategy 2050. Thanks to its topography and high levels of annual rainfall, Switzerland has ideal conditions for the utilisation of hydropower. Based on the estimated mean production level, hydropower still accounted for almost 90% of domestic electricity production at the beginning of the 1970s, but this figure fell to around 60% by 1985 following the commissioning of Switzerland’s nuclear power plants, and is now around 57%. Hydropower therefore remains Switzerland’s most important domestic source of renewable energy. The Swiss Federal Office of Energy deals with policy-related aspects of hydropower (promotion, strategies, perspectives, etc) as well as technical and safety aspects, while the Swiss Federal Office for the Environment (SFOE) is responsible for environmental aspects (residual water, protection of bodies of water, etc).

From the latest available data from 2018 (12.31.2018), there are 658 hydropower plants in Switzerland that each have a capacity of at least 300 kilowatts, and these produce an average of around 36,449 gigawatt hours (GWh/y) per annum, 48.5% of which is produced in run-of-river power plants, 47.2% in storage power plants and approximately 4.3% in pumped storage power plants. Roughly 63% of hydroelectricity is generated in the mountain cantons of Uri, Grisons, Ticino and Valais, while Aargau and Bern also generate significant quantities [20] (SFOE, Hydropower research programme).

Swiss Confederation with the Energy Strategy 2050, intends to increase the average annual production of electricity from hydropower of at least 37 400 gigawatt hours (GWh) for 2035 and this value will rise to 38 600 GWh by 2050. In the coming years, this will require a net increase of 85 GWh / year on average (since 2011 the average has been 87 GWh / year). To achieve these results and to exploit the achievable hydroelectric potential, current power plants need to be renovated and expanded considering ecological aspects. In terms of quantity, the goal is to increase the average estimated production level by at least 2,000GWh versus the level recorded in 2000 by renovating existing hydropower plants and constructing new ones. The instruments that will be used to promote the use of hydroelectric energy include cost-remuneration for new hydroelectric plants with a capacity up to 10 megawatts for feed-in to the electricity grid, as well as investment contributions for renovations and expansions of existing hydro
plants with up to 10MW output [21]. The potential deriving from the expansion and renewal of the large hydroelectric power plants remains unchanged, while it is decidedly lower for the small hydroelectric power plants which are not profitable without a financial support. Similarly, production losses must also be considered for the provisions on residual outflows, for concessions expiring between 2030 and 2050.

Federal Act on the Exploitation of Hydropower (WRA) [22], Article 2, states that cantonal law regulates which community (canton, district, municipality or corporation) is entitled to exploit the public waters for hydropower. The community may then make use of the hydropower itself or confer the right to third parties. For the installation of a hydropower plant the operator must acquire a permit and a concession from the relevant canton or municipality. In accordance with cantonal law, the awarding authority shall determine the services and conditions against which the licensee is granted the right of use, such as fees, water interest, water or electricity supply, duration of the licence, provisions on electricity prices, community participation in profits, reversion of the licence and repurchase. The procedure for the award by the cantonal authority is to be regulated by the cantons. In Ticino Canton, a Regional Alpine Waterworks (Podiac project) and a Local hydroelectric power station (Ritom hydroelectric plant) were presented in the templates, as example of hydropower RES implementation. It has been explored the potential of the small hydroelectric installations that could be placed in the aqueducts to exploit this water resource identifying the more promising situations to date for possible hydropower exploitation, responding to one of the measures of the Cantonal Energy Plan (PEC).

- **Related to Historic Buildings and protected sites:**

  As the same as Wind energy, the cantons, with the support of the Confederation (article 11, LENE Energy Law), must develop a renewable energy development project with a planning that offers a global vision and open to compromises which entails, in certain circumstances, that the territories are to be excluded from exploitation for large wind / water systems (negative planning and buffer distances). The development project with an overall national vision (mapped perimeter) aims to allow a targeted and efficient use of the potential represented by wind and hydraulic energy in suitable sites. In this way it is possible to ensure that the national monuments and objects of the federal inventories of the Swiss settlements to be protected (ISOS) and that Landscapes and Natural Monuments of National Importance (ILNM) are not damaged in their integrity and appearance.

  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.
3.1.2.4 Hydrothermal (surface waters, groundwater, sewage) energy vector

With its Energy Strategy 2050, the Swiss Confederation intends to increase the average annual production of electricity from hydropower to 38,600GWh by 2050 (and to 37,400GWh by 2035). In Switzerland, hydropower plants with capacities above 10 MW are categorized as “Large hydropower (LHP)”. Two types can be distinguished: reservoir/storage (damming the water and creating a reservoir lake) and run-of-river (only the water in the rivers coming from upstream is available for generation) power plants. In addition, there are pumped storage power plants, which produce electricity to supply high peak demands by moving water between reservoirs at different elevations using pumps. Often, pumped storage and reservoirs are combined using pumped water plus natural inflows to reservoirs for electricity generation. Hydropower plants use water turbines for electricity generation and now they are a mature technology where no major technology development can be expected in the future. In addition, the current situation on the electricity market reduces profitability of LHP.

Below 10 MW of installed capacity, hydropower plants are categorized as “Small hydropower (SHP)” and can be categorized according to construction type (run-of-river,”Ausleitkraftwerk”/diversion, storage, “Umwälzwerke”/circulation power plants) or according to runoff medium (river-fed, wastewater, drinking water, “Dotierkraftwerk”/discharge power plant). SHP technologies as such are similar to LHP technologies. However, technical limitations for small plants for certain applications and circumstances exist, and current research aims at providing alternative solutions for medium head and low-head, respectively, low-runoff applications. The potential for new SHP plants is relatively small, but non-negligible.

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Figure 11: Examples of local Wind and Hydroelectric power plants in Ticino Canton.
Groundwater flow, heat and mass transport in geothermal or hydrothermal systems occur locally in the Alpine chain, where a number of precise conditions such as active runoff, deep permeability, concentrated and rapid flow and favorable geomorphological models occur surface. Advanced studies of regional and local geology, thermal water chemistry, mixing processes, infiltration area, water-rock interactions, depth of circulation, groundwater residence time, mineral-chemical footprint, etc. allow to understand the deep flow system. Besides, in Switzerland, the exploitation of surface water for energy purposes is generally realized by exploiting the waters of the lake, which is a big resource. However, there is also room for maneuver with regard to rivers. Both of these energy sources are exploited in combination with a heat pump that allows heat to be extracted from the water for the production of thermal energy. Hydrothermal systems require, in some cases, high underground temperatures (>100°C), water-bearing geological formations and adequate generation of hot water in these formations. These pre-conditions seem to be present only a few places in Switzerland. Many aspects are still under study as for example the sustainable use of the reservoirs; and interactions arising from the use of subsurface resources on humans, environment and natural surroundings; possible new concepts for use; interaction with other concepts for use and protection; regulatory aspects; life cycle assessment aspect, etc. (Bauer et al. 2017)

- Methodologies to assess and better exploit the hydrothermal energy resources

Swiss Federal Office for the Environment (FOEN) offer all digital GEODATA maps for the country, regarding waters: current situation of the rivers and the lakes, water temperature rivers, flood hazard levels etc. At the same time, it is possible to check the state of surface water (i.e. monitoring networks, quantity, quality, structure and morphology) and the state of groundwater levels and spring discharges in Switzerland compared with the expected conditions. Groundwater, water protection maps and residual flow maps in relation to geography, for all the country and Cantons are provided by FOEN.

Groundwater exploitation for energy purposes it depends on some factors including, the composition of the subsoil from a geological and hydrogeological point of view; the suitability of the territory, and the available water quantities among others. Surface waters (lake or rivers) exploitation feasibility of must take into account a minimum flow rate and the energy requirements. An important factor is the investment costs for the construction of the water network of collection pipes and the distribution to the users directly influenced by the distance to the lake or river. Waste water exploitation can be an interesting source of residual heat that can be used for heating and cooling buildings. This is possible because in winter the waste water is considerably warmer than the outside air, while in summer it is colder (the water temperatures are around 12 °C). In Switzerland, over 100 waste-to-energy plants are
in operation. According to calculations made by the Federal Office of Energy, this heat production system could be applied to around 5 percent of all buildings.

![Operating scheme of a plant that uses the residual heat of the sewage](Figure 12: Operating scheme of a plant that uses the residual heat of the sewage (Source: Heizen und kühlen mit Abwasser, Deutsche Bundesstiftung Umwelt, Bundesverband Wärmepumpe e.V., Institut Energie in Infrastrukturanlagen, 2009)).

- **Related to Historic Buildings and protected sites**

It is clear that the possibility of exploiting all these resources for the thermal conditioning of historic buildings is limited to the availability of the distribution infrastructure network in the relevant area. The possibility of direct exploitation of river waters by individual end users loses technical-economic interest for distances greater than 50 meters from the shore, in relation to the high infrastructure costs. For distances greater than 50 meters, a centralized approach could be assumed, with a heating system consisting of a large heat pump and public distribution network.

In this template fact sheet a **local example of possible exploitation of Hydrothermal renewable sources in Ascona Municipality (ISOS village)** is presented. This report presents the feasibility study, carried out by SUPSI, University of applied sciences and arts of southern Switzerland, to exploit groundwater, surface water and sewage water as thermal conditioning network in the city of Ascona in Switzerland (Canton Ticino), which is a place of particular historical value, located on the shores of Lake Maggiore. Ascona city core is a national Swiss Heritage Site of the Federal Inventory of Swiss Heritage Sites, ISOS. A study conducted by SUPSI University has been the basis of the Municipal energy plan of Ascona (PECo Ascona, [23]) which considers the possible exploitation of RES in the municipal area and investigates several options to exploit different renewable energies, such as Solar, Hydrothermal, Geothermal and Biomass (**Figure 13**).
The PECo deals primarily with the analysis of the Ascona area from the point of view of energy production and consumption, as well as greenhouse gas emissions. Therefore, it takes into consideration the potential of the territory from the point of view of the development of renewable energy sources, the reduction of consumption in buildings and the development of district heating networks. The action plan guides the municipality towards the pursuit of the PECo objectives and includes the essential indications for its implementation. The template fact sheets in the Annex presents the feasibility study, carried out by SUPSI, to exploit hydrothermal energy (groundwater, surface water and sewage water) as thermal conditioning network in the city of Ascona in Switzerland (Canton Ticino), which is a place of particular historical value, located on the shores of Lake Maggiore.

**Switzerland (Ticino)**

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Application to HB:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar (PV &amp; ST)</td>
<td>Guidelines for HB and historic city centres, CARSOL PILOT PROJECT (Carouge, GE CH)</td>
</tr>
<tr>
<td>Wind power</td>
<td>NO Examples</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>NO Examples</td>
</tr>
<tr>
<td>Hydrothermal (surface waters, groundwater, sewage)</td>
<td>Ascona Municipality (ISOS National Importance)</td>
</tr>
<tr>
<td>Geothermal</td>
<td>Ascona Municipality (ISOS village), GEO4CIWHC Project / Villa Carlotta,Orselina</td>
</tr>
<tr>
<td>Biomass</td>
<td>District heating Carona (ISOS village), Ascona Municipality (ISOS National Importance)</td>
</tr>
</tbody>
</table>

*Ascona, Federal Swiss Heritage Site of National Importance (ISOS)*

**Figure 13: Municipal energy plan of Ascona municipality, PECO Ascona (ISOS village of national important) consider the possibility to exploit different RES energy sources in the municipal area.**

### 3.1.2.5 Geothermal energy vector

Swiss Federal Office of Energy, includes the Geothermal Energy research programme is geared towards the Energy Strategy 2050, with specific tasks devoted to energy saving, the increased contribution of the renewable energies and the reduction of CO2 emission. The potential for geothermal electricity production in Switzerland is very high, but there is still a great deal of uncertainty regarding the associated costs and feasibility. Over 3,700,000 megawatt hours (MWh) of geothermal energy were produced in Switzerland in 2018. Over 80 percent of the geothermal energy produced comes from geothermal probes [24] (Table 4). Between 2004 and 2017, geothermal heat production increased by 177 percent. (Source: GEOTHERMIE-SCHWEIZ).
The potential provided for deep geothermal power generation, from hydrothermal systems and from so-called Enhanced Geothermal Systems (EGS) is the most uncertain among domestic generation options and still needs to demonstrate its technical, economic and social viability (Bauer et al. 2017). Despite this, the potential for production of electricity using geothermal energy are increasingly important along with exploration for and the commercially viable development and production from geothermal reservoirs. Research priorities in Switzerland are the direct use and production of electricity using geothermal energy and shallow geothermal energy. One of the main obstacles to the development of this technology is the fact that very little is known as yet about the local conditions deep underground.

For this reason, geothermal energy projects are able to benefit from a guarantee financed from the network surcharge fund. The Confederation supports projects for the direct use of geothermal energy for heat supply in order to reduce CO2 emissions from buildings in the long term, as the federal government promotes the generation of electricity from renewable sources. Operators of new plants that produce electricity from geothermal energy can profit from the remuneration of the feed-in at cost. By 2030, around a dozen geothermal plants are expected to operate, which will produce a combined total of 800 GWh of electricity. As for deep geothermal systems, there are several in function that are used to provide heat, for example for district heating networks. Several deep geothermal energy projects are currently planned in Switzerland and are in various stages of development [25]. GEOTHERMIE-SCHWEIZ association is the central federation of geothermal actors in Switzerland and the SCCER-SoE, is the Swiss Competence Center for Energy Research - Supply of Electricity.

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**Table 4 – Heat production in Switzerland 2018 by Geothermal energy. (Source: Link K. et al. 2018) [24]**

<table>
<thead>
<tr>
<th>Technology and use</th>
<th>Heat production (MWh / year)</th>
<th>Part (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal probes and underground collectors</td>
<td>2'981'600</td>
<td>80.8</td>
</tr>
<tr>
<td>Exploitation of groundwater</td>
<td>425'900</td>
<td>11.5</td>
</tr>
<tr>
<td>Thermal waters</td>
<td>193'800</td>
<td>5.3</td>
</tr>
<tr>
<td>Geostructures (heating and / or cooling)</td>
<td>54'500</td>
<td>1.5</td>
</tr>
<tr>
<td>Deep aquifers (including direct exploitation)</td>
<td>25'300</td>
<td>0.6</td>
</tr>
<tr>
<td>Tunnel waters (including direct exploitation)</td>
<td>8'500</td>
<td>0.3</td>
</tr>
<tr>
<td>Deep geothermal probes</td>
<td>2'500</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3'692'100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
- Related Historic Buildings and protected sites

The template fact sheets in the Annex collect all the information regarding methodologies to estimate the Geothermal potential (Geothermal digital maps) in Switzerland with a practical application in the example of Ascona municipality (ISOS Village).

The tabs gather other two examples (Figure 14), the GEO4CIVHIC H2020 research project (Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings) [26] related the practical application on using geothermal energy in Historic Buildings are also presented. GEO4CIVHIC intends to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitting of existing and historical buildings. Virtual and real demonstrators, including historical buildings in world heritage areas, are used to validate and demonstrate the feasibility of different technical solutions. Furthermore, a real best practice case study in Ticino Canton was presented. An Historical Building Villa Carlotta in Orselina, has been recently energy renovated, using a solar-powered heat pump with a geothermal system. The energy for heating and hot water is supplied not only by the geothermal heat pump but also by vacuum tube solar collectors. The solar photovoltaic and thermal system are harmoniously integrated in the context of the building. The project has been awarded with the Swiss Solar Prize 2018 [27].

![Figure 14: Examples of application in Historic Building of solar and geothermal energies, collected in the Switzerland template fact sheets.](image)

3.1.2.6 Biomass energy vector

Within the context of the energy transition the Swiss government foresees a massive increase in the share of renewable energy (e.g. wind, water, biomass, geothermal energy, solar, etc.). **Biomass can**
be transformed into several forms of energy: heat, electricity, biogas or liquid fuels. Compared to other renewable energies, biomass is mainly storable and can therefore be used to compensate for other more intermittent renewable energy sources. Sustainable potential of woody biomass resources for bioenergy in Switzerland at the municipality level are a priority for the Swiss Federal Office of Energy (SFOE).

Biomass resources are a heterogeneous group, comprising feedstocks ranging from wastewater and manure, to municipal and industrial waste products, to forest wood. Three main categories are used when considered potentials for biomass-based electricity generation systems: 1) Waste management sector (waste incineration systems, municipal and industrial wastewater treatment plants, and industrial biogas plants); 2) Wood sector: Installations which use woody biomass as a feedstock; 3) Agricultural sector: Installations which mainly use agricultural substrates as a feedstock.

The largest potential for the future biomass-based electricity generation is from the mobilization woody biomass and manure resources which is today a large resource currently not utilized, while that the future potential from woody biomass comes from a combination of utilizing unused resources and redirecting wood from heat-only systems to CHP systems (cogeneration). Realization of biomass potentials faces challenges in terms of logistics and, more important, costs. In addition, is important to consider, that biomass can be used not only for electricity generation, but also for heating and as transport fuels. The federal government promotes electricity generation from renewable energies, among others, the operators of new installations producing electricity from biomass may profit from the feed-in remuneration at cost. According to the Energy Act, EA, in Switzerland, grid operators must purchase and remunerate electricity in their grid area. Moreover, the EA states that operators of biomass plants may obtain an investment contribution. The investment contribution for biomass installations is determined on a case-by-case basis and shall not exceed 20 per cent of the eligible investment costs (Bauer et al. 2017).

Wood is the most extensively available type of biomass in Switzerland, whereby most timber of better quality is used in construction and in interior design. Some wood is also exploited for energy, especially for generating heat. However, non-woody biomass, such as farmyard manure, organic waste, sewage sludge and by-products of agricultural crops also contain valuable energy. The Swiss Competence Centers for Energy Research (SCCER), hunt for solutions to the technical, social and political challenges posed by the Energy Transition. The SCCER BIOSWEET (Biomass for Swiss Energy Future) aims to increase the contribution of biomass to Switzerland’s energy supply (Phase 1: 2014-2016; Phase 2: 2017-2020, Figure 15) and investigate all relevant bioresources (e.g. manure, organic wastes) [28, 29].
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

INVESTIGATION OF THE PRIMARY ENERGY POTENTIALS IN SWITZERLAND

Figure 15: Potential of domestic biomass resources for energy in Switzerland taking into account their spatial distribution of all biomass resources per canton (theoretical potential), primary energy in petajoules per year in 2014. Results of the from the SCCER BIOSWEEET Phase 1 and Phase 2 studies (Source: Swiss Federal Institute for Forest, Snow and Landscape Research WSL) [28, 29]

- Methodologies to assess and better exploit biomass energy resources

Biomass templates fact sheets for Switzerland in the Annex, presents the methodology and maps developed by Swiss Federal Office of Energy (SFOE) to estimate the Biomass exploitation potential in the country. The Swiss Federal Institute for Forest, Snow and Landscape Research WSL quantified and localised the potential of important biomass resources in Switzerland (Woody and non-woody biomass for bioenergy maps), particularly with regard to their sustainable availability. The results are useful as a basis for identifying promising biomass-use pathways and the best sites for their implementation. The potential of energy exploitation of wood at regional and local level was presented for Ticino Canton area. In Ticino, as the same as in other parts of Switzerland, district heating is starting to be considered, up to now mainly through the use of biomass-fueled power plants (wood, pellets, wood chips, wood waste, etc.). Biomass is a solution that can exploit a fuel of indigenous origin, reducing on one hand the dependence on fossil fuels and on the other the production of CO2 in the atmosphere. The study on the potential of district heating in Ticino lays the foundations for identifying the optimal areas for district heating plants in the region.

- Related Historic Buildings and protected sites

An example of district heating network application on the municipality of Carona (ISOS protected historical site of national importance) has been presented in the templates. Besides, the feasibility study and potential exploitation of biomass, as function of the forest potential exploitation in Ascona municipality, ISOS protected historical site of national importance, has also been reported there.
3.2 Germany (Bavaria)

The following table (Table 5) summarizes the information collected in the template fact sheets presented in the Annex to this document.

Table 5 – Information collected by MUAS for Germany (Bavaria).

The summary below provides the information collected about Germany.

3.2.1 STRATEGIES

In order to keep temperatures from rising not more over 2 °C, Germany is committed to reduce its energy-related carbon dioxide emissions and modify its entire energy generation system. An essential element of the energy concept of the German government is a significant increase of energy efficiency of the buildings by reducing their energy demand. In the course of the transition of the energy system to a sustainable economy based on renewable energies, electricity as a key element of this economy originates more and more from renewable energy sources. This results in shifting to power plant scheduling as well as market, grid and system integration of renewable energies. Large power stations, that generate energy based on central fossil and nuclear fuels, must make a way for an increasingly large share of decentral energies from renewable sources. In order to avoid energy fluctuations, stabilization measures have to be taken such as the use of quick-reacting gas power plants, linking cogeneration plants to virtual power plants, load and generation management procedures in conjunction
with smart grids as well as efficient storage technologies. The German Government aims to develop an energy system which is entirely based on renewable energies and energy efficiency by the year 2050, a National Energy Concept 2050 (Energiekonzept 2050, 2010) [30].

On a federal level, Bavaria’s goal is to lower the carbon dioxide emissions significantly below 6 tons per capita by the year 2020. This requires the renewable energies to be expanded and energy saving as well as energy efficiency to be further developed. Therefore, key actions are to comprise multiple investments:

- Investment in power highways which transport electricity from other parts of Germany or abroad to Bavaria.
- Investment in regional power supplies in order to receive increasingly large amounts of electricity from decentralized production.
- Investment in power plants based on renewable energies, which will shape landscape and natural areas.
- Investment in new and highly efficient gas power plants that are provide secure and readily available performance in the future instead of nuclear power plants.
- Investment in storage that integrates fluctuating provision of electricity based on wind and solar energy into the supply system.
- Investment in energy research and new energy technologies, which introduce new solutions for the future energy supply.
- Investment in energy efficiency which allows same user benefits with less energy consumption and less use of resources.

Furthermore, Bavaria promotes innovative technologies and mechanisms in order to lower the cost of renewable energies and achieve full market viability for green energy, which is reflected in the Bavarian energy concept "Energy innovative" (Bayerisches Energiekonzept "Energie innovativ", 2011) [31]. This Concept aims at 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.

In 2011 the State Government announced a fundamental reorganization of Bavaria’s energy supply. Consequently, the defined goals included securing a sustainable energy infrastructure, protection of ecological und cultural interests regarding installations of new power plants and power lines, use of cogeneration as well as consistent integration of citizens. This requires a secure and climate friendly combination of renewable energies and conventional energy sources as well as infrastructures for
energy saving purposes. In order to accomplish the goals, the regional development program was developed, including fixed objectives and principles. The State Development Program Bavaria, Region of “Südostoberbayern” specifies enhanced development and use of renewable energies to re-structure Bavaria’s energy supply, conservation of resources and climate protection. According to the Program, designation of land for installations of power plants based on renewable energies must take into consideration regional compatibility and all affected interests such as nature and landscape or settlement development (Landesentwicklungsprogramm Bayern, LEP) [32].

On local level, Bavaria is divided into 18 regions. Each regional planning association creates a regional plan and updates it as necessary. The regional plans are developed based on the regional development program and specify the program’s regulations for each individual region. The regional plans include specifications regarding interdisciplinary and disciplinary matters such as localized priority- and restricted areas [33].

Germany (Bavaria) - RES

<table>
<thead>
<tr>
<th>STRATEGIES To Increase the share of RES</th>
<th>(National Level)</th>
<th>(Regional Level)</th>
<th>(Local Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Strategic Plan</strong></td>
<td><strong>Bavarian Energy Concept “ENERGY INNOVATIVE”</strong></td>
<td><strong>Region of “SÜDOSTOBERBAYERN”</strong></td>
<td></td>
</tr>
<tr>
<td>German Government’s aim is to develop an energy system entirely based on RES and energy efficiency by 2050</td>
<td>Key actions investments:</td>
<td>Regional program</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• power highways</td>
<td>Regional plans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• regional power supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• RES power plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• efficient gas power plants</td>
<td>To support the renovation of Bavaria’s energy supply, conservation of resources and climate protection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• research &amp; new technologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HB and protected areas ISOS</td>
<td>Specific Regulations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 16:** Scheme of the strategies to increase the share of RES energies in Germany (Bavaria).

3.2.2 METHODOLOGIES

German national and regional interactive WEB-GIS maps (Figure 17) provide comprehensive information on all renewable energies. The tool includes (the same as for Switzerland) 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 (www.energieatlas.bayern.de) [34] developed by the Bavarian Government. The map’s information is based on data provided by the Bavarian State Office of Statistics and the Bavarian Agency for Surveying, such as the 3D-model LoD2 (Level of Detail 2) with integrated common shapes of roofs.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
- Related to Historic Buildings and protected sites

Monumental protection and climate protection pursue equal interests and do not exclude one another. Due to the fact, that solar energy systems often affect the protected authentic appearance of historic buildings, it is mandatory by law (article 6 Bavarian heritage protection law = DSchG) to obtain a construction permit from the licensing authority. This applies to architectural monuments, ensembles of architectural monuments as well as to immediate surroundings of monuments. The permission can be denied according to article 6 paragraph 2 sentence 1 DSchG when serious reasons of monumental protection speak against an installation.. Each decision on authorization related to conservation legislation is decided on a case-by-case basis. There is no list of criteria determining the conditions of permit for solar systems in case of a monument. A monument's value is decisive for assessment of a possible official permit. In this context, the term of division adequacy has developed. This means, that the assessment is based on the monument's category of meaning. For instance, the undisturbed and comprehensive preservation of an art monument is of paramount importance, whereas adjustments in scientific and local history monuments are more likely to receive an approval. 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. Processes not requiring planning permission are managed in article 57 paragraph 1 (3) of the Bavarian building regulations. Still the substantive requirements of the Federal State Building Order have to be observed [37]. The historic Maximilianeum in Munich, which houses the Bavarian Parliament, serves as an example of a photovoltaic (PV) plant installation on a historic building and is documented in the corresponding detail fact sheet (Figure 18).

<table>
<thead>
<tr>
<th>Germany (Bavaria) - RES</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar (PV &amp; ST)</td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td>Methodologies: Regulations HB (PV and ST)</td>
</tr>
<tr>
<td></td>
<td>Strategies: Specific regulations HB</td>
</tr>
<tr>
<td></td>
<td>- Example: Maximilianeum</td>
</tr>
<tr>
<td>Wind power</td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td>NO Examples</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>Application to HB: Methodologies</td>
</tr>
<tr>
<td></td>
<td>Reactivation of a Hydroelectric Plant</td>
</tr>
<tr>
<td></td>
<td>Strategies</td>
</tr>
<tr>
<td></td>
<td>- Hydropower near monument (KEMPTEN)</td>
</tr>
<tr>
<td></td>
<td>- LISTED HYDROPOWERPLANT (UNTEREGIESBACH)</td>
</tr>
<tr>
<td>Hydrothermal</td>
<td>Application to HB: Methodologies</td>
</tr>
<tr>
<td></td>
<td>- eCO2centric, Biberach City</td>
</tr>
<tr>
<td>Geothermal</td>
<td>Application to HB: Specific considerations HB</td>
</tr>
<tr>
<td></td>
<td>- Example: ST DRYING OF CHOPPED WOOD</td>
</tr>
</tbody>
</table>

In 2004 a PV system (20 kWp) upon the roof of the historic Maximilianeum (Bavarian Parliament) was into operation by the Bürgerenergie Isar eG, a cooperative which administers several RES systems providing energy to the region.
3.2.2.2 Wind energy vector

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. The Government aims to extend exploitation of wind energy and therefore, created the map series (Bavarian Wind Atlas) as a planning resource [38]. In addition, comprehensive information and digital maps are provided via an online platform (www.energieatlas.bayern.de). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to meet expected energy demand and requirements of suppliers and consumers. The Bavarian Government as well as the Federal Government aim to increase the applicability and use of wind energies. While on a national level the focus is set on technological development and further development of plant engineering (Energienutzungsplan, ENP 2017), the Bavarian Government aims to ease the planning process and approval procedures, (Bayerisches Energiekonzept "Energie innovativ", 2011) [31].

In Bavaria the so called 10 H-regulation came into force in November 2014. According to Article 82 (1) of the Bavarian Building Regulations, wind energy plants must keep a minimum distance of ten times their own height to residential areas to be seen privileged according to §35 (1), point 5 of the Building Code. A shortfall of the minimum distance is only possible if there is a development plan that determines lower distances. The 10 H-regulation is supposed to help establishing a balance of interests between energy policy and local resident populations [34].

3.2.2.3 Hydroelectric energy vector

In Bavaria, hydroelectric energies are already widely used and the Government aims to extend the exploitation in the years to come. To promote the use of renewable energies 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 and digital maps (www.umweltatlas.bayern.de, www.energieatlas.bayern.de). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to meet expected energy demand and requirements of suppliers and consumers. The Bavarian Government as well as the Federal Government aim to increase the use of hydroelectric energies. The Government focuses on promotion of the use of existing facilities and increasing compatibility of hydroelectric systems with nature conservation issues, which is contemplated.
in the National energy concept 2050 (Energiekonzept 2050, 2010) [30] and on a regional level within the Bavarian Energy Concept "Energie innovativ" (Bayerisches Energiekonzept "Energie innovativ", 2011) [31].

- Related Historic Buildings and sites

Hydroelectric power plants can be monuments of a technical nature where their value as monuments must be preserved (Figure 19). This templates fact sheet includes different examples of application of Hydropower RES energy in Historic Buildings. Besides retrofitting existing systems, such as installation of turbines in Drinking Water Pipelines (e.g. Thannberg), there is an example of Reactivation of a Historic Hydroelectric Power Plant that was built in 1896, used as a spinning mill and shut down in the 1970s. The hydroelectric historic installation was reactivated in 2004 with an installed capacity of 120 kW and in 2006 it provided 200 households with hydroelectric energy, producing annually 0,7 million kWh and resulted in environmental improvements as well. Another interesting example of a historic technical monument is the Danube power plant Jochenstein, in Untergriesbach, at the German-Austrian border. The hydropower plant was built from 1952 to 1956. It is the only joint monument of technology of Austria and Bavaria and is listed in Bavaria since 2011 and in Austria since 2012.

Other example presented in the Annex is a new hydropower plant in a historical protected site, in Kempten. A power plant built in the 1958 was demolished in 2007 and replaced by a new run-of-river power station in Kempten at the River Iller. Alongside the power plant are historic and listed brickwork buildings that were used by spinning and weaving mills up until the middle of the last century.

All the information is well-documented in the specific template fact sheet and provided in the Annex of this document.
3.2.2.4 Hydrothermal and Geothermal energy vector

Although the temperature at the earth’s surface in Bavaria is relatively low, shallow-ground geothermal energy is conditionally exploited [39]. 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) [31]. To promote the use of geothermal energies, the Bavarian State Ministry of Economy, Regional Development and Energy created the Geothermal Atlas Bayern which comprises comprehensive information referring to local conditions and expected values [40].

In addition, the Bavarian Government provides further information and digital maps via an online platform (www.energieatlas.bayern.de). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to meet expected energy demand and requirements of suppliers and consumers. The Bavarian Government as well as the Federal Government aim to increase the use of geothermal energies. Therefore, the government promotes development of innovative technologies, especially for systems based on hot water deposits and dry rock formations. In order to reach the established goals on a national as well as on a regional level, special attention is paid to technologies which are transferable to similar situations worldwide, to the combined use of different renewable energy sources and to funding programs promoting the use of geothermal energies, contemplated in the
National energy concept 2050 (Energiekonzept 2050, 2010) [30] and on a regional level within the Bavarian energy concept "Energie innovativ" (Bayerisches Energiekonzept "Energie innovativ", 2011) [31].

At the federal state level focus is mainly set on the domestic energy source in the "Malm carbonate" in the south Bavarian region, which forms the largest directly usable deposit of geothermal energy in Central Europe (Bayerisches Energiekonzept "Energie innovativ", 2011) [31].

- Related Historic Buildings and protected sites

The research project "eCO2centric" [41] conducted by the university of Biberach was presented in this template fact sheet. The use of waste water and heat recovery, hydrothermal or geothermal energy was considered to develop energy efficient options for urban development, taking the listed building stock into account.
3.2.2.5 Biomass energy vector

In Germany, 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) [30]. To promote the use of biomass fuel, the Bavarian Government provides comprehensive information and digital maps via an online platform (www.energieatlas.bayern.de). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to meet expected energy demand and requirements of suppliers and consumers. Therefore, energy saving, efficiency enhancement and a transition to the use of regenerative energy sources can be coordinated. The Bavarian Government as well as the Federal Government aim to increase the use of biomass energy. The focal point of the research and development of biomass lies, inter alia, on organic residues and waste materials. Furthermore, the Governments promote the installation of systems based on biomass in existing building stocks. At best, the intervention is linked to insulation measures in order to reduce the overall thermal demand (Bayerisches Energiekonzept "Energie innovativ", 2011) [31].

- Related Historic Buildings and protected sites

Nowadays, the utilization of renewable energies such as biogas is no more bound directly to a building structure. Certified pipeline-bound energies can be purchased on the trading market. The question of biogas plant setups is mainly posed in rural regions. During construction of large facilities and related interventions in the soil with a possibility of discovering archeological findings, the issues of preservation of historical monuments affect the archeological heritage. The excess planning of archeological monuments is to be avoided. The conservation of the visual appearance and surroundings relates to the preservation of architectural monuments. In cases of internal consumption of biogas, the intervention has no further impact on the monument than other condensing boilers [42]. Biogas plants in the immediate proximity of an architectural or art monument can have a negative impact on the historic image. In order to perform an individual assessment, an approval procedure according to Article 6 of the Bavarian heritage protection Law is mandatory. Sites in the area of ground monuments or upon surfaces, that indicate a ground monument, require an approval procedure according to Article 7 of the Bavarian heritage protection Law [43]. Examples of local heat network taking advantage of Biomass exploitation in Lupburg, where the center of the network is the heating plant based on biomass boilers and a cogeneration with a 30 kWp PV system, are presented in the corresponding fact sheets, in the Annex. Another example, in Bad Alexander concerns a listed property that supplies the municipal biomass plant.
3.3 Austria (Vorarlberg)

The following table (Table 6) summarize the information collected in the template fact sheets presented in the Annex to this document.

<table>
<thead>
<tr>
<th>AUSTRIA</th>
<th>Strategies</th>
<th>Methodologies</th>
<th>Application to HB - Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar (PV &amp; ST)</td>
<td>National Level - BDA-brochure (National level) Regional - Local Level - Energy subsidies by State of Vorarlberg</td>
<td>Regional – Local Level - tool USI - Heizrechner (Heat calculator) - VOGIS – online tool (solar potential)</td>
<td>Application to HB: - Example PV (House Breuer) - Example ST (House Nenning Hittisau)</td>
</tr>
<tr>
<td>Wind power</td>
<td>Not relevant for municipalities in Vorarlberg (there is no political will to install one)</td>
<td>Application to HB: - No data</td>
<td></td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>Not relevant for municipalities in Vorarlberg (everything is organized and managed by the national energy provider, owned by state of Vorarlberg)</td>
<td>Application to HB: - No data</td>
<td></td>
</tr>
<tr>
<td>Hydrothermal (surface waters, groundwater, sewage)</td>
<td>Not relevant for municipalities in Vorarlberg – No hydrothermal in Vorarlberg</td>
<td>Application to HB: - No data</td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td>Not relevant for municipalities in Vorarlberg – No geothermal power plants (only geothermal uses are heat pumps)</td>
<td>Application to HB: - No data</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 – Information collected by EIV for Austria (Vorarlberg).

Below a summary of what emerged from the collection of information for Vorarlberg is described.

3.3.1 STRATEGIES

In the state of Vorarlberg mainly three different renewable energy sources are used and are supported with strategies and methodologies. 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).

The following strategies and methodologies are relevant to spread the renewable energy sources in Vorarlberg in historic building (Figure 20):

- STRATEGIES (National -Regional – Local Level) & Examples
  - BDA-brochure - Brochure of the monument office for energy efficiency
  - Energy subsidies by State of Vorarlberg
APPLICATION TO HISTORIC BUILDINGS & Examples
  - See examples House Breuer, House Nenning, Old School Lech, School Lauterach and Town Hall Zwischenwasser

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.

Energy subsidies by State of Vorarlberg

As part of the 2018/19 energy promotion programme, the state of Vorarlberg is supporting 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. There are no restrictions on the size of the house. The systems must be installed as central heating in buildings that are the main residence all year round. 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.

**Figure 20:** Scheme of the strategies to increase the share of RES energies in Austria (Vorarlberg).

- Related to Historic Buildings and protected sites

There is available the **BDA-brochure of the monument office for energy efficiency**. This guideline, intended as a strategy and methodology, comprises the principles of the Federal Monuments Office with regard to energetic refurbishment of architectural monuments. The Directive constitutes a guide to the
assessment of those measures, which are connected to a monument within the framework of the energetic remediation (being justifiable or, as the case may be, are not justifiable).

3.3.2 METHODOLOGIES

In Austria, and also in the state of Vorarlberg, there are also interactive tools for solar potential calculation and visualization or tools which provides the electrical energy balance of a building or for comparison of heating systems. A brief summary is described below (Figure 21):

- METHODOLOGIES (National -Regional – Local Level) & Examples
  - SUSI - Online-Tool for electrical energy balance of a building
  - Heizrechner - Online-Tool for comparison of heating systems
  - VOGIS - Online-Tool for solar potential calculation / visualization
  - BDA-brochure - Brochure of the monument office for energy efficiency
  - Energy subsidies by State of Vorarlberg

- APPLICATION TO HISTORIC BUILDINGS & Examples
  - See examples House Breuer, House Nenning, Old School Lech, School Lauterach and Town Hall Zwischenwasser

Figure 21: Scheme of the methodologies to assess the potential exploitation of renewable energies RES energies in Austria (Vorarlberg).

Regarding the different renewable energy vectors studied, in Vorarlberg:
3.3.2.1 Solar energy vector

Thermal solar energy and PV systems are used widely, but no so often in historic buildings. Despite this, two interesting examples are shown in detail on the template fact sheets in the Annex to this document, House Breuer, in Hittisau and House Nenning, in Montafon (Figure 22). The first example, House Breuer (Hittisau),

In the second example, House Nenning (Montafon), the existing roof covering is completely replaced by the full integrated PV and solar thermal modules, which is a disadvantage from the conservation point of view. Nevertheless, it is possible to remove the panels without damaging the original roof structure and replace them by a roof covering similar to the original one. The full-surface arrangement of the integrated PV and solar thermal modules gives the roof a uniform appearance, which is additionally supported by choosing non-reflecting modules with a dark background and metal frame. The roof pitch of 35 ° and the orientation of this building make this half of the roof an ideal energy source. Thus, about 200% of the electricity demand and the majority of the hot water and heating demand can be produced locally.

Figure 22: Examples of Solar energy exploitation in historic buildings in the state of Vorarlberg.

3.3.2.2 Wind power energy vector

Wind power is not present; there is also no political will to change it.

3.3.2.3 Hydroelectric energy vector

Not relevant for municipalities in Vorarlberg (everything is organized and managed by the national energy provider, owned by state of Vorarlberg).
3.3.2.4 Hydrothermal (surface waters, groundwater, sewage) energy vector

Not relevant for municipalities in Vorarlberg because there are not hydrothermal sources in Vorarlberg.

3.3.2.5 Geothermal energy vector

Not relevant for municipalities in Vorarlberg. There are not no geothermal power plants. Only geothermal uses are combined with heat pumps which are very often not possible in historic building due to the need of high temperature for heating system.

3.3.2.6 Biomass energy vector

Biomass as single heating system or district heating is very common and supported by subsidies. Three examples and best cases of application in Historic Buildings are reported in the template fact sheets in the Annex to this document. In the three examples (Figure 23), mainly public buildings (School Building in Lauterach; Old School Lech, kindergarten 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 in the Town Hall Zwischenwasser).

Figure 23: Examples of Biomass energy exploitation in public historic buildings in the cities of Lautherach, Lech and Zwischenwasser.

The School Building in Lauterach is a protected historical building and as shown in the examples district heating network, represent a good solution for monuments combined with other RES energies.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
3.4 Slovenia (Soča)

The following table (Table 7) summarize the information collected in the template fact sheets presented in the Annex to this document.

<table>
<thead>
<tr>
<th>SLOVENIA</th>
<th>Strategies</th>
<th>Methodologies</th>
<th>Application to HB - Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar (PV &amp; ST)</td>
<td>National renewable energy action plan</td>
<td>National: Slovenian environmental fund</td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National: Guidelines for the energy</td>
<td>- No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>renovation of cultural heritage buildings</td>
<td></td>
</tr>
<tr>
<td>Wind power</td>
<td>National renewable energy action plan</td>
<td>National: Slovenian environmental fund</td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- No data</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>National renewable energy action plan</td>
<td>National: Slovenian environmental fund</td>
<td>Regional: suitability of water uses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regional: suitability of (different) water uses</td>
<td>- Example: upper Soča catchment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Treinta hydropower plant.</td>
</tr>
<tr>
<td>Hydrothermal</td>
<td>National renewable energy action plan</td>
<td>National: Slovenian environmental fund</td>
<td>Application to HB:</td>
</tr>
<tr>
<td>(surface waters,</td>
<td></td>
<td>National: Guidelines for the energy</td>
<td>- No data</td>
</tr>
<tr>
<td>groundwater,</td>
<td></td>
<td>renovation of cultural heritage buildings</td>
<td></td>
</tr>
<tr>
<td>sewage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td>National renewable energy action plan</td>
<td>National: Slovenian environmental fund</td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National: Guidelines for the energy</td>
<td>- No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>renovation of cultural heritage buildings</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>National renewable energy action plan</td>
<td>National: Slovenian environmental fund</td>
<td>Application to HB:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National: Guidelines for the energy</td>
<td>- No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>renovation of cultural heritage buildings</td>
<td></td>
</tr>
</tbody>
</table>

Table 7 – Information collected by PRC for Slovenia (Soča).

Below a summary of what emerged from the collection of information for Slovenia (Soča Region) is described.

3.4.1 STRATEGIES and METHODOLOGIES

RES in Slovenia (Figure 24)

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. 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.
The NREAP therefore covers:

1. the national policy of renewable sources of energy;
2. expected gross final energy consumption in the period 2010-2020;
3. targets and trajectories regarding renewable energy sources,
4. measures for achieving binding target shares of renewable energy sources;
5. estimates of the contribution of individual technologies to achieving the target shares of renewable energy sources and estimates of the costs of carrying out measures and of impacts on the environment and on job creation.

The plan was updated in 2017 also with a vision towards 2030.

Support measures include, among other things:

- the improvement of energy efficiency of buildings and construction of net zero energy buildings;
- substitution of oil for heating with biomass and other renewable energy sources; district heating systems based on renewable energy sources and heat and power cogeneration;
- replacing electricity for producing sanitary hot water with solar energy and other renewable energy sources;
- generation of electricity from renewable energy sources, introducing biofuels and other renewable energy sources in transport and farming and introducing electric vehicles;
- developing industrial production of technologies for efficient energy use and renewable energy source;
- developing distribution networks for incorporating dispersed electricity generation, including the development of active/smart networks;
- increasing the share of railway and public transport.

All Slovenian strategic documents related to energy production, renewable energy sources and efficient use of energy are covering the national level. As Slovenia doesn’t have a regional administration, also the majority of grant/subsidy systems are based on the national level.

Regional and Local Level

RES that are mostly used in Soča valley at the moment and still show potential are (Figure 25):

- Solar (many small production sites, national approach of subsidies);
- Hydroelectric (a combination of large and small plants);
- Biomass (individual and district heating systems).
The information gathered in the template fact sheets are mainly focus only on national legal framework with subsidy/grant scheme [44, 45]. An example is the Slovenian “Ekosklad, National Environmental Funding Scheme” [46]. The Ekosklad funding scheme provides financial support for environmental projects including enhancing the energy efficiency of buildings. The financial assistance is offered mainly through soft loans from revolving funds and is granted to legal and private entities.

**Slovenia (Soča) – RES**

**METODOLOGIES**
- existing tools for potential assessment of renewables

**STRATEGIES**
- To increase the share of RES

- **(National - Regional – Local Level)**
  - **Energy Action Plan, NREAP 2010-2020**
  - **Grant/subsidy system**
    - Eco Fund’s - EKOSKLAD (Slovenian environmental fund)

Slovenia has a goal set forth, by 2020 achieve 25% share of RES in gross final energy consumption. The majority of RES is produced in hydropower plants. All strategic documents and grant/subsidy systems are based on national level, as doesn’t have a regional administration.

**Figure 24:** Scheme of the strategies and methodologies to assess the potential exploitation of renewable energies RES energies in Slovenia (Soča).

**Slovenia (Soča) – RES**

**STRATEGIES**

- **Solar (PV & ST)** Application to HB: No data
- **Wind power** Application to HB: No data
- **Hydroelectric** Regional: suitability of water uses
  - Example: upper Soča catchment
  - Application to HB: Trenta hydropower plant
- **Hydrothermal (surface waters, groundwater, sewage)** Application to HB: No data
- **Geothermal** Application to HB: No data
- **Biomass** Application to HB: No data

**Figure 25:** Examples of renewable energy exploitation in Slovenia, Soča region (at regional and local level).

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
- 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. At the moment the most used public funding is the one offered by the Slovenian environmental fund that 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 (SMERNICE za energetsko prenovo stavb kulturne dediščine, 2016) [47].

3.4.1.1 Hydroelectric energy vector

As explained before, the majority of RES in Slovenia and in the area of Soča valley is produced in hydropower plants. In the annex two best practice examples are described, as practical advice for model regions. A case of water uses planning in order to avoid conflicts and one example where it was possible to construct a small hydropower plant within the protected area. The first example describes a methodology to plan and crosscheck different water uses in the SOČA catchment (Figure 26). Based on the water use trend analysis and interviews with the representatives and stakeholders of relevant local communities, the following water uses were selected to be modelled and analysed: hydropower, fish farming, fishery infrastructure and bathing sites.

![Figure 26: Examples of hydroelectric exploitation in the Soča catchment.](image)

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
The second example reported in the template fact sheets in the Annex to this document is the **TRENTA hydropower plant**, a new small hydropower plant built and owned by a cooperative of inhabitants taking into account economic, social and environmental aspects (**Figure 27**).

**Slovenia (Soča) – RES**

<table>
<thead>
<tr>
<th>Solar (PV &amp; ST)</th>
<th>Application to HB:</th>
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<th>Wind power</th>
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<tr>
<th><strong>Hydroelectric</strong></th>
<th>Regional: suitability of water uses</th>
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<tr>
<td></td>
<td>- Example: upper Soča catchment</td>
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<td></td>
<td>- TRENTA hydropower plant</td>
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<th>Hydrothermal (surface waters, groundwater, sewage)</th>
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<th>Geothermal</th>
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<th>Biomass</th>
<th>Application to HB:</th>
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**Figure 27**: Examples of hydroelectric power plant, the TRENTA hydropower plant.
4 Conclusion – Main outcomes

The work done has shown remarkable application opportunities for the use of renewable energy sources in the Alpine Space are of study. The deliverable gathers information and capitalize existing tools and strategies for potential assessment of renewables in the areas of the Alpine Space studied with focus on their impact on historic structures. This report has described strategies and methodologies on different level of scale (from national, regional to local scale) in the countries that participates on gathering the information, which allows increasing the share of renewable energy sources (RES), also applicable for historic buildings and protected sites. The information here collected study in deep the exploitation possibilities of most important RES sources: Solar (photovoltaic and solar thermal), Wind, Hydroelectric, Hydrothermal, Geothermal and Biomass.

Comparison between Countries (Atlas PPs) - Main Outcomes

A summary the most important remarks are:

STRATEGIES AND METHODOLOGIES

- Most countries/regions use multi-layered interactive Web-GIS tool maps to assess RES (renewable energy systems) potential. Municipalities and private owner can estimate the availability and possible exploitation of different renewables energies (single buildings and areas). For example, in Switzerland, Germany or Austria there are effective tools to assess renewable potentials from national to local level of detail. In Switzerland, also the solar cadaster analyse solar potential for roofs but even for facades of buildings, what supposes a very evolved tool with respect to others;

- Inventories (Historic Buildings and protected areas) are usually taken into account in these Mapping tools. However, for data aggregation there are not considered in the calculation. Laws and regulations of all countries consider that visual appearance conservation of surroundings areas near RES plants relates to the preservation of architectural monuments. In the majority of countries RES plants in the area of ground monuments or archaeological sites can have a negative impact and require an approval procedure;

- Strategies to increase the share of RES energies are implemented in all Alpine areas from National to Regional and Local Level, by means of energy programs, action investments,
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

Regional and action plans (at Municipal Level). In this document there is an overview of the different strategies implemented in the Alpine Space countries participating in the activity.

- **National and Regional Handbooks and guidelines** are put in practice at local level. Examples are been documented, as for example, in Switzerland, Cultura solare based on CarSOL research project in Carouge (GE) ISOS municipality or Cantonal Swiss Solar Guidelines; In Autria, the BDA-brochure of the Monument office for energy efficiency or in Slovenia, Slovenian guideline for energy retrofitting of historical buildings (SMERNICE, 2016).

**RES ENERGIES RELATED HISTORIC BUILDINGS**

- **Solar and Biomass** are the only RES energies implemented in a few Historical Building (HB). Examples has been documented in Germany, e.g. Maximilianeum; In Switzerland, Villa Carlotta or in Austria, the houses in Hittisau and Montafon. Solar systems directly affect the construction and external appearance of buildings and settlements. Due to greatest impact on the HB, it is preferred installing plants on adjoining structures or not visible surfaces;

- **Biomass**, exploited mainly in rural regions, can be turn into other energies: heat, electricity, biogas or liquid fuels, easily storable to compensate other intermittent RES. Furthermore, it is possible to obtain high delivery temperatures ideal for old buildings poorly insulated or with ancient heating systems (radiators). Examples have been documented in Autria – Vorarlberg (Public buildings in Lech, Lauterach, Zwischenwasser), Germany (eCO2centric Biberach, Lupburg and Bad Alexandersbad);

- **District heating network**, represent a good solution for monuments and can be produced from different renewable energy sources (e.g. wind energy, hydroelectric, or biomass) depending on local availability. Examples are well-documented in the Annex: In Switzerland-Ticino (Carona/Ascona ISOS national protected sites), in Germany (eCO2centric Biberach, Lupburg and Bad Alexandersbad), in Autria (Lech, Lauterach, Zwischenwasser) and Slovenia.

- **Wind and Hydroelectric** energy are mainly exploited at regional level depending on its feasibility in the specific Alpine area. For example, in Switzerland, in Ticino region there are the examples of Gotthard or Ritom plants or in Slovenia, the documented of the hydro-exploitation of the Soča catchment. Furthermore, as the same as to other RES plants (e.g. biogas or geothermal plants can affect the archaeological heritage) many countries considers to look after suitable sites, considering buffer spaces and protected perimeters when in proximity to historical
buildings or protected sites. In this way it is possible to ensure that cultural monuments or protected natural landscapes are not damaged in their integrity and appearance.

- **Hydroelectric plants can be monuments of a technical nature.** Listed small Hydropower stations examples, reactivated, protected or new plants in historical contexts are presented in the Annex. Examples in Germany (Bavaria) and Slovenia (Soča Valley) have been documented, as important examples of local ancient industries from the past (e.g. spinning and weaving mills) or traditional installations that have been renovated with a positive impact also in the economic, social and environmental in the local area;

- **Hydrothermal potential (surface waters, groundwater, sewage),** are not widely exploited till now, but there are promising studies for its implementation at local level (e.g. in Switzerland, the example of Ascona municipality, ISOS national protected site, or in Germany, the eCO2centric Biberach project);

- **Geothermal energy in Historic Buildings (HB) still remains in a research stage (e.g. GEO4CIVHIC and GRETA project) with not so much examples of direct application in Historic Buildings (e.g. Villa Carlotta, in Ticino, Switzerland).**

When the **renewable energy system is directly implemented in an historical building, from a technical point of view,** it is also necessary to consider other important aspects, as the following, for example:

- In historic buildings, the use of renewables in the renovation of the building allows as far as possible to compensate and to reduce the heat loss through the envelope;

- In historic buildings, therefore, a higher flow temperature is usually required, due to the poor thermal insulation of the construction elements and the distribution system (radiator heating bodies). For this reason, in the case of a transition to a heating system with a heat pump, geothermal energy could be preferred, which allows higher energy efficiencies to be achieved compared to traditional air-source heat pumps;

- A poorly insulated building requires higher flow temperatures. It therefore becomes necessary to evaluate the efficiency of the installation of a heat pump. The lower the flow temperature of the heating system, the higher the efficiency of heat pump systems. With the use of renewable combustion sources, such as biomass, it is possible to obtain high delivery temperatures;

- Centralizing heat production increases the efficiency of the systems. For this reason, if a district heating network is available for connection to a historic building, regardless of the energy source that produces the heat, connection to it is preferable.
• Today there is an increasing need for summer cooling, due to the effects of the ongoing climate change. In this case one solution to increase the energy efficiency of the historic building could be a reversible heat pump with the possible use of renewable sources such as hydrothermal or geothermal;
• Nevertheless, the problems related to air-to-air or air-to-water heat pumps in historic buildings are conditioned by the feasibility of creating heat distribution ducts or the integration of new thermal energy distribution systems in the building which may involve large changes.

To conclude, the document study in deep the exploitation possibilities of most important renewable energy sources: Solar (photovoltaic and solar thermal), Wind, Hydroelectric, Hydrothermal, Geothermal and Biomass considering also specificities and new ways to exploit RES by overcoming technical and legal barriers while preserving authenticity of historic buildings and historical settlements to be protected.

RES exploitation is possible also in historic building and protected sites to contribute to hit the EU targets of energy efficiency and RES incrementation and despite of this topic could be subject to heavy preservation restrictions. When facing a retrofitting project to improve the energy performance of a cultural heritage building by including also renewable energies it is necessary to weigh carefully different aspects such as the energy efficiency, technical feasibility and end-user comfort achieved.

Examples presented consider also specificities and new ways to exploit the full potential of these RES by overcoming technical and legal barriers while preserving authenticity of historic buildings and historical settlements to be protected. These suppose a practical advice for other model regions.
5 References


This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

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6 Annex
6.1 Annex 1: Templates Switzerland (Ticino)
<table>
<thead>
<tr>
<th>SWITZERLAND</th>
<th>Strategies</th>
<th>Methodologies</th>
<th>Application to HB - Examples</th>
</tr>
</thead>
</table>
| **Solar (PV & ST)** | National -Regional – Local Level Solar swiss policy  
- Examples: “Sole per tutti” (Ticino)  
- Generoso purchasing group | National: Swiss Solar Cadastre  
Regional – Local Level Examples  
- BFAST research project  
- Ascona municipality (ISOS village) | Application to HB:  
Methodologies: Specific Regulations  
Strategies:  
- Guidelines for HB and historic city centres  
- CARSol PILOT PROJECT (Carouge, GE CH)  
- LESO - QSV Quality Site Visibility analysis tool |
| **Wind power** | National -Regional – Local Level Wind power swiss policy | National Level: Swiss wind map tool  
Local Level Example: Gotthard wind farm project (Ticino) | Application to HB:  
NO Examples |
| **Hydroelectric** | National -Regional – Local Level Hydroelectric swiss policy | National Level: Hydropower in Switzerland  
Regional Level: Alpine Waterworks Exploitation  
- Example: POIDAC project  
Local Level:  
- Example: Ritom power station | Application to HB:  
NO Examples |
| **Hydrothermal (surface waters, groundwater, sewage)** | National -Regional – Local Level Hydrothermal swiss policy | National Level: Swiss water maps  
Regional -Local Level (Ticino)  
- Example: Ascona Municipality (ISOS village) | Application to HB:  
- Ascona Municipality (ISOS of National Importance) |
| **Geothermal** | National -Regional – Local Level Geothermal swiss policy | National Level: Geothermal maps  
Regional, Local Level (Ticino)  
- Example: Ascona Municipality (ISOS village) | Application to HB:  
- Ascona Municipality (ISOS village)  
- GEO4CIVHIC Project  
- Villa Carlotta, Orselina (TI) |
| **Biomass** | National -Regional – Local Level Biomass power swiss policy | National Level: Woody and non-woody biomass maps  
Regional Level, Example (Ticino)  
- Biomass exploitation (Municipalities) | Application to HB:  
- District heating Carona (ISOS village)  
- Ascona Municipality (ISOS village) |
## Switzerland (Ticino) - RES

### STRATEGIES

List of renewable Energies to be studied

<table>
<thead>
<tr>
<th>Renewable Energy Systems (RES)</th>
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<tbody>
<tr>
<td>1 Solar (Photovoltaic &amp; Solar thermal)</td>
<td>2 Wind power</td>
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<tr>
<td>3 Hydroelectric</td>
<td>4 Hydrothermal</td>
</tr>
<tr>
<td>5 Geothermal</td>
<td>6 Biomass</td>
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</table>
Strategies to promote the use of renewable energies which allows increasing the share of RES are set usually at National level and subsequently implemented on regional and local scale.

Within the context of the energy transition the Swiss government foresees a massive increase in the share of renewable energy (e.g. wind, water, biomass, geothermal energy, solar, etc.). Federal Council has drawn up the Energy Strategy 2050 (Energy Act 2050) [1] to remove gradually dependence on nuclear energy and nuclear power plants are to be decommissioned at the end of their safety-related operating period and not replaced. Furthermore, energy efficiency is to be increased and renewable energy sources such as solar energy expanded. The use of renewable energies and their expansion is granted the status of a national interest. Within the context of the energy transition the Swiss government foresees a massive increase in the share of renewable energy (e.g. wind, water, biomass, geothermal energy, solar, etc.).

Actually, 59% of Swiss overall electricity production comes from RES (PSI-BFE, 2017, update 2019) [2-3]:
- Hydropower dominates as the biggest contributor by far 95%;
- Wind power generation currently covers 0.2%;
- Deep geothermal power is zero and negligible, the potential is very high with uncertainties regarding costs and feasibility;
- Biomass, can be turn into other energies: heat, electricity, biogas or liquid fuels, easily storable to compensate other intermittent RES;
- Solar PV exhibits the largest potential for incoming years, from 3.4% to 20% by 2050.

Switzerland are in line with the relevant EU regulations. These requirements facilitate international trading in electricity produced from renewable energy sources.

In this template fact sheet reported in the Annex, well documented information has been gathered regarding the strategies implemented in Switzerland from National to Regional (cantonal level) and Local level (municipalities). Here there is a brief summary that synthesize the information presented:

At National level, Swiss Confederation Energy Strategy 2050 are based in four pillars: energy efficiency, renewable energy, replacement/consstruction of new large-scale electricity production facilities (including nuclear power plants), and foreign energy policy. The first set of measures in Energy Strategy 2050, at national scale, aims at increasing energy efficiency and promoting the development of renewable energies [4] with specific policies and regulations measures, as incentives, feed-in-tariff, tax relief options, that are implemented from national to regional and local scale. Cantons can define a maximum percentage of energy for heating and hot water that may originate from non-renewable sources for new buildings, according to the Energy Strategy 2050 and the CO2 Act [5]. The main measures considered are:
1) Measures for increasing energy efficiency includes a “Building Programme” to reduce energy consumption in buildings and to subsidise the cost of the energy-saving renovation of buildings; Tax incentives for building renovation, preferably total renovations; Competitive tenders, programmes and projects which contribute towards more economical energy consumption in industry, the services sector and households.

2) Measures for promote the development of renewable energies includes: a Feed-in remuneration scheme; contributions towards investment costs; support for existing large hydropower plants; National interest status for production of electricity from renewable sources if be compatible with the protection of nature and landscapes; facilitated licensing procedures for the production of electricity from renewable sources are to be shortened and simplified which must be abbreviated and simplified when submitted to the Federal Commission for the Protection of Nature and Cultural Heritage.

At regional level, the measures to increase the share of RES energies are integrated in specific regulations and energy planning strategies (e.g. Cantonal Energy Plan (PEC); Cantonal Energy Prescription Model (MuKen/MoPEC); Land Use Planning (LPT), etc.) and through regional funds the energy policy is supported (e.g. in Ticino region, there is the FER, Fondo energie rinnovabili (FER) a Cantonal Fund, which is one of the important measures to achieve the objectives set at national level, to finance the construction of plants that produce electricity from renewable sources in Ticino, research projects primarily in the electricity sector and municipal activities in the field of efficiency and energy saving. Furthermore, the implementation of the cantonal energy policy, as well as through incentives and, must absolutely be operated through sensitization, information and specific training strategies for the energy sector to the final end-users. Local associations (as for example in Ticino, TicinoEnergia or at national level, SvizzeraEnergia) support the federal and cantonal energy policy with concrete measures to sensitize public opinion in Switzerland towards energy issues, promotes innovative projects and supports training and professional development.

At local level, there are many energy programs and tools available to municipalities, regarding all energy strategies in the building sector. Some of these energy programs and tools, as for example: City of Energy® Label; Region-Energy tool; Sustainable Neighborhoods, an online tool that consists of supporting decision-making and building sustainable neighborhoods; 2000 Watt Areas, an Energy City certificate; Prokilowatt program which supports projects that reduce electricity consumption; or the The KliK Foundation promotes various greenhouse gas reduction activities, are well-described in the template fact sheet in the Annex to this document. Besides, at the level of the municipalities, cities, areas and regions, there are techno-economic models to promote renewable energies. An example are the participatory models, applicable to collective projects like for example, share-purchasing groups and projects with a third-party investor involved, who invests, maintains and operates a RES installation (ad example a solar plant installed on a roof), offering a competitive price for the energy. Specific examples of application are presented in the documented template fact sheet in the Annex. Furthermore, in Switzerland, there is a specific program for strategic “Flagship projects”, that are demonstrative pilot projects subsidized by the Swiss Federal Office of Energy (SFOE) to develop and demonstrate innovative energy solutions at real scale.

With regard the application to historic buildings and protected areas ISOS (federal Inventory of Swiss Heritage Sites) there are: Specific Regulations; National Handbooks (e.g. Energy and monument and Solarkultur / Cultura solare) or Regional Guidelines (e.g. cantonal guidelines) when consider the implementation and use of renewable energies. Examples are reported in the Annex, as for example, CarSol pilot project, for the global solar planning of the City of Carouge, Swiss heritage site ISOS of national significance in the Canton of Geneva, which has been the basis for a national handbook published by the Swiss Federal Office of Culture (OFC) on how to better join solar energy and construction culture in Switzerland, illustrating how the Municipalities can reconcile photovoltaic and quality constructions (Solarkultur / Cultura solare). The new approach to solar planning has shown that it is possible to achieve optimal use of solar energy - thermal and photovoltaic - while preserving the heritage and architectural quality of the site. An intelligent solar strategy must therefore set priorities that will vary according to the territory in order to reconcile two aspects that seem to be contradictory, modern solar plants on one side and settlements with high historical-cultural value on the other.
### STRATEGIES

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#### Renewable Energies


**POLICIES & REGULATIONS: INCENTIVES, FEED-IN-TARIFF, TAX RELIEF**

To incentivize the use of RES, government uses feed-in tariff policies and tax relief, regulated by the Energy Ordinance (OEn) of the Swiss Federal Council (OEn, 1st November 2017) [7]. The feed-in-tariff system evolves in the last years reducing the rates of remuneration to cover the costs for placing electricity on the grid (RIC) over the years promoting on-site self-consumption of the energy generated. Nowadays, plant operators can consume at the production site all or part of the energy produced or sell all or part of the energy produced, so that it is consumed, in the place of production. There are three different incentives or feed-in-tariff methods: 1) system of remuneration for electricity input (RIC, art. 19 LEnE); 2) single remuneration (RU, art. 25 LEnE) or 3) contribution to the investments according to article 26 or 27 LEnE (ST solar thermal and PV photovoltaics). For photovoltaic systems, the single remuneration RU (2) has a rate of remuneration (ct./kWh) for the supply of electricity that varies according to the following power classes: ≤ 100 kW (RUP, small PV systems); or large PV systems RUG ≤ 1000 kW and > 1000 kW, besides depending on the period of commissioning of the system (Energy Promotion Ordinance, OPEn) [8]. The Federal Council, in the last update of February 2019, starting from 1st April 2019, has adopted new reductions on feed-in-tariff rates and explicitly provides for the possibility of establishing a Grouping for the purposes of own consumption [9].

For electricity generated with hydroelectric, biomass, geothermal, wind power plants, for installations with a power ≥ 100 kW there is a feed-in remuneration system (SRI). There are also single payment for small installations (RUP) installations with a power defined based on equal market prices (approx. 30% of average investment costs).

The information is contained in the pronovo.ch platform ([https://pronovo.ch/](https://pronovo.ch/)).
Renewable Energies

**TICINO CANTON**

**REGULATIONS & ENERGY PLANNING STRATEGIES**

Energy strategies are implemented at regional level in the building sector through the Cantonal Energy Plan (PEC) [10]. The needs of energy supply, the free market and the economic and social development are integrated, coordinated and weighted in the PEC. From the energy point of view, the plants must meet the requirements defined by the Regulation on the use of energy (RUEn) [11], which came into force on 16 September 2008. The RUEn regulates the application of chapter IV "Measures on buildings and installations" of the Law Cantonal Energy Council of 8 February 1994 in accordance with the new Cantons Energy Prescription Model (MukEn/MoPEC, 2014) [12], adopted by the Conference of Cantonal Energy Directors (EnDK) on 8 April 2008.

At cantonal level, for example, the expected potential for the coming years (Figure 4), as targeted on the Cantonal Energy Plan (PEC), is to achieve a production of 280 GWh per year of electricity through PV, representing the 7% of electricity production expected (Cereghetti and Pampuri, 2013) [13]. Even though the goal to reach 99 MW by 2035 is already achieved at 45% (Impianti fotovoltaici in Ticino, 2017) [14]. Regarding solar thermal production PEC objectives are to achieve 140 GWh per year [15].

**Figure 4 – Example, objectives of the PEC for solar thermal and electricity from solar renewable sources [GWh/year] [13]**
Renewable Energies

TICINO CANTON

REGIONAL FUNDS

Complementary programs to federal subsidies and tax deductions, for investments in RES and energy efficiency measures, are offered in most cantons and by many municipalities to make renewable energy installations even more attractive. At regional level, in Ticino, the Renewable Energy Fund (RES) [16], since May 2014, finances the construction of electricity plants from renewable sources, research projects, studies, consultancy and municipal activities in the field of efficiency and energy saving. Furthermore, the Canton’s incentive programme (decree of 6 April 2016) aims to promote the economical and rational use of energy and the production and use of energy from indigenous renewable sources. In order to obtain the incentives, the minimum amount of Fr. 2,000 per request must be reached. Incentives can only be granted if the interventions and works to be promoted are carried out by companies and/or firms based in Switzerland (www.ti.ch/incentivi).

SENSITIZATION, INFORMATION AND TRAINING STRATEGIES

The implementation of the cantonal energy policy, as well as through incentives and energy planning strategies, must absolutely be operated through information, consultancy and specific training for the energy sector, to the final actor, be it the individual, a private or public entity. TicinoEnergia Association (Figure 5) was set up on September 2008, by initiative of the Canton, as entity outside the administration, with the aim of promoting the rational use of energy, the use of energy renewables and sustainable mobility in the territory, supporting federal and cantonal energy policies for a sustainable energy supply.

Furthermore, at national level, the SvizzeraEnergia (Figure 6) program was set up by the Federal Council to promote energy efficiency and renewable energy. The program sensitizes public opinion in Switzerland towards energy issues, promotes innovative projects and supports training and professional development.

Figure 5 – TicinoEnergia Association webpage. Source: www.ticinoenergia.ch

Figure 6 – SvizzeraEnergia webpage. Source: www.svizzeraenergia.ch
### Renewable Energies

**STRATEGIES**

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<th>NATIONAL LEVEL</th>
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<th>LOCAL LEVEL</th>
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#### ENERGY PROGRAMS & TOOLS

Energy policy tools available to municipalities, regarding all energy strategies in the building sector (Figure 7):

- **City of Energy® Label** ([www.cittadellenergia.ch](http://www.cittadellenergia.ch)): an instrument aimed at managing the municipal energy policy at the forefront.

- **Region-Energy** ([www.regione-energia.ch](http://www.regione-energia.ch)): Free tool provided by the Swiss Federal Office of Energy to draw up energy balances and CO₂ gas emissions and estimate the potential for efficiency and use of renewable energy at municipal level and regional.

- **Sustainable Neighborhoods** ([www.quartieri-sostenibili.ch](http://www.quartieri-sostenibili.ch)): an online tool that consists of supporting decision-making and building sustainable neighborhoods and is aimed at municipalities and all other potentially interested parties.

- **2000 Watt Areas** ([www.2000watt.ch](http://www.2000watt.ch)): The Energy City certificate for 2000 Watt areas stand out the settlement characterized by a sustainable use of resources for the constructions, their management, modernization and mobility induced. The methodology is based on the City of Energy label and the SIA energy efficiency path for buildings. The certificate is awarded for a fixed term and must be periodically renewed.

- **ProKilowatt** is a program of the Federal Office of Energy, supports projects that reduce electricity consumption. The incentive contributions are a means of motivating companies to renew obsolete installations and invest in high-efficiency technologies.

- **The KliK Foundation** promotes various greenhouse gas reduction activities in Switzerland on the four platforms Transport, Enterprise, Buildings and Agriculture.

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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
### Renewable Energies

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<thead>
<tr>
<th>MUNICIPALITIES, CITIES, AREAS AND REGIONS</th>
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<tbody>
<tr>
<td>TECHNO-ECONOMIC MODELS TO PROMOTE RENEWABLE ENERGIES</td>
</tr>
<tr>
<td>Techno-economic models now available fall into two categories:</td>
</tr>
<tr>
<td>1) <strong>Participatory models</strong>, applicable to collective projects:</td>
</tr>
<tr>
<td>a) Investments in a RES project; b) Shared Renewable Programs; c) Share-purchase program/groups</td>
</tr>
<tr>
<td>2) <strong>Strategic - third-party investor involved</strong>, that are mainly: a) financial aids, incentives and feed-in tariff methods (e.g. subsidies, tax deductions, bonuses, etc. at federal or cantonal level, explained before; b) Solar contracting and Flagship or Pilot Projects, at local level.</td>
</tr>
</tbody>
</table>

The first group, participatory models could be based on crowdfunding or crowdlending practices (1.a); based on on-bill crediting or utility sponsored (1.b); or based on purchasing strategies (1.c), with option to purchase shares in PV facilities located closed their neighborhood or to set up ownership groups to make their purchases jointly to benefit from market conditions.

In the second group, at local level, **solar contracting model**, consist in an all-inclusive offer by a third-party investor who invests, maintains and operates a solar installation on a roof, offering a competitive price for the energy. "Flagship projects" are **demonstrative pilot projects** subsidized by the Swiss Federal Office of Energy (SFOE) to develop and demonstrate innovative energy solutions at real scale and in a real economic and social context [17], an example is “La Cigale” pilot project, shown in Figure 9 [18].

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[Figure 9 – “La Cigale” pilot project](http://renov-lacigale.ch/en/) in Geneva, which is the largest Minergie-P® renovation project in Switzerland with 80% of heat generation through renewable energy (1,670 m2 of solar collectors) and approximately 70% reduction in energy requirements after renovation. Swiss Solar Prize 2014. Source: [http://renov-lacigale.ch/en/](http://renov-lacigale.ch/en/) [18]
Example

Solar Energy

**“SOLE PER TUTTI” Program (TICINO)**

<table>
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<th>NATIONAL LEVEL</th>
<th>REGIONAL LEVEL</th>
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<tr>
<td>Share-purchase program</td>
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</tbody>
</table>

**“SOLE PER TUTTI” Program (TICINO)**

Share-purchase program “Sole per tutti” (Sun for everyone) is a project born from the synergy between different electricity distribution companies in the Canton of Ticino to promote the development and spread of renewable energy (Figure 10).

The initiative gives anyone, property owners and tenants, the opportunity to buy shares in photovoltaic installations located the territory. The purchase of shares should be reserved for those who cannot install a photovoltaic system mainly.

Achievements:
- Installed power 445 kWp;

**GENEROSO SOLAR PURCHASING GROUP**

Solar purchase groups have been created in four municipalities of Generoso Region (Ticino, 2012-2014) [19-21], to promote and manage renewable solar installations and to provide cost-effective options. This initiative has allowed motivating many small property owners to realize their own installation, while reducing the investment costs (Figure 11). Breggia, Castel San Pietro, Morbio Inferiore and Vacallo municipalities have created in 2012 a solar thermal purchase group, and successively in 2014, a photovoltaic purchase group.

“Solar purchase group” enables to acquire a greater negotiation power by leveraging the collective purchasing power of individuals, businesses, or municipal agencies, in order to benefit from conditions regarding price, quality, and transparency. It has been possible to install the largest possible number of solar plants that are correctly planned and executed (e.g. using certified products or turning to experienced installers). This participatory and collective approach has been multiple benefits for both the citizens and the local authority that joined the program and respectively the region, which promotes it (Figure 12). Real estate owners, researchers, municipal administrations, neutral consultants and installers, have joined forces to take this successful initiative forward, which was awarded with the Swiss Solar Prize 2014 (Category A, Institutions) [22], as best practice.

Achievements:
- As results, 35 small solar thermal installations and 50 photovoltaic plants were realized thanks to this initiative;
- Price reduction for solar thermal up to 50% and for photovoltaic in a range of 15-20%;
- Direct promotion of the local economy, through the involvement of the region’s companies.

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
Renewable Energies

GUIDELINES AND WHITE PAPERS

Energy and monument document (22 June 2018) [23], published by Federal Department of Home Affairs Federal, Commission for Historic Monuments, defines and specifies possibilities and strategies to weight the case by case the needs to safeguard both natural resources and protection of the monumental heritage. Regarding the production of energy suggests that, as far as possible, the use of district heating should be preferred to other measures and should be clarify with the competent authorities if and how photovoltaic and thermal systems placed on the roofs and on the facades of monuments can be installed. In any case, it is preferable to identify possible nearby places without affecting their heritage appearance (e.g. on secondary buildings, retaining walls, slopes, industrial or craft buildings nearby).

The Ticino Cantonal Guideline for interventions in historical centers (2016, Figure 13) [24], describes the value of historical assets and defines the assessment criteria for transformations and the methods of intervention. The installation of solar panels must be carefully evaluated and consider also if the roof is very visible and prominent from an external view, in a privileged position in the landscape, or if it is very visible from a public space of which constitutes an important scenography. The document states that:

→ The solar system on the roof is considered admissible if it is coplanar, protrudes by a maximum of 20 cm, the shape is compact and rectangular, of an appropriate colour and appears without visible connections or pipes.

SPECIFIC REGULATIONS FOR SOLAR SYSTEMS

The installation of solar systems in Switzerland (Photovoltaic and Solar Thermal) is regulated by current legislation, the Federal Law on Land Use Planning (LPT) [25], in particular art. 18, Art. 18a LPT and the relative updated ordinance (art. 32a OPT) states that, in residential zones, carefully integrated (on roofs and facades) solar installations are permitted as long as they do not ruin the heritage structures or natural sites of Cantonal or National importance. The last amendment, which came into force on 1.5.2014, facilitates the procedure for the installation of solar systems on the roofs of buildings, considering that, in the building zones and in the agricultural areas, the solar systems sufficiently adapted to the roofs can be built without referring to authorization release procedure, but through a simple announcement to the competent authority. The systems must be coplanar to the roof, not protrude, and present a compact shape with a low rate reflection. It is also necessary to consider all the existing Cantonal guidelines

→ The authorization requirement remains valid for solar plants in historical centers, settlements surveyed by ISOS inventory as objects of national importance, in areas of landscape protection, on rustic buildings, and on cultural heritage.

**Example**

**Solar Energy**

**APPLICATION TO HISTORIC BUILDINGS**

### CARSol PILOT PROJECT (Carouge, Geneve)

CarSol is a pilot project, for the global solar planning of the City of Carouge, Swiss heritage site ISOS of national significance in the Canton of Geneva. It aims to reconcile the protection of built heritage with the installation of solar systems (mainly photovoltaic and solar thermal). The new solar planning approach has demonstrated that an optimal use of solar energy - thermal and photovoltaic can be reached by conserving the heritage and the architectural quality of the site. The project, supported by the Swiss Federal Office of Culture (OFC) in collaboration with the Cantonal Office of Heritage and Landscape (OPS), the Cantonal Energy Office (OCEN), the Office of Planning (OU) and the City of Carouge giving rise a document which illustrates how municipalities can merge the use of solar energy with the culture of construction [26].

An interdisciplinary team, led by the Haute école du paysage, d’ingénierie et d’architecture (Hepia) together with an expert historian architect, specialist in solar research (SUPSI) and the energy supplier company of Geneve (SIG, Geneva Industrial Services), work together to pursue the objectives of this solar planning considering the quality of interventions while observing all singularities of this architectural heritage site [27].

Today Carouge is undergoing an important urban transformation redeveloping important city areas (i.e. City PAVs) close to historical site and heritage buildings. Following principles of the Swiss Energy Strategy 2050, solar renewable energy will be certainly considered. The new solar planning approach intends to overturn the current trend in which the solar power generation is handled individually considering setting up general strategies in the master plan of the city. A first step concerns the estimation of the solar energy potential (theoretical maximum production with photovoltaic and thermal) on the territory of the City of Carouge. The solar cadaster of canton of Geneva, which is freely available on the Land Information System in Geneva - SITG (https://sitg-lab.ch/solaire) with updated cadastral data, which is basis to develop the calculation method (Figure 14, Desthieux et al., 2018) [28].

**Achievements and factors assessed:**

- Solar potential estimation;
- Factors and constraints, in relation to the specific cultural and architectural values of the different areas of the city to downsize the solar potential;
- Priority perimeters for intervention, harmonized zones as function of building types and urban areas (Figure 15);
- Sensitivity of the urban context and integrability factors based on also in the legislation in force;
- Solar technologies and future solutions that will enter the market;
- Techno-economic models suitable for the spread of solar installations in each perimeter.

![Figure 14](image1.png)

**Figure 14** – Solar radiation outputs (intensity in kWh/m²/year) on building façades in a sector of the Municipality of Carouge: Source: (Desthieux et al., 2018) [28]

![Figure 15](image2.png)

**Figure 15** – Priority perimeters of intervention (CarSOL research project). Source: Hepia, Anita Frei architect, SUPSI, SIG [27]
References


[27] Culture solaire – Planification solaire – Culture du bâti (2019), Published by the Federal Office of Culture, Cultural Heritage Section and Historical Monuments. Pages 60.

Switzerland (Ticino) - RES

METHODOLOGIES

List of renewable Energies to be studied

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<thead>
<tr>
<th></th>
<th>Renewable Energy Systems (RES)</th>
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<tr>
<td>1</td>
<td>![Solar] Solar (Photovoltaic &amp; Solar thermal)</td>
</tr>
<tr>
<td>2</td>
<td>Wind power</td>
</tr>
<tr>
<td>3</td>
<td>Hydroelectric</td>
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<tr>
<td>4</td>
<td>Hydrothermal</td>
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<td>5</td>
<td>Geothermal</td>
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<td>6</td>
<td>![Biomass] Biomass</td>
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</tbody>
</table>
Solar energy vector

The potential for additional electricity generation from PV in Switzerland is the largest among all renewables, even if only roof-top PV modules are considered. Solar power has enormous potential: by 2050 it would be possible to meet around 20 percent of the current level of electricity demand in Switzerland through the use of photovoltaic systems. In 2018, about 270 MW of PV systems were installed in Switzerland, increasing the total capacity to 2.2 GW [1, 2]. In 2018, PV power generated 1.9 TWh or 3.4% of the Swiss electricity demand. Since PV faces much less opposition than other renewables in Switzerland, realizing this potential seems to be more realistic. However, since electricity from PV in Switzerland is still expensive, implementation within the next years will depend on governmental incentives and appropriate regulation. In addition, decentralized and small-scale intermittent PV generation might be a challenge for the electricity grid from a system perspective, and self-consumption is being promoted. New ways of integration considering the option of storage need to be investigated. The federal government promotes the generation of electricity from renewable energies and operators of new photovoltaic plants of at least 100 kWp can profit from the feed-in remuneration. For the installation of solar photovoltaic systems, a cantonal building permit must be obtained. The Spatial Planning Act (SPA) regulates the authorization of solar systems in construction and agricultural areas. According to Article 18 bis of the SPA, for solar systems that are carefully integrated into the roof or façade of a building, a notification to the competent authorities is sufficient instead of a building permit. Monuments and historic buildings of cantonal or national importance remain subject to the authorization requirement.

Solar energy can also be utilised very effectively in solar thermal power plants, but this is not a feasible option in Switzerland like in other parts of the earth. Although the proportion of solar heat to overall consumption in Switzerland is still relatively low, its potential is considerable. If all existing buildings were to be optimally improved in terms of energy efficiency, it would be possible to meet the heating requirements of all Switzerland's households through the use of solar collectors (source: Swiss Federal Office of Energy SFOE, [3]).

Swiss solar cadaster is an interactive web-based map covering the country to estimate the theoretical potential for solar energy applications RES [4]. This tool that can calculate the potential heat and electricity production from building roofs (www.sonnendach.ch) and façade surfaces (www.sonnenfassade.ch) and calculates solar potentials based on the model of Swiss buildings in 3D that uses geo data for high level of detail. Swiss solar cadaster is based on three groups of basic data: climate data (radiation and temperature), geo-data (building geometry and land data) and statistical data (register of buildings and housing). It is a very advanced tool and one of the few solar cadasters that contemplates the calculation of the solar potential of the façades. This solar cadaster is also used at regional and local level, through the OASI (Swiss Italian Environmental Observatory) web platform since 2012 and connected to the national system since 2018. Examples of application at local level [5] and specific research project
in Ticino to better implemented the calculation model to assess solar potential for building façades considering typological features are shown (e.g. bFAST research project, [6]). At local level, the tool is also useful for municipalities to estimate the potential of solar energy and solar heat (considering the solar thermal potential, photovoltaic or a mix of both carriers), in order to attract attention and raise awareness citizens regarding the potential exploitable of solar energy, in the entire municipal area [7].

Related to Historic Buildings and protected sites

- Swiss solar mapping tool takes into account types of objects (historical buildings and protected areas (ISOS) [8];
- For data aggregation, surfaces of façades whose distance from a Swiss settlement of national importance is less than a minimum value (ISOS criteria) are not considered.
- Solar systems are one of the RES sources that could be more easily integrated into historic buildings.

Furthermore, in Switzerland, the acceptability of solar solutions when integrated in historical contexts has been further investigated by LESO (Laboratoire d’énergie solaire et physique du bâtiment) at EPFL (Ecole polytechnique fédérale de Lausanne), in collaboration with architects and authorities, to develop the LESO-QSV Architectural integration tool (Quality Site Visibility analysis tool) [9, 10]. This tool defines a new approach for promoting solar energy while preserving urban and historical contexts.

Detailed information is shown in this specific fact sheet.
### METHODOLOGY

#### NATIONAL LEVEL

**SWISS SOLAR MAPPING TOOL (solar Cadastre)**

Swiss Federal Office of Energy (SFOE), in cooperation with the Federal Office of Topography (swisstopo) and the Federal Office of Meteorology and Climatology (MeteoSwiss), provided an interactive national solar map covering the country to estimate the theoretical potential for solar energy applications RES. The federal tettosolare.ch / facciatasolare.ch project calculates solar potentials based on the model of Swiss buildings in 3D that uses geo data from “swissBUILDINGS3D 2.0” (Figure 1), a vector-based dataset model of buildings for high level of detail.

This interactive national solar cadaster, can calculate the potential heat and electricity production from building roofs ([www.sonnendach.ch](http://www.sonnendach.ch)) and façade surfaces ([www.sonnenfassade.ch](http://www.sonnenfassade.ch)), see Figure 2. In the case of roofs, it assumes a theoretical potential for suitable surfaces at 70% considering a partial coverage due to constructive and / or technical restrictions. In the case of façades, it assumes a theoretical potential (100% occupancy of façade surfaces with solar modules). Windows, doors, balconies or eaves are not taken into consideration. In updated version (e4plus, BFE Report 8th March 2019) [4], in order to aggregate the data, this theoretical potential is reduced to a technical potential.

Solar cadaster is based on three groups of basic data: climate data (radiation and temperature), geo-data (building geometry and land data) and statistical data (register of buildings and housing). Output data for photovoltaic (PV) potential are the average insolation on the in the midpoint of roof/façade surfaces in kWh/m²/year, the total insolation on the roof/façade surfaces in kWh/year which, multiplied by defined performance factors, provides electricity yield in kWh/year and are classified from “low” to “excellent”; it makes allows to compare different locations in Switzerland and a direct connection to the PV system’s performances. For solar thermal (ST) potential estimation, building surfaces are not considered if the heat demand (hot water and heating) of the building is equal to 0 [kWh / a], the partial roof area is lesser than 10m² or the classification of annual irradiation is “low” (class 1) or “Medium” (class 2).

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**Figure 1** – swissBUILDINGS3D 2.0 describe buildings as 3D-models, considering facades, roof overhangs and realistic roof shapes without textures and dormers or annexes. Source: Federal Office of Topography (swisstopo) web page.

**Figure 2** – Screenshot from [www.sonnenfassade.ch](http://www.sonnenfassade.ch). The tool allows you to make an estimate of the energy yield and consider a portion of the façade, in a simplified way.
**METHODOLOGY**

**Solar Energy**

### NATIONAL LEVEL

**TICINO CANTON**

#### Solar Potential: Rooftops

In 2012 the **Swiss Italian Environmental Observatory (OASI)** had developed a solar mapping for the region currently no longer used, because in 2018 was proposed a new solar mapping at national level with an updated methodology ([tettosolare.ch](#)).

The estimation of solar potential of rooftops in Ticino has been evaluated by SUPSI-ISAAC recently by commissioned of the Republic and Canton Ticino, Office of Energy / Air, Water and Soil Protection Section (Soma, D’Ottavio & Cereghetti, 2017) [5]. As a first stage the calculation methodology for Ticino has considered to analyze the potentials calculated on the basis of tettosolare.ch and compare them with the data on the photovoltaic plants already installed. In order to compare the actual and potential production values, the energy yield of existing photovoltaic plants was estimated, whose power is known, multiplying the powers (kW) by 1’100 kWh / kW, in order to estimate the energy production for individual PV plants.

From the tettosolare.ch database, two subgroups of the roof are extrapolated to avoid keeping all the surfaces that are not particularly favorable for the installation of solar energy and based on insulation factors (Figure 3) and depending on the type of roof—flat or tilted—corrective factors have been considered (Figure 4).

Finally, all the geometries linked to the same EGID code (Federal Building Identifier) have been merged to compare the installations present on a certain building (associated with an EGID), with all the surfaces present in tettosolare.ch, referable to that EGID (Figure 5).

#### Solar potential: Façades

The research project bFAST [6], co-financed by the cantonal energy renewable fund (FER) developed a new approach to assess the solar potential for photovoltaic integration in façades of existing buildings by evaluating both energy and building features, by considering its typological and constructive constraints (e.g. balconies, windows, volumes, etc.) which could reduce the solar potential.

Swiss solar map ([facciatasolare.ch](#)), as decision tool for supporting the preliminary estimation of solar potential, do not has the purpose to quantify the “real” solar potential but rather to provide an indicative scenario based on the available irradiation of the building surfaces. A more accurate and realistic estimation is possible considering typological and morphological aspects based on building archetypes. The methodology (Figure 6), based on an analysis of the Ticino building stock (e.g. most relevant categories according to building uses, year of construction, energy and refurbishment needs, etc.) were performed to define the most frequent façade archetypes.

As result, quantitative and qualitative typological “indicators”, considered as positive or negative aspects affecting PV integration, have been adopted to calculate the final value closer to the real solar potential through the equation of solar potential, validated through real case studies.

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**Figure 3** – Data selection based on insolation: (1) buildings analyzed by the solar roof database (gray polygons); (2) buildings with insolation greater than 800 kWh/m²/year (light blue) and (3) buildings with insolation greater than 1’000 kWh/m²/year (blue).

**Figure 4** – Classification of data based on the roof inclination: all roofs in solar roof (1), pitched roofs with an angle between 0° and 5° (2) and with an angle greater than 5° (3).

**Figure 5** – Fusion of polygons by EGID code (Federal Building Identifier): visible roofs in tettosolare.ch (1), selected roofs with insolation greater than 800 kWh/m²/year (2, light green) and roofs melted by pitch corrections with equal EGID (3, dark green). When EGIDs were equal to 0, the roofs were not melted and the data were considered separately.

**Figure 6** – Methodological process of bFAST research project [6].
Example

Solar Energy

<table>
<thead>
<tr>
<th>NATIONAL LEVEL</th>
<th>REGIONAL LEVEL</th>
<th>LOCAL LEVEL</th>
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**TICINO CANTON**

**Solar potential: Rooftops**

The total potential indicated by [tettosolare.ch](http://tettosolare.ch) for Ticino is 4'844 GWh, as a maximum value, estimated without taking into account any corrective factor.

In the study performed by SUPSI-ISAAC in 2016 [5], the potential still exploitable, as a sum of all the potentials at the municipal level considering all the corrective factors, corresponds to 2'612 GWh (coverage through photovoltaics without making considerations on the plants already installed). This, reduced by the portion related to the 76 GWh of production coming from plants already installed (Figure 7), would bring this value to 2'536 GWh (Figure 8).

Considering, moreover, the results from the analysis presented by ISAAC, always taking into account the corrective factors and excluding the less interesting portions of the roof and the portions of the roof already exploited, a maximum potential of 2'472 can be estimated (larger portions of roof of 800 kWh/m²/year and 2'172 GWh (portions of roof greater than 1'000 kWh/m²/year).

**Solar potential: Façades**

bFAST [6] research study confirms a significant potential for the use of solar systems in façades at the cantonal/regional level. Based on a statistical data from different available datasets, such as the federal Register of Buildings and Dwellings RBD, the Building Programme data (2010-2016) for energy retrofit of buildings and the Cantonal Energy Certificate of Buildings (CECE®) data since 2009, the Canton Ticino building stock consists mainly of residential buildings (96.28 % that's account for 108'817 of a total of 113'023 buildings analyzed).

A relevant part (up to 70%) was built before 1980 most will require an energy retrofit in the coming years.

However, from the data processed in the annual reports of the Building Incentives Program, it appears that only a small percentage of buildings have requested financing for the renovation (2.9% if we consider the analyzed Ticino real estate from this 3.5% are multi-family houses MFH). This means that 96.5% of the multi-family buildings are yet to be rehabilitated and can benefit from a combined intervention including both facade energy retrofit and the use of active solar systems. Considering only residential buildings, the total estimated gross usable façade area is about 41.67 km². If only the 5% of all theoretical gross façade area available was used to integrate solar systems (which corresponds to 2.24 km² for the total of buildings and 0.99 km² only for MFH), considering a PV exploitation factor of 1 kWp/10 m² and an average energy yield of 500 kWh/kWp, this could generate about 112 GWh/year at Cantonal level, namely configuring a realistic contribution of façades for about 43% to the Cantonal Energy Plan (about 208 MWp installable for approx. 104 GWh/year).

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**Figure 7** – Example of photovoltaic systems visible from orthophotos with reference information. Source: Confederazione Svizzera, «map.geo.admin,» 2018. [Online]. Available: [https://map.geo.admin.ch/](https://map.geo.admin.ch/)

**Figure 8** – Example from the comparison between the installed photovoltaic systems (estimated production) and the solar potentials of tettosolare.ch. The color of the polygons represents the percentage differences between the estimated production of the existing PV systems and the theoretical potential from the tettosolare.ch data. Source: [5]
SOLAR ENERGY

METHODOLOGY

Solar potential per community (MUNICIPALITIES)

On the basis of the solar potentials of individual rooftops and façades at national level, the SFOE tool calculates the total potential for solar power and solar heat for the municipalities.

The methodology to estimate the solar potential per community consider three different possibilities or statements:

1. Potential Solar heat: Calculation of the expected yield of solar heat, if the best roof surface or the best façade surface of a house is used only for solar heat.
2. Potential Solar power 1: Calculation of the expected yield of solar power if, in addition to the solar heat, the remaining roof surfaces and façade surfaces are used for photovoltaic systems.
3. Potential Solar power 2: Calculation of the expected output of solar power, if all roof surfaces and façade surfaces are only used for photovoltaic systems.

At municipality scale the estimate of the potential is based on the usable area, according to the following assessments:

- Estimate of usable surfaces (roof surfaces of less than 10 m² and façade surfaces of less than 20 m² are not included in the calculation);
- Estimated production potential per m² of suitable surfaces;
- Reduction based on physical and legal limitations and considering constructive and / or technical restrictions (i.e. usable roof surfaces are exploited to the extent of 70% and usable façade surfaces are exploited to the extent of 45-60% depending on the type of building).

The tettosolare.ch facciatasolare.ch application can be integrated into the web sites of the Municipalities in order to easily offer its citizens this service and to draw attention to the energy potential that has remained unused so far (Figure 9).

Results for each municipality of Switzerland are available on the website of SvizzeraEnergia. EnergieSchweiz (Figure 10) shows the example of results for the municipality of Ascona) [7].

To estimate a solar thermal installation potential that makes sense, is also necessary to consider the need for heat and the type of energy vector for heating for each building.
Example

Solar Energy

ASCONA MUNICIPALITY

Solar potential per community (MUNICIPALITIES)

Solar potential of the Municipality of Ascona (Figure 11):

1. Potential of thermal energy production (heating and hot water):
   - Rooftops: 18.1 GWh per year
   - Rooftops and Façades: 18.1 GWh per year (Limitation: in the historic center - ISOS - it is not possible to install solar panels).

2. Electric energy production potential in addition to thermal energy:
   - Rooftops: 30.61 GWh per year
   - Rooftops and Façades: 49.7 GWh per year


Solar potential of the Municipality of Ascona (BFS-No. 5091)

<table>
<thead>
<tr>
<th>Only roofs</th>
<th>Combination of electrical and thermal energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric power production potential:</td>
<td>Potential of thermal energy production (heating and hot water):</td>
</tr>
<tr>
<td>45.89 GWh per year</td>
<td>18.1 GWh per year</td>
</tr>
<tr>
<td>Electric energy production potential in addition to thermal energy:</td>
<td>30.61 GWh per year</td>
</tr>
</tbody>
</table>

Energy production potential power for electricity (3):
- Rooftops: 64.98 GWh per year
- Rooftops and Façades: 64.98 GWh per year

METHODOLOGY

Solar Energy

RELATED TO HISTORIC BUILDINGS

Solar potentials: Historical Buildings and protected areas ISOS

The methodology used by Swiss solar mapping tool to estimate solar potentials takes into account types of objects (historical buildings, towers, etc.) and protected areas (ISOS), as seen in Figure 12. To test the calculation methodology the available geodata of the Federal Inventory of Switzerland worthy of protection of national importance ISOS (opendata.swiss) were used.

The Federal Inventory of Switzerland’s protected sites ISOS [8] sets conservation objectives in various stages. In ISOS-protected town centers a solar use of façades is therefore currently not realistic. Therefore, in the calculation method, for data aggregation to estimate the solar potential at national, regional or local level, the surfaces of façades whose distance from a Swiss settlement of national importance is less than a minimum value (ISOS criteria) are not considered. ISOS data is today only georeferenced as points, which implies that all façades in the following orbits of ISOS points are excluded from aggregation but each ISOS category has different perimeters: 1) hamlet and village: 100 m; 2) Town / village and urbanized village: 150 m; 3) City: 200 m; 6) special case (mostly single objects): no exclusion criterion. Should the ISOS data be available as surfaces in the future, it would make sense to use these ISOS surfaces as exclusion areas. Furthermore, Swiss solar tool does not consider the characteristics of a particular municipality, such as, for example, a number of protected buildings above the average.

Figure 12 – Screenshot from tettosolare.ch / facciatasolare.ch that shows the solar potential of Castel Grande, Bellinzona. Source BFE [4]. Complex Castel Grande complex is the first settlement center of Bellinzona starting from 5500 a. C. approximately; UNESCO World Heritage. Close to the main building there is also a current construction dating back approx. to the sec. XIII, on pre-existing early medieval buildings; restorations 1981–1991 (architect A. Galfetti). ISOS object A, Swiss National Importance.
Example

Solar Energy

APPLICATION TO HISTORIC BUILDINGS

LESO - QSV Quality Site Visibility analysis tool

Acceptability of solar solutions

Acceptability of solar solutions when integrated in historical contexts has been further investigated by LESO (Laboratoire d’énergie solaire et physique du bâtiment) at EPFL (Ecole polytechnique fédérale de Lausanne), in collaboration with architects and authorities, to develop the LESO-QSV Architectural integration tool [9-10]. This tool defines a new approach for promoting solar energy while preserving urban and historical contexts.

Solar energies, photovoltaic and solar thermal systems applied in the built environment results in new materialities and geometries changing the architecture and modifying city landscapes or already existing environments. In some contexts, like protected areas or heritage buildings, might require a thoughtful planning of these systems to avoid compromising the architectural quality of the heritage buildings and cultural assets. Quality well-designed solar systems, although if cost more, can contribute for a good solar global implementation, while not-quality solar integrations or ugly solutions can generate a rejection of technology and poor acceptability.

The LESO-QSV Quality Site Visibility analysis tool defines minimal local levels of integration quality, identifying the factors needed to set solar energy policies, able to preserve the quality of existing urban contexts. The tool helps authorities to set and implement local acceptability requirements, based on the architectural “critical issues” and threats, when integrate solar systems, which is the basis of the whole approach (i.e. sensitivity of the urban context and visibility from the public domain mainly). Three levels of visibility and three levels of sensitivity (low-medium-high) identified a grid defining nine “critical situations” for which quality expectations have to be determined (Figure 13).

The LESO-QSV method also proposes how to adapt solar energy policies to local urban specificities by crossing previous information with solar mapping tools (irradiation cadaster of the city). It will serve to set priorities of intervention, planning oriented subsidies, etc.

LESO-QSV methodology was applied to several case studies within the IEA-SHC Task 51: Solar Energy and Urban Planning, activities [9] (Figure 14).

Figure 13 – Integration quality evaluation method LESO-QSV. Source: LESO –EPFL [9-10]

Figure 14 –LESO-QSV applied to the Energy Innovation Solar Purchase Group, Ticino (Switzerland), case study of IEA-SHC Task 51. Source: SUPSI [9]

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
References


Switzerland (Ticino) - RES

**METHODOLOGIES**

List of renewable Energies to be studied

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Wind Power
Energy

Wind energy vector

- Approximately 59% of Switzerland's overall electricity production comes from renewable sources, with hydropower as the biggest contributor by far (95%). Wind power generation currently covers 0.2% of the Swiss electricity consumption. The Confederation's energy strategy predicts that wind energy will cover around 7% of Switzerland's electricity consumption by 2050. New wind turbines or wind farms are in the national interest if they have an expected average annual production of at least 20 GWh. This makes it more difficult to oppose power plants when referring to the protection of nature and heritage, but of course, the protection of nature, the environment and fauna is not underestimated. The Suisse Eole Association [1], partner of SvizzeraEnergia, supports the cantons and investors in planning wind energy projects in order to encourage and improve the acceptance of wind generators by the population. It also created a network of collaborations between electricity companies, authorities, engineering firms, investors and environmental associations to implement a sustainable energy policy.

Wind renewable energy vector are part of the 2050 Energy Strategy measures in Switzerland contemplated at a national level scale. In Switzerland, 2015, there were 34 wind farms in Switzerland with a total production of approx. 100-gigawatt hour (GWh) of electricity per year. Thanks to it, it is possible to meet the electricity consumption of around 28 000 households. The interactive on-line tool "Wind power plants" [2] (Figure 1), document current wind farms in Switzerland, based solely on information released by the operators of the plants, however, wind power in Switzerland still has great development potential. For the country there are wind maps to show wind speed (Wind Atlas of Switzerland) [1], the high potential zones, and the restricted zones. Cantons with the most wind-power potential are Vaud, Bern, Neuchâtel, Jura, Fribourg and St. Gallen. Regions particularly well suited to wind power include the crests of Jura, Gros-de-Vaud, Vaud and Fribourg Prealps regions, Bern’s Seeland region, the region around Lake Constance, and the Rhine valley in Graubunden. There will be a regional distribution of wind energy plants across the country as function of the best capacity and potentialities of the area.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
Regional and local hydroelectric / wind power exploitation depends on the measures of the Cantonal Energy Plan (PEC). In Ticino Canton, is now under construction a big wind plant in the Gotthard area with a total capacity of 11.75 MW and an estimated annual production of about 20 GWh to cover the needs of about 5,000 households. There are specific limitations to build turbines close to residential areas, and should not be built within at least 300m of homes. This is to limit noise nuisance. Densely packed turbine parks are preferred than to small numbers of turbines across a large area. In historical monuments and buildings where it is not possible to carry out an energy retrofit intervention in the building envelope, to improve energy performance, such as insulation, or only to a limited extent, modern heating systems allow to compensate the high heat requirement through the use of renewable energies.

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.
METHODOLOGY

NATIONAL LEVEL

SWISS WIND MAPPING TOOL (Wind Atlas of Switzerland)

Swiss Federal Office of Energy (SFOE), in cooperation with the Federal Office of Topography (swisstopo) and the Federal Office of Meteorology and Climatology (MeteoSwiss), provided some Swiss National Wind Maps [1] containing information about annual average of the modelled wind speed and direction at five different heights above the ground, areas with wind-power potential and federal government interests.

The data are based on a nation-wide modelling system with a horizontal grid width of 100 metres. The modelled average annual wind speed is depicted in the atlas at each grid point. The classification of wind speeds into categories can be approximated with the aid of Weibull parameters $\lambda$ (scale parameter) and $k$ (shape parameter). It is not possible to directly obtain the average wind speed from the Weibull parameters because the result is only an approximation to wind distribution and for this reason it cannot be adequately indicated for each location. The wind rose shows the relative frequency of the modelled wind directions. The averaged wind speeds and corresponding Weibull parameters are visible for each sector.

The calculation of wind speeds and directions is based on long-term measurements that have been incorporated into the models. Because the measurement points are not available everywhere throughout the country at a suitable density, and inaccuracies can occur in the modelling of wind flows in complex terrain, the results are subject to uncertainties. These range from +/- 0.5 metres per second in the Jura range, +/- 0.8 metres per second in the central plain and +/- 1.0 metres per second in the pre-Alps, to +/- 1.5 metres per second in the Alps. For maps at heights of more than 100 metres above the ground, significantly fewer measurements are available for modelling purposes, and this leads to increased uncertainties in the results. The data have to be regarded as rough estimates of the wind conditions. To assess the wind conditions at a specific location, measurement on site is therefore essential.

Source: www.bfe.admin.ch

Figure 2 – Areas with wind-power potential in CH (http://www.uvek-gis.admin.ch/BFE/storymaps/EE_Windatlas/).

Figure 3 – Areas with wind-power potential in CH (http://www.uvek-gis.admin.ch/BFE/storymaps/EE_Windatlas/).
Wind power

Example

GOTTHARD WIND FARM PROJECT (TICINO)

The **Gotthard wind farm** is an *azienda elettrica ticinese* (AET) initiative that plans to build the first 5 wind turbines in Canton Ticino at 2.130 metres above sea level.

The Gotthard is one of the few sites identified in Ticino suitable for the construction of a wind farm, thanks to its excellent windiness, suitable road accesses and an adequate electricity grid. With a total capacity of 11.75 MW and an estimated annual production of about 20 GWh, the Gotthard wind power plant will be able to cover the needs of about 5,000 households, corresponding to those in the neighboring districts of Leventina and Blenio. In addition, the project includes a series of compensation and restoration measures in the areas of landscape, soil, cultural heritage, flora and fauna. In particular, the following measures have been planned: soil remediation, the dismantling of old deposits, landfills and dirt tracks and the burial of some overhead power lines.

Additional wind measurements were carried out between November 2013 and June 2016 in order to define the most suitable wind turbine model to be installed. With regard to the authorization procedure for the project, in March 2014, two appeals to the Council of State were submitted to the variant of the zoning plan and the detailed plan, which will lengthen the initial design process and therefore the construction time of the wind farm. In November 2016, the application for construction was finally submitted. Work began in June 2019. The construction site for the plant will last two years and will be active only during the opening months of the mountain pass. It is scheduled to be commissioned in the autumn of 2020. The 2019 has been dedicated to the completion of the civil engineering works, including access to the site areas, assembly yards, foundations for the towers and tracks for the electrical connections to the network. In 2020 it will be the turn of the wind turbines, which will have to be transported on site, hoisted and connected to the grid.

From 2020 it will be integrated into AET’s Leventina production chain and will be telegraphed from the Monte Carasso Command Centre. Its production will be complementary to hydroelectric production and important synergies will arise between the various plants in the region in terms of management and maintenance.

Source: [4] AET, Azienda Elettrica Ticinese (https://www.aet.ch/IT/Progetti-92d69d00)

References

[4] Gotthard wind farm project (TICINO) - Parco eolico del San Gottardo. AET, Azienda Elettrica Ticinese (https://www.aet.ch/IT/Progetti-92d69d00)
### List of renewable Energies to be studied

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Hydroelectric Energy

SWITZERLAND - TICINO
DELIVERABLE T3.2
METHODOLOGIES - CONCLUSIONS

- Hydroelectric energy vector

In Switzerland, hydropower contributes a little more than half the electricity produced Switzerland with a share about 60% to the national production of electricity (Swiss Confederation Press Release, Bern, 02.09.2019). The maintenance and further development of this renewable energy source is therefore a declared objective of the Energy Strategy 2050. Thanks to its topography and high levels of annual rainfall, Switzerland has ideal conditions for the utilisation of hydropower. Based on the estimated mean production level, hydropower still accounted for almost 90% of domestic electricity production at the beginning of the 1970s, but this figure fell to around 60% by 1985 following the commissioning of Switzerland's nuclear power plants, and is now around 57%. Hydropower therefore remains Switzerland's most important domestic source of renewable energy. The Swiss Federal Office of Energy deals with policy-related aspects of hydropower (promotion, strategies, perspectives, etc) as well as technical and safety aspects, while the Swiss Federal Office for the Environment (SFOE) is responsible for environmental aspects (residual water, protection of bodies of water, etc).

From the latest available data from 2018 (12.31.2018), there are 658 hydropower plants in Switzerland that each have a capacity of at least 300 kilowatts, and these produce an average of around 36,449 gigawatt hours (GWh/y) per annum, 48.5% of which is produced in run-of-river power plants, 47.2% in storage power plants and approximately 4.3% in pumped storage power plants. Roughly 63% of hydroelectricity is generated in the mountain cantons of Uri, Grisons, Ticino and Valais, while Aargau and Bern also generate significant quantities [1] (SFOE, Hydropower research programme).

Swiss Confederation with the Energy Strategy 2050, intends to increase the average annual production of electricity from hydropower of at least 37 400 gigawatt hours (GWh) for 2035 and this value will rise to 38 600 GWh by 2050. In the coming years, this will require a net increase of 85 GWh / year on average (since 2011 the average has been 87 GWh / year). To achieve these results and to exploit the achievable hydroelectric potential, current power plants need to be renovated and expanded considering ecological aspects. In terms of quantity, the goal is to increase the average estimated production level by at least 2,000GWh versus the level recorded in 2000 by renovating existing hydropower plants and constructing new ones. The instruments that will be used to promote the use of hydroelectric energy include cost-remuneration for new hydroelectric plants with a capacity up to 10 megawatts for feed-in to the electricity grid, as well as investment contributions for renovations and expansions of existing hydro plants with up to 10MW output [2]. The potential deriving from the expansion and renewal of the large hydroelectric power plants remains unchanged, while it is decidedly lower for the small hydroelectric power plants which are not profitable without a financial support. Similarly, production losses must also be considered for the provisions on residual outflows, for concessions expiring between 2030 and 2050.
Climate change will cause changes in the future. The melting of glaciers will lead to greater volumes of runoff and therefore to a greater production of hydroelectric energy in the coming decades and their function as a reservoir for the accumulation of natural precipitation will be lost. The effect can be partially compensated by creating artificial lakes in the basins that will be released [3].

Federal Act on the Exploitation of Hydropower (WRA) [4], Article 2, states that cantonal law regulates which community (canton, district, municipality or corporation) is entitled to exploit the public waters for hydropower. The community may then make use of the hydropower itself or confer the right to third parties. For the installation of a hydropower plant the operator must acquire a permit and a concession from the relevant canton or municipality. In accordance with cantonal law, the awarding authority shall determine the services and conditions against which the licensee is granted the right of use, such as fees, water interest, water or electricity supply, duration of the licence, provisions on electricity prices, community participation in profits, reversion of the licence and repurchase. The procedure for the award by the cantonal authority is to be regulated by the cantons. In Ticino, a Regional Alpine Waterworks (Podiac project [5]) and a Local hydroelectric power station (Ritom hydroelectric plant) were presented in the following templates, as example of hydropower RES implementation. It has been explored the potential of the small hydroelectric installations that could be placed in the aqueducts to exploit this water resource identifying the more promising situations to date for possible hydropower exploitation, responding to one of the measures of the Cantonal Energy Plan (PEC) [6].

Related Historic Buildings and sites

As the same as Wind energy, the cantons, with the support of the Confederation (article 11, LEnE Energy Law), must develop a renewable energy development project with a planning that offers a global vision and open to compromises which entails, in certain circumstances, that the territories are to be excluded from exploitation for large wind / water systems (negative planning and buffer distances). The development project with an overall national vision (mapped perimeter) aims to allow a targeted and efficient use of the potential represented by wind and hydraulic energy in suitable sites. In this way it is possible to ensure that the national monuments and objects of the federal inventories of the Swiss settlements to be protected (ISOS) and that Landscapes and Natural Monuments of National Importance (ILNM) are not damaged in their integrity and appearance [7].

District heating systems can be produced from different energy 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.

Furthermore, the Swiss Federal Office of Culture claims that hydroelectric power plants can be classified as monuments of a technical nature, both individual buildings of hydroelectric power plants, but also entire plants, as such express a dynamic interaction between technical and economic, political and landscape factors. The very essence of the technical installations and their complexity and dynamics are decisive aspects of their testimony value. In the case of extensions or adjustments to hydroelectric power plants of historical importance, their value as monuments must be preserved.
Hydroelectric

METHODOLOGY

HYDROPOWER IN SWITZERLAND

Based on the estimated mean production level, hydropower still accounted for almost 90% of domestic electricity production at the beginning of the 1970s, but this figure fell to around 60% by 1985 following the commissioning of Switzerland’s nuclear power plants, and is now around 57%. Hydropower therefore remains Switzerland’s most important domestic source of renewable energy.

The federal government wants to promote the future use of hydropower to a greater extent through a variety of measures. In order to exploit the achievable potential, existing power plants are to be renovated and expanded while taking the related ecological requirements into account. The instruments to be used here include cost-covering remuneration for feed-in to the electricity grid for hydropower plants with a capacity up to 10 megawatts, and the measures aimed at promoting hydropower included in the “Renewable energy” action plan. In terms of quantity, the goal is to increase the mean estimated production level by at least 2,000 GWh versus the level recorded in 2000 by renovating existing hydropower plants and constructing new ones.

Source: www.bfe.admin.ch

ALPINE WATERWORKS EXPLOITATION

The POIDAC project [5], ended in the spring of 2017, has explored the potential of the small hydropower installations that could be placed in the aqueducts, while assessing the possible increase of energy from this type of particularly sustainable exploitation of the water resource. The analysis carried out on the cantonal territory, starting from 300 theoretical case studies has made it possible to assess from a technical point of view and economic 54 case studies. In addition to providing a state of the art aqueducts existing and their complexity, the research has made it possible to identify the main barriers to technical-economic feasibility. Finally, it identified the more promising situations to date for possible energy exploitation, responding to one of the measures of the Cantonal Energy Plan (PEC) [6] extrapolation of the cases to be deepened for the second phase, v) on-site inspections, with relative completion of the technical data, vi) technical-economic analysis of the cases, vii) calculation of the energy cost. The methodology has specifically followed the following phases: i) collection of general data of the aqueducts (average flow rate, share of collection chambers, quota of tanks, with geolocation and vectorization in a GIS environment (Geographic Information System), ii) verification of availability of all the data to carry out the following steps iii) calculation of the theoretical potentials, iv) extrapolation of the cases to be deepened for the second phase, v) on-site inspections, with relative completion of the technical data, vi) technical-economic analysis of the case studies, vii) calculation of the energy cost.

### RITOM HYDROELECTRIC POWER STATION

**Ritom hydroelectric power station**

In autumn 2010, the Swiss Federal Railways (SBB), Canton Ticino and Azienda Elettrica Ticinese (AET) reached an agreement in principle for the common hydroelectric exploitation of the water currently used by the Ritom plant.

Since 1920, the water management of Lake Ritom has been the responsibility of the SBB. The agreement led to the creation of Ritom SA: a public limited company 75% owned by SBB and 25% by the Canton of Ticino, which is responsible for the construction and management of the new power plant. Ritom SA will exploit the Ticino waters that flow into Lake Ritom, for which it has obtained an 80-year concession, the waters of the Cadlimo Valley that would flow naturally to Graubünden, and the waters of Canton Uri derived from the Unteralpreuss.

The new Ritom hydroelectric power station will replace the existing plant built by the SBB in 1917. The project foresees two turbines of 60 MW each, one with a 16.7 Hz generator to supply the railway and the other with a 50 Hz generator to supply the cantonal network of AET. The plant will produce 160 GWh/year of electricity: 120 GWh for use by SBB and 40 GWh for AET.

It is also planned:
- A 60 MW pump, which will make it possible to exploit the capacities of the Ritom and Airolo reservoirs;
- A 60 MW frequency converter that will allow the exchange between the 16.7 Hz network of SBB and the 50 Hz network of AET allowing a more flexible production;
- A 100,000 m³ demodulation basin that will collect the Ritom and Stalvedro waters, mitigating the effects in the Ticino river due to minimum and maximum outflows.

The possibilities of network regulation, storage and therefore of exploiting its waters are extremely limited, particularly in the Leventina, where there are about 350 MW of installed turbines, of which about 285 MW in favour of the Canton Ticino, and no possibility of pumping. The new Ritom plant therefore plays a strategic role in the implementation of the canton’s energy policy.

Source: [www.aet.ch](http://www.aet.ch)

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### Figures

**Figure 4** – Ritom artificial lake. (Source: [www.bellinzonese-altoticino.ch/](http://www.bellinzonese-altoticino.ch/))

**Figure 5** – Rendering of the new demodulation basin (Source: [www.aet.ch](http://www.aet.ch))

**Figure 6** – Scheme of the new Ritom hydroelectric power station (Source: [www.aet.ch](http://www.aet.ch))
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

References


Switzerland (Ticino) - RES

METHODOLOGIES

List of renewable Energies to be studied

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

**Hydrothermal Energy**

**Switzerland Deliverable T3.2 Methodologies - Conclusions**

- Hydrothermal (surface waters, groundwater, sewage) energy vector:

  With its Energy Strategy 2050, the Swiss Confederation intends to increase the average annual production of electricity from hydropower to 38,600GWh by 2050 (and to 37,400GWh by 2035). In Switzerland, hydropower plants with capacities above 10 MW are categorized as “Large hydropower (LHP)”. Two types can be distinguished: reservoir/storage (damming the water and creating a reservoir lake) and run-of-river (only the water in the rivers coming from upstream is available for generation) power plants. In addition, there are pumped storage power plants, which produce electricity to supply high peak demands by moving water between reservoirs at different elevations using pumps. Often, pumped storage and reservoirs are combined using pumped water plus natural inflows to reservoirs for electricity generation. Hydropower plants use water turbines for electricity generation and now they are a mature technology where no major technology development can be expected in the future. In addition, the current situation on the electricity market reduces profitability of LHP. Below 10 MW of installed capacity, hydropower plants are categorized as “Small hydropower (SHP)” and can be categorized according to construction type (run-of-river, “Ausleitkraftwerk”/diversion, storage, “Umwälzwerke”/circulation power plants) or according to runoff medium (river-fed, wastewater, drinking water, “Dotierkraftwerk”/discharge power plant). SHP technologies as such are similar to LHP technologies. However, technical limitations for small plants for certain applications and circumstances exist, and current research aims at providing alternative solutions for medium head and low-head, respectively, low-runoff applications. The potential for new SHP plants is relatively small, but non-negligible [1].

Groundwater flow, heat and mass transport in geothermal or hydrothermal systems occur locally in the Alpine chain, where a number of precise conditions such as active runoff, deep permeability, concentrated and rapid flow and favorable geomorphological models occur surface. Advanced studies of regional and local geology, thermal water chemistry, mixing processes, infiltration area, water-rock interactions, depth of circulation, groundwater residence time, mineral-chemical footprint, etc. allow you to understand the deep flow system. Besides, in Switzerland, the exploitation of surface water for energy purposes is generally realized by exploiting the waters of the lake, which is a big resource. However, there is also room for maneuver with regard to rivers. Both of these energy sources are exploited in combination with a heat pump that allows heat to be extracted from the water for the production of thermal energy. Hydrothermal systems require, in some cases, high underground temperatures (>100°C), water-bearing geological formations and adequate generation of hot water in these formations. These pre-conditions seem to be present only a few places in Switzerland. Many aspects are still under study as for example the sustainable use of the reservoirs; and interactions arising from the use of subsurface resources on humans, environment and natural surroundings; possible new concepts for use; interaction with other concepts for use and protection; regulatory aspects; life cycle assessment aspect, etc. [1].
Methodologies to assess and better exploit the hydrothermal energy resources

Swiss Federal Office for the Environment (FOEN) offer all digital GEODATA maps for the country, regarding waters: current situation of the rivers and the lakes, water temperature rivers, flood hazard levels etc. At the same time, it is possible to check the state of surface water (i.e. monitoring networks, quantity, quality, structure and morphology) and the state of groundwater levels and spring discharges in Switzerland compared with the expected conditions. Groundwater, water protection maps and residual flow maps in relation to geography, for all the country and Cantons are provided by FOEN.

Groundwater exploitation for energy purposes it depends on some factors including, the composition of the subsoil from a geological and hydrogeological point of view; the suitability of the territory, and the available water quantities among others. Surface waters (lake or rivers) exploitation feasibility of must take into account a minimum flow rate and the energy requirements. An important factor is the investment costs for the construction of the water network of collection pipes and the distribution to the users directly influenced by the distance to the lake or river. Waste water exploitation can be an interesting source of residual heat that can be used for heating and cooling buildings. This is possible because in winter the waste water is considerably warmer than the outside air, while in summer it is colder (the water temperatures are around 12 °C). In Switzerland, over 100 waste-to-energy plants are in operation. According to calculations made by the Federal Office of Energy, this heat production system could be applied to around 5 percent of all buildings.

Related to Historic Buildings and sites

It is clear that the possibility of exploiting all these resources for the thermal conditioning of historic buildings is limited to the availability of the distribution infrastructure network in the relevant area. The possibility of direct exploitation of river waters by individual end users loses technical-economic interest for distances greater than 50 meters from the shore, in relation to the high infrastructure costs. For distances greater than 50 meters, a centralized approach could be assumed, with a heating system consisting of a large heat pump and public distribution network.

A local example of possible exploitation of Hydrothermal renewable sources in Ascona Municipality (ISOS village) is presented. Ascona city core is a national Swiss Heritage Site of the Federal Inventory of Swiss Heritage Sites, ISOS [2]. A study conducted by SUPSI (University of applied sciences and arts of southern Switzerland), has been the basis to the Municipal energy plan of Ascona (PECo Ascona [3]) which considers the possible exploitation of RES in the municipal area and investigates several options to exploit different renewable energies, such as Solar, Hydrothermal, Geothermal and Biomass. This template fact sheets presents the feasibility study, carried out by SUPSI, to exploit hydrothermal energy (groundwater, surface water and sewage water) as thermal conditioning network in the city of Ascona in Switzerland (Canton Ticino), which is a place of particular historical value, located on the shores of Lake Maggiore [4-5].
Hydrothermal energy exploitation (surface waters, groundwater, sewage) deals with many information that needs to be considerate for each situation. Switzerland has a large water supply that depends on natural factors such as weather conditions or glaciation. However, the volume of water in watercourses is influenced by hydropower production (residual flow, hydropoeaking) and due to climate change, in the future, water availability will be limited during dry periods.

The Swiss Federal Office of Energy (SFOE) deals with policy-related aspects of hydropower (promotion, strategies, perspectives, etc.) as well as technical and safety aspects, while the Swiss Federal Office for the Environment (FOEN) is responsible for environmental aspects (residual water, protection of water, etc.). The FOEN monitors the flow and flow rate of Swiss rivers and operates a network of hydrological study areas. In watercourses, discharges downstream from power plants can fluctuate daily. Swiss Federal Office for the Environment (FOEN) offer all digital GEODATA for the country, regarding waters: current situation of the rivers and the lakes, water temperature rivers, flood hazard levels etc. At the same time, it is possible to check the state of surface water (i.e. monitoring networks, quantity, quality, structure and morphology) and the state of groundwater levels and spring discharges in Switzerland compared with the expected conditions.

**Groundwater, water protection maps and residual flow map**

Groundwater and water protection maps (Figure 2), show data in relation to geography, for all the country and Cantons. **Groundwater maps** show the extent and thickness of the groundwater resources and their flow directions. For a construction projects, for instance, groundwater maps indicate how high the groundwater level is. For water supplies, they provide information on the flow direction and therefore the origin of the moving groundwater or the best places to exploit new groundwater resources. the information available concerns above all: a) Groundwatermap; b) areas with usable groundwater reserves and the peripheral areas required for their protection ; c) Groundwater protection zones/areas.

The cantons generally produce **water protection maps** to a scale of 1:25,000. Furthermore, the **cantonal water protection maps** is accessible in the FOEN-WebGIS Digital water protection map of Switzerland (Figure 3). An analysis using geographical information systems has formed the basis e.g. for outline maps of the groundwater protection zones and water protection regions.

The FOEN's Swiss **residual flow map** (Figure 4) shows where water is withdrawn from rivers and streams, what it is used for, how much remains in the river, and where water withdrawals are causing ecological problems. Most of these withdrawals are used for hydropower. The map provides a preliminary survey of the application of residual water provisions. Alpine rivers downstream from storage power plants are particularly affected by changing flow rates all the way up to their mouths in Pre-Alp lakes. In addition to electricity production, water is also withdrawn from bodies of water for irrigation or cooling.
Local estimation model potential of ambient heat – groundwater

The potential for exploitation of groundwater for thermal purposes is estimated according to the following steps:

- Analysis of the composition of the subsoil from a geological and hydrogeological point of view;
- First classification of the studied territory in relation to the suitability of exploiting groundwater for thermal purposes;
- Estimation of available water quantities, through a comparison with the characteristics of the settlement system.

Local estimation model potential of ambient heat – surface water

The exploitation of surface water for energy purposes is generally realized by exploiting the waters of the lake, which is a big resource in Switzerland and the region of Ticino. However, there is also room for maneuver with regard to rivers. Both of these energy sources are exploited in combination with a heat pump that allows heat to be extracted from the water for the production of thermal energy.

Nevertheless, some conditions are essential to allow the exploitation of these surface waters:

- First of all, a minimum flow must always be respected.
- A further factor is that relating to the location of the current energy requirement. As the distance from the lake increases, the investment costs for the construction of the water collection pipes and the distribution to the users with them increase proportionally. In general, the possibility of direct exploitation of river water by individual end users loses technical-economic interest for distances greater than 50 meters from the shore, in relation to the high infrastructure costs. For distances greater than 50 meters it could possibly be assumed that the water will be used according to a centralized approach, with a thermal plant consisting of a large heat pump, flanked by a network for distributing heat to the individual users.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
METHODOLOGY

Hydrothermal

ASCONA MUNICIPALITY (ISOS Village of National Importance)

Feasibility study for drinking and sewage water exploitation

The study conducted by SUPSI, in the PECo Ascona, energy plan of Ascona municipality [3-5], estimates the infrastructures’ available energy production potential. The existing infrastructures in the area can have a dual function: in addition to the primary function for which they were built, they can be used as a source of energy, thermal or electric, with a double benefit. Potential exploitation residual heat from industrial processes is neglected in this area. Due to a preliminary assessment of the characteristics and potential of the infrastructures present in the Ascona area, it was considered the following energy potentials:

- Potential to exploit energy from the aqueduct: heat and swirling from drinking water;
- Potential for sewage exploitation: heat;

Hydrothermal energy exploitation from the aqueduct:

Heat from drinking water, the Drinking Water Company of the Municipality of Ascona deals with the distribution of drinking water in the village of Ascona. The production of water is guaranteed by 8 sources and 2 wells for pumping groundwater. The water flowing into the aqueduct has an average temperature higher than the outside air temperature. The exploitation possibilities investigated are essentially two: 1) connection of the heat pump of a single building to the distribution network and 2) the installation of a heat exchanger directly in the main pipe.

Electricity from the swirling of drinking water, based on the possibility of profitable management of a hydroelectric power station powered by drinking water.

Potential for sewage thermal energy exploitation

Waste water can be an interesting source of residual heat that can be used for heating and cooling buildings. This is possible because in winter the waste water is considerably warmer than the outside air, while in summer it is colder (the water temperatures are around 12 °C). The analysis carried out in the Ascona municipality focused on the canalization system of the fog network taking into consideration the eligibility criteria linked to the number of users and the structure of the canals, defining the catchment area of the canals present in the territory. A further criterion concerns the minimum diameter of a pipe of at least 80 cm so as to allow the installation of heat exchangers inside them. Furthermore, to define the potential of exploitation of residual heat from sewage in reference to the current building park, only buildings located at a maximum distance of 100 m from the canalization have been considered and equipped with heat pumps.
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
Switzerland (Ticino) - RES

METHODOLOGIES

List of renewable Energies to be studied

<table>
<thead>
<tr>
<th>Renewable Energy Systems (RES)</th>
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<td>5 Geothermal</td>
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<td>6 Biomass</td>
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</tbody>
</table>
Geothermal Energy

Switzerland

Switzerland - Ticino

Deliverable T3.2

Methodologies - Conclusions

- Geothermal energy vector

Swiss Federal Office of Energy, includes the Geothermal Energy research programme is geared towards the Energy Strategy 2050, with specific tasks devoted to energy saving, the increased contribution of the renewable energies and the reduction of CO2 emission. The potential for geothermal electricity production in Switzerland is very high, but there is still a great deal of uncertainty regarding the associated costs and feasibility. Over 3,700,000 megawatt hours (MWh) of geothermal energy were produced in Switzerland in 2018. Over 80 percent of the geothermal energy produced comes from geothermal probes (Table 1). Between 2004 and 2017, geothermal heat production increased by 177 percent. (Source: GEOTHERMIE-SCHWEIZ).

The potential provided for deep geothermal power generation, from hydrothermal systems and from so-called Enhanced Geothermal Systems (EGS) is the most uncertain among domestic generation options and still needs to demonstrate its technical, economic and social viability [2, 3]. Despite this, the potential for production of electricity using geothermal energy are increasingly important along with exploration for and the commercially viable development and production from geothermal reservoirs. Research priorities in Switzerland are the direct use and production of electricity using geothermal energy and shallow geothermal energy. One of the main obstacles to the development of this technology is the fact that very little is known as yet about the local conditions deep underground.

For this reason, geothermal energy projects are able to benefit from a guarantee financed from the network surcharge fund. The Confederation supports projects for the direct use of geothermal energy for heat supply in order to reduce CO2 emissions from buildings in the long term, as the federal government promotes the generation of electricity from renewable sources. Operators of new plants that produce electricity from geothermal energy can profit from the remuneration of the feed-in at cost. By 2030, around a dozen geothermal plants are expected to operate, which will produce a combined total of 800 GWh of electricity. As for deep geothermal systems, there are several in function that are used to provide heat, for example for district heating networks. Several deep geothermal energy projects are currently planned in Switzerland and are in various stages of development [4]. GEOTHERMIE-SCHWEIZ [5] association is the central federation of geothermal actors in Switzerland and the SCCER-SoE, is the Swiss Competence Center for Energy Research - Supply of Electricity [6].

Related Historic Buildings and sites

This document collects all the information regarding methodologies to estimate the Geothermal potential (Geothermal digital maps) in Switzerland with a practical application in the example of Ascona municipality (ISOS Village). Ascona appears in the federal Inventory of Swiss Heritage Sites, ISOS of National Importance [7-9]. The tabs gather other example, the GEO4CIVHIC H2020 research project (Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings) related the practical application on using geothermal energy in Historic Buildings are also presented. GEO4CIVHIC [10] intends to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitting of existing and historical buildings. Virtual and real demonstrators, including historical buildings in world heritage areas, are used to validate and demonstrate the feasibility of different technical solutions.

Furthermore, a real best practice case study in Ticino Canton was presented. An Historical Building in the municipality of Orselina [11, 12], has been recently energy renovated, using a solar-powered heat pump with a geothermal system. The energy for heating and hot water is supplied not only by the geothermal heat pump but also by vacuum tube solar collectors. The solar photovoltaic and thermal system are harmoniously integrated in the context of the building.
METHODOLOGY

Geothermal

NATIONAL LEVEL

REGIONAL LEVEL

LOCAL LEVEL

SWITZERLAND

Geothermal potential

Swiss Federal Office of Energy, includes the Geothermal Energy research programme is geared towards the Energy Strategy 2050. The potential for geothermal electricity production in Switzerland is very high, but there is still a great deal of uncertainty regarding the associated costs and feasibility. The Swiss Geothermal Society (SGS) was entrusted with the mandate to promote the application of geothermal energy at a national level. In the longer term it is conceivable that a significant proportion of the electricity consumed in Switzerland could be produced at geothermal power plants.

The main production of heat by Geothermal energy in Switzerland of about 3'692'100 (MWh/year) in 2018, came from: geothermal probes and underground collectors, 80.8%; exploitation of groundwater 11.5%; thermal waters, 5.3%; Geostructures (heating and / or cooling) accounts for 1.5%; deep aquifers (including direct exploitation) 0.6%; tunnel waters (including direct exploitation) 0.3%; and the deep geothermal probes which represent only 0.1% (Source: Link K. Geo-Future GmbH: Statistik der geothermischen Nutzung in der Schweiz, Ausgabe 2018). Between 2004 and 2017, geothermal heat production increased by 177 percent. (Source: GEOTHERMIE-SCHWEIZ).

Research priorities in Switzerland are the direct use and production of electricity using geothermal energy and shallow geothermal energy. The potential for production of electricity using geothermal energy are increasingly important along with exploration for and the commercially viable development and production from geothermal reservoirs. One of the main obstacles to the development of this technology is the fact that very little is known as yet about the local conditions deep underground. Many aspects are still under study as for example the sustainable use of the reservoirs; and interactions arising from the use of subsurface resources on humans, environment and natural surroundings; possible new concepts for use; interaction with other concepts for use and protection; regulatory aspects; life cycle assessment aspect, etc.

The Confederation supports geothermal electricity projects with the following measures: 1) Guarantee of geothermal risks by assuming up to 50% of the investment costs attributable, if a project does not achieve the expected success; 2) Remuneration to cover the costs for the introduction into the grid of electricity (RIC) which favors the production of electricity starting from deep geothermal energy for a certain period; 3) Pilot and demonstration projects. While the Confederation focuses in particular on deep geothermal energy, the support of shallow geothermal energy lies with the cantons. There is also information about deep geothermal energy in the Swiss plateau available from a simplified 3D geothermal model map from GEOWATT AG from 2007 (only Malm in the area of the Swiss Molasse Basin).

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
METHODOLOGY

TICINO CANTON

Local estimation—geothermal potential

The identification of the potential of exploitation of the energy contained in the subsoil is carried out according to the following steps:

• Delimitation of areas where the installation of geothermal probes is not precluded for groundwater protection reasons;
• Estimation of the energy needs expressed by the existing buildings located in these areas;
• Identification of the categories of buildings that are most likely to convert their heating system to geothermal energy (geothermal probes).

EXAMPLE OF THE ASCONA MUNICIPALITY

The town of Ascona is a place of particular historical value, whose core is composed of buildings mainly built in the 19th century (historical city core). Ascona Village is in the federal Inventory of Swiss Heritage Sites (ISOS) of National Importance [7].

An estimation of geothermal potential for Ascona municipality was made by SUPSI, University of applied sciences and arts of southern Switzerland. After a delimitation of areas, resulting from the analysis of the geological situation, a quantitative assessment is therefore made of the “conversion” potential of existing buildings to geothermal probes”. For this purpose, existing buildings located in areas suitable for the installation of geothermal probes are considered. As a precaution, buildings of a craft and industrial nature are not considered, as they frequently require high temperature heat, for which the geothermal probes with heat pump are not suitable.

In the event that the installation of geothermal probes for the existing building were to spread in significant terms, the danger that the subsoil may become impoverished should not be neglected, with a gradual decrease in the heat that it is able to release. In order to avoid this effect, which in the long run could have repercussions on the chemical-bacteriological characteristics of the subsoil and groundwater, it is necessary to ensure that during the summer months the soil can recharge itself with the heat taken in the winter months. To this end, geo-cooling techniques could be exploited, which allow both the recharging of the heat in the subsoil and the cooling of the building in the summer months. These are techniques that, at present, are of particular interest for large, administrative and commercial buildings, as they allow a faster return on investment.

Source: Pampuri et al., SUPSI [8, 9]
Example

Geothermal

GEO4CIVHIC Project

The main goal of GEO4CIVHIC H2020 project (Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings) is to develop and demonstrate easier to install and more efficient GSHEs, using innovative compact drilling machines tailored for the built environment & developing or adapting HPs and other hybrid solutions in combination with RES for retrofits through a holistic engineering and controls approach improving the return of investments.

GEO4CIVHIC’s target is to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitting existing and historical buildings. It is based on innovative solutions investigated by an international expert group of companies and research centers. The project includes virtual and real demonstrators.

Virtual demonstration facility example:
Administrative building AIL (Muzzano, Switzerland)

The administrative building of AIL (Aziende Industriali di Lugano) is located in Muzzano, Switzerland. The building was built in 60’s ages, and it is actually heated through a gas co-generator, thermal solar panels and a gas burner. In 2017 the construction site began, with the goal of a complete energetic refurbishment of the building and the creation of new offices. The Energetic Reference Area of the completed building is about 6’000 m2 (3’500 m2 for the refurbishment and 2’500 m2 for the new building part). The gas co-generator and the gas burner are going to be decommissioned, and the future heat will be produced through heat pumps coupled with boreholes heat exchangers. Solar panels will be kept on the roof.

Real demonstration facility example:
UNESCO Historical ‘Angel’s Gate’ building (Ferrara, Italy)

The ‘Angel’s Gate’ building is a historical building in which the medium sized hybrid dual source high temperature heat pump developed will be installed. The Angel’s Gate is a remarkable example of fortified heritage, associated with Ferrara’s defensive walls built in 1525 and designed by the renowned renaissance architect Biagio Rossetti. Conceived as a watchtower, it commands a special view to the walls of the town and to the surrounding landscape, which remained exceptionally well preserved for hundreds of years. The building frequently hosts expositions and meetings organized by local authorities, and it is equipped with an old, inadequate heating system without cooling. Working in close cooperation with the City’s department for Urbanism and Urban Regeneration, GEO4CIVHIC will turn this iconic element of the city’s urban landscape into a more accessible, sustainable and comfortable site for visitors, while preserving its historical features and characteristics.

Source: [10] geo4civhic.eu

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
**Example**

Geothermal

**Villa Carlotta Project, Orselina (TICINO CANTON)**

Villa Carlotta in Orselina / TI, an historic building in Ticino Canton, built in 1939 has been renovated in 2018.

The Villa stands on a slope above Locarno overlooking Lake Maggiore. The large building with an energy reference area of 795 m² is used as a summer residence and for weekends. Since the villa was renovated, the old oil heating has been replaced with a 38 kW solar-powered heat pump with six geothermal probes from 140 to 165 m deep.

The roof was renovated covering the entire roof area (350 m²) with a 51-kW solar integrated photovoltaic BIPV plant. The photovoltaic system with monocrystalline photovoltaic modules, installed over the entire surface and integrated in an exemplary way flush with the ridge, sides and roof cornice. This 51.1 kWp photovoltaic system produces approximately 42,300 kWh of solar current per year, guaranteeing coverage of 87% of the total energy requirement, which amounts to approx. 53'500 kWh / a.

The energy for heating and hot water is supplied not only by the geothermal heat pump but also by 14 m² of vacuum tube solar collectors, which produce 4'300 kWh / a of thermal energy which are harmoniously integrated in the context of the garden. Inside the building, heat is released through underfloor heating and through radiators. It was also possible to significantly reduce the building’s energy needs by providing better insulation of the walls, floor and roof.

Central heating is used to heat the outdoor pool. Heating and other technical systems are regulated by monitoring and can be managed remotely. There is also an electric car with a charging station.

The Villa Carlotta demonstrates how modern solar technology can be integrated in an exemplary architectural manner in a historic building. For this reason, this renovation project was awarded with the Swiss Solar Prize 2018 for Category B: building renovations.

Source: [11, 12]
References


Brochure: 

Geothermie in der Schweiz, eine vielseitig nutzbare Energiequelle (PDF, 4.9 MB, 01.02.2017) ID: 2184 | 473

Reports Swiss Federal Office of Energy, SFOE:


Schweizerische Gesamtenergiestatistik 2018, Bundesamt für Energie, Schweiz.

Links

Switzerland (Ticino) - RES

METHODOLOGIES

List of renewable Energies to be studied

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</table>
SWITZERLAND
DELIVERABLE T3.2

METHODOLOGIES - CONCLUSIONS

- **Biomass energy vector**

Within the context of the energy transition the Swiss government foresees a massive increase in the share of renewable energy (e.g. wind, water, biomass, geothermal energy, solar, etc.). Biomass can be transformed into several forms of energy: heat, electricity, biogas or liquid fuels. Compared to other renewable energies, biomass is mainly storable and can therefore be used to compensate for other more intermittent renewable energy sources. Sustainable potential of woody biomass resources for bioenergy in Switzerland at the municipality level are a priority for the Swiss Federal Office of Energy (SFOE).

Biomass resources are a heterogeneous group, comprising feedstocks ranging from wastewater and manure, to municipal and industrial waste products, to forest wood. Three main categories are used when considered potentials for biomass-based electricity generation systems: 1) Waste management sector (waste incineration systems, municipal and industrial wastewater treatment plants, and industrial biogas plants); 2) Wood sector: Installations which use woody biomass as a feedstock; 3) Agricultural sector: Installations which mainly use agricultural substrates as a feedstock.

The largest potential for the future biomass-based electricity generation is from the mobilization woody biomass and manure resources which is today a large resource currently not utilized, while that the future potential from woody biomass comes from a combination of utilizing unused resources and redirecting wood from heat-only systems to CHP systems (cogeneration). Realization of biomass potentials faces challenges in terms of logistics and, more important, costs. In addition, is important to consider, that biomass can be used not only for electricity generation, but also for heating and as transport fuels. The federal government promotes electricity generation from renewable energies, among others, the operators of new installations producing electricity from biomass may profit from the feed-in remuneration at cost. According to the Energy Act, EA, in Switzerland, grid operators must purchase and remunerate electricity in their grid area. Moreover, the EA states that operators of biomass plants may obtain an investment contribution. The investment contribution for biomass installations is determined on a case-by-case basis and shall not exceed 20 per cent of the eligible investment costs [1].
Wood is the most extensively available type of biomass in Switzerland, whereby most timber of better quality is used in construction and in interior design. Some wood is also exploited for energy, especially for generating heat. However, non-woody biomass, such as farmyard manure, organic waste, sewage sludge and by-products of agricultural crops also contain valuable energy. The Swiss Competence Centers for Energy Research (SCCER), hunt for solutions to the technical, social and political challenges posed by the Energy Transition. The SCCER BIOSWEET (Biomass for Swiss Energy Future) aims to increase the contribution of biomass to Switzerland’s energy supply (Phase 1: 2014-2016; Phase 2: 2017-2020, Figure 1) and investigate all relevant bioresources (e.g. manure, organic wastes) [2, 3]

**Figure 1 – a)** Potential of domestic biomass resources for energy in Switzerland taking into account their spatial distribution and spatial distribution of all biomass resources per canton (theoretical potential), primary energy in petajoules per year in 2014. Results of the from the SCCER BIOSWEET Phase 1 and Phase 2 studies (Source: Swiss Federal Institute for Forest, Snow and Landscape Research WSL) [2, 3]; b) Samples of feedstock and torrefied biomass from Swiss torrefaction technology developer GRT Group (Source: https://bioenergyinternational.com/).

- **Methodologies to assess and better exploit biomass energy resources**

Biomass templates for Switzerland presents the methodology and maps developed by Swiss Federal Office of Energy (SFOE) to estimate the Biomass exploitation potential in the country. The Swiss Federal Institute for Forest, Snow and Landscape Research WSL quantified and localised the potential of important biomass resources in Switzerland (Woody and non-woody biomass for bioenergy maps), particularly with regard to their sustainable availability. The results are useful as a basis for identifying promising biomass-use pathways and the best sites for their implementation. The potential of energy exploitation of wood at regional and local level was presented for Ticino Canton area. In Ticino, as the same as in other parts of Switzerland, district heating is starting to be considered, up to now mainly through the use of biomass-fueled power plants (wood, pellets, wood chips, wood waste, etc.). Biomass is a solution that can exploit a fuel of indigenous origin, reducing on one hand the dependence on fossil fuels and on the other the production of CO2 in the atmosphere. The study on the potential of district heating in Ticino lays the foundations for identifying the optimal areas for district heating plants in the region.

- **Related Historic Buildings and sites**

An example of district heating network application on the municipality of Carona (ISOS protected historical site of national importance) has been presented. Besides, the feasibility study and potential exploitation of biomass, as function of the forest potential exploitation in Ascona municipality, that is also an ISOS protected historical site of national importance, has also been reported here [4-8].
**Biomass**

**METHODOLOGY**

**Biomass exploitation potential**

Biomass is a renewable energy source which can be transformed into several forms of energy: heat, electricity, biogas or liquid fuels. Sustainable potential of woody biomass resources for bioenergy in Switzerland at the municipality level are a priority area of study by the Swiss Federal Office of Energy (SFOE). Within the implementation of the energy strategy 2050 the Swiss government foresees a massive increase in the share of renewable energy. The Swiss Competence Center for Energy Research (SCCER) Biosweet (Biomass for Swiss Energy Future) seeks solutions to the technical, social and political challenges posed by the Energy Transition with regard to biomass [1].

Wood is the most extensively available type of biomass in Switzerland, whereby most timber of better quality is used in construction and in interior design. Some wood is also exploited for energy, especially for generating heat. However, non-woody biomass, such as farmyard manure, organic waste, sewage sludge and by-products of agricultural crops also contain valuable energy [1]. The use of wood for the production of thermal energy is of great interest to avoid fossil sources. The biomass cycle is in fact neutral from the point of view of CO₂ emissions and Switzerland has great availability of the wood resource: about 30% of its surface (12,340 km²) is in fact covered by forests [Source: National Forest Inventory]. Besides, in recent years, the production of organic waste in Switzerland and in the Canton of Ticino has reached quite large quantities. The techniques currently available to exploit the energy potential contained in organic waste are based on two types of processes: 1) fermentation (biogas production). The gas spontaneously produced during the decomposition process (biogas) is neutral from the point of view of CO₂ emissions and can be directly used for the production of electricity and heat or, if duly purified, as a gaseous fuel for automotive traction and fuel for the production of heat and/or electricity (injection into the network); 2) gasification (syngas production). Syngas can power internal combustion engines for the production of electricity. The plants that produce syngas are few since it is a technology that is still being tested.

The Swiss Federal Institute for Forest, Snow and Landscape (www.wsl.ch) has quantified and located the potential of important biomass resources in Switzerland. Biomass can generally be stored and can therefore be used to offset inconsistent wind and solar energy production. Woody types of biomass were investigated using methodically comparable approaches: forest wood, wood from landscape maintenance, waste wood and industrial wood residues. Non-woody and Woody biomass maps (Figure 2 and Figure 3) show the sustainable potential of this RES resource in Switzerland and a detailed report are available online [1, 2]. Figure 3 shows the sustainable potential of woody biomass for bioenergy (maximum amount of nationally produced woody biomass that could be used, after deducting any ecological, economic, legal and political constraints) in Switzerland at the municipality level in primary energy (maximum amount of energy available in a resource without conversion) in petajoules. An example is shown in (Figure 3) for Bellinzona district, in Ticino Canton.
### METHODOLOGY

**National Level**

<table>
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<tr>
<td>The entire procedure (Figure 4) can be summarized in the following formula:</td>
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<td>[ \text{Net Wood Energy Potential} = \sum_{i} \text{wood typologie surface}_i \times (\text{Theoretical woody growth}_i - \text{Mortality}_i) \times \text{Percentage Woodland Public/Private} \times \text{Percentage Wood Energy} \times \text{Influence Terrain Conditions and Protection Woods} \times \text{Energy Yield}_i ]</td>
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<tr>
<td><strong>EXAMPLE: THE CANTONAL TERRITORY</strong></td>
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<tr>
<td>The total number of woods in the cantonal territory therefore amounts to around 115,000 hectares. It should be noted that the national forest inventory published by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) estimates a total area of 122'100 ha of forest [third forest inventory NFI3, 2004-2006, <a href="http://www.lfi.ch">www.lfi.ch</a>]. To determine this value, WSL does not use the same methodology used by the Canton. The allocation of the different categories of woods to the generalized categories (conifers / broad-leaved trees) is not facilitated by the presence of ambiguous categories (alluvial forest, pioneer forest, plantations), which represent a considerable part of the Ticino forest area (18%). For this reason, the &quot;Mixed Forest&quot; category was created, covering about 4% of the Ticino forest area. The same statistics supplied to us by the WSL indicates that in the Canton Ticino around 35% of the woods are composed of conifers and 61% of broad-leaved trees. This broadly reflects what was calculated starting from the cantonal data and makes it possible to consider the grouping (conifers / broad-leaved trees) proposed here as correct. Due to the morphological situation of the land or the lack of accessibility, it is possible that an important source of wood energy cannot be exploited. In order to consider this parameter, the &quot;Charter of wood harvesting conditions&quot; (Figure 5) published by the Department of the territory of the Canton of Ticino was used [Cantonal Forestry Plan, 2007].</td>
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**Regional Level**

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**Local Level**

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**Figure 4** – Scheme of the calculation method Potential Wood Energy Actually Available (SUPSI, Technical report Municipal energy plan Ascona PECo [4]).

**Figure 5** – Cantonal map of wood collection conditions - Ticino Canton (CH) (source: Cantonal Forestry Plan, 2007)[4].
### TICINO CANTON

**District heating systems analysis in Ticino**

The technical literature underlines the strategic role of district heating systems (DHS) in the decarbonization process in the European context.

A method for identifying areas potentially suitable for DHS, taking heat need density as the main metric, is tested for the case study of Canton Ticino (Switzerland) and allows analysis of the total and public building stock. This implies the collection and elaboration of energy data about public buildings, providing a dataset formerly unavailable. Because these buildings are managed by a few owners who are generally asked to be exemplary in terms of sustainability, they could have a pivotal role for the development of DHS. By using a multi-criteria and GIS-supported method, the study ensures the mapping of areas potentially suitable for DHS and renewable sources available for thermal purposes toward low carbon targets. Based on the results of the research, it is estimated that potentially 17% of the heat needs in Canton Ticino could be satisfied by DHS, by also exploiting thermal renewable energy sources locally available. The consistency of the method was tested through a validation on the existing DHS. Areas potentially suitable for DHS in Canton Ticino are shown in Figure 6.

Source: Pampuri L. et al., 2018, 2019 [5, 6]

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**Carona biomass district heating systems (DHS)**

The town of Carona (Figure 7) is a place of particular historical value in Switzerland, located on top of Mount San Salvatore, whose core is composed of buildings mainly built in the 19th century (Nucleo storico, city historical core). Carona has a medieval city core with compact rural and elegant building and are listed in the federal Inventory of Swiss Heritage Sites (ISOS) of National Importance, A Category

Inaugurated in May 2017, the entire district heating network is fed by a large wood chip power station mainly from Lugano. The boiler has an output of 700kW and is able to cover 90% of the heating requirements. To guarantee the supply of heat at any time, it will be flanked by a fuel oil boiler that will be operated in case of need. The district heating network extends for over a kilometer and a half and reaches 70 users concentrated mostly in the core of the country.

Source: [www.ail.ch](http://www.ail.ch)

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**Figure 6 – Areas potentially suitable for DHS in Canton Ticino, with a resolution of 4 ha (Source: Pampuri et al. 2018 Cantonal Technical Report [5, 6]).**

**Figure 7 – Carona town is a place of particular historical value in Switzerland (ISOS heritage site of national importance).**
METHODOLOGY

RELATED TO HISTORIC BUILDINGS

EXAMPLE OF THE ASCONA MUNICIPALITY

The town of Ascona is a place of particular historical value, whose core is composed of buildings mainly built in the 19th century (historical city core). Ascona Village is listed in the federal Inventory of Swiss Heritage Sites (ISOS) of National Importance [8].

An estimation of biomass potential for Ascona municipality was made by SUPSI, University of applied sciences and arts of southern Switzerland. This study provides the energy plan of Ascona municipality PECo Ascona [4], and estimates the available energy production potential for different renewal energy sources (Figure 8 and Figure 9). The PECo defines the possibilities of intervention that are established in an action plan. There are orientation measures to achieve the objectives set at the municipal level and it is proposed to adopt a guide procedure to choose the energy source with which to cover the thermal needs of a building. Taking into account the specific opportunities available in each point of the municipal territory, the guiding procedure suggests the choice between the available energy sources, according to the prefixed order of priority. This guiding procedure can be used validly for both new and existing buildings, when replacing the heating system or renovating. The Municipality suggests adopting this procedure on a voluntary basis, since it is not a binding provision, and favors its diffusion through awareness-raising measures.

Feasibility study for biomass exploitation

Due to the high calorific value of the essences that compose wood, the function performed in the prealpine and alpine valleys, rich in woods, has been very important in the past. Energy from wood is in fact regaining important market shares, in particular with regard to wood chip and pellet heating. In Ticino, this resource is theoretically available in large quantities: the cantonal forest area corresponds to about 125,000 ha. There are different types of biomass wood systems: 1) Heating for single or several spaces with variable power, between 1 and 15 kW (e.g. storage heater, stove-fireplace, closed fireplace, pellet stove, heating stove, etc.); 2) Central heaters, connected to a hydraulic heat distribution system, whose power can vary from 2 kW (for example in low-energy single-family buildings) up to 500 kW or more (wood chip thermal plants with district heating network); 3) Cogeneration plants, with simultaneous production of heat and electricity. This type of system if powered by biomass is advantageous only starting from very high thermal powers.

The study proves that the available surface and consequently the production potential from the native forest is very low. The potential present in the municipal area does not manage to satisfy even 1% of the thermal needs of the houses located in the municipality. It makes more sense to rely on wood that also comes from neighboring municipalities which could meet 7% of the energy needs of buildings present throughout the municipal area.
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
6.2 Annex 2: Templates Germany (Bavaria)
### Germany

<table>
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<th>National Level</th>
<th>Regional Level: BAVARIAN &quot;ENERGY INNOVATIVE&quot; CONCEPT</th>
<th>Local Level</th>
<th>Application to HB - Examples</th>
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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
Germany (Bavaria) - RES

STRATEGIES

List of renewable Energies to be studied

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<td>5  ![Geothermal icon] Geothermal</td>
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<td>6  ![Biomass icon] Biomass</td>
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</table>
Renewable Energies

**GERMANY - BAVARIA**

**DELIVERABLE T3.2**

**STRATEGIES - CONCLUSIONS**

In order to keep temperatures from rising not more over 2 °C, the European Union and Germany must reduce its energy-related carbon dioxide emissions by at least 90% and furthermore completely modify its entire energy system. An essential element of the energy concept is a significant increase of energy efficiency by reducing the energy demand. Measures can be the efficient conversion and use of energies such as heat use in cogeneration systems. In the course of the transition of the energy system to a sustainable energy service economy based on renewable energies, electricity as a key element of this economy originates more and more from renewable energy sources. Linked to this is a change of paradigm in terms of power plant scheduling as well as market, grid and system integration of renewable energies. Large power stations generating energy based on central fossil and nuclear fuels must make way for an increasingly large share of decentralized energies from renewable sources. In avoidance of energy fluctuations, stabilization measures have to be taken such as the use of quick-reacting gas power plants, linking cogeneration plants to virtual power plants, load and generation management procedures in conjunction with smart grids as well as efficient storage technologies. The German Government aims to develop an energy system which is entirely based on renewable energies and energy efficiency by the year 2050 (Energiekonzept 2050, 2010) [1].

On a federal level, Bavaria’s goal is to lower the carbon dioxide emissions significantly below 6 tons per capita by the year 2020. In order to do so, the renewable energies must be expanded and energy saving as well as energy efficiency must be further developed. Therefore, key actions comprise multiple investments:

- Investment in power highways which transport electricity from other parts of Germany or abroad to Bavaria.
- Investment in regional power supplies in order to receive increasingly large amounts of electricity from decentralized production.
- Investment in power plants based on renewable energies which will shape landscape and natural areas more than ever.
- Investment in new and highly efficient gas power plants which instead of nuclear power plants in the future provide secure and readily available performance.
- Investment in storage which integrate fluctuating provision of electricity based on wind and solar energy into the supply system.
- Investment in energy research and new energy technologies which introduce new and today not yet available solutions for the future energy supply.
- Investment in energy efficiency which allows same user benefits with less energy consumption and less use of resources.
Furthermore, Bavaria promotes innovative technologies and mechanisms in order to lower the cost of renewable energies and achieve full market viability for green energy. Measures are: 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 (Bayerisches Energiekonzept "Energie innovativ", 2011) [2].

In 2011 the State Government announced a fundamental reorganization of Bavaria’s energy supply. Defined goals are securing a sustainable energy infrastructure, protection of ecological and cultural interests regarding installations of new power plants and power lines, use of cogeneration as well as consistent integration of citizens. In this course a secure and climate friendly combination of renewable energies and conventional energy sources as well as infrastructures for energy saving purposes must be achieved. In order to accomplish the goals, the regional development program was developed, including fixed objectives and principles. The program stipulates an enhanced development and use of renewable energies to support the restructuration of Bavaria’s energy supply, conservation of resources and climate protection. Designation of Land for installations of power plants based on renewable energies must take place in consideration of regional compatibility and all affected interests such as nature and landscape or settlement development, State Development Program Bavaria (Landesentwicklungsprogramm Bayern, LEP) [3].

On a local level, Bavaria is divided into 18 regions. Each regional planning association creates a regional plan (e.g. Region of “Südostoberbayern”) and updates it as necessary. The regional plans are developed from the regional development program and put the program’s regulations in concrete terms for each individual region. The regional plans include specifications regarding interdisciplinary and disciplinary matters such as localized priority- and restricted areas [4].
STRATEGIES

Solar Energy

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To increase the electricity generation based on PV systems, the German Government aims to lower the costs of PV plants and its technology.

**Tendering Procedure**

Since nowadays PV plants are more affordable than other conventional power plants, the funding rates of the Renewable Energy Act have to sink in accordance to avoid an immoderate promotion. Since 2015, a tendering procedure determines the amount of support of PV plants on open spaces. Annually, there are three calls for tender in which various investors can participate. A simple, transparent and comprehensible designed procedure also allows civil energy societies and energy cooperatives the attendance. Consequently, only operators of newly installed open space PV plants receive financial support, if they win the call for tender due to a subsidy amount as low as possible for the economic operation of their solar park. Each solar park has to supply a performance of at least 100 KW and 10 MW to the maximum. Due to this adjustment, the expansion target of PV plants is supposed to be realized cost-effectively. Moreover, experiences with the tendering procedure are collected and referred to the remaining renewable energies divisions [5].

**Concentrated Photovoltaic**

Besides the common PV systems based on Si-modules and technologies of thin-film solar cells, the concentrated photovoltaic is an alternative technical approach to lower the costs of the PV generated performance. A cheap optical concentrator bundles the solar light and therefor replaces the demand of comparable cost-intensive surfaces for solar cells. A small cell located in the focus of the light beam efficiently converts the radiation density. In order to concentrate the solar light sufficiently, the system has to track the course of the sun and therefor has to be located in a region of high solar radiation. Concentrated photovoltaic systems are preferably used in a power range of kW-MW. Whereas the system efficiency is currently utilized to 25%, the Government’s long-term goal is it to increase the module efficiency up to 50% [6].

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*Figure 1– Examples of optical concentrators. Source: CPV für Länder mit hoher direkter Einstrahlung, Fraunhofer ISE*
STRATEGIES

Solar Energy

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**Bavarian energy concept “Energy Innovative”**

**Photovoltaic**

The energy concept “Energy innovative” published by the government of Bavaria aims to realize the available potential of photovoltaic by 2021 (estimated total output: 14,000 MW) and thereby covering over 16% of Bavaria’s total power consumption.

In order to fulfill the object, the German Renewable Energy Act (EEG) must grant security of investment by adjusting the compensation rates of electricity feed. Other measure is lowering the cost of PV plants by further development of existing systems and development of innovative technologies with regard to solar cell technology. In particular, the technology of thin film and organic solar cells needs to be expedited. In addition, the grid feed by solar energy has to be need-oriented, instead of the generation being decisive. To this, the incentive of internal consumption, as well as the use of storage technologies relieve the energy grid by avoiding distribution losses.

**Solar Energy**

Bavaria’s target for 2050 is a climate-neutral building stock with a share of at least 50% in renewable energies and permanently double the installed solar collector systems in the years ahead. By the year 2021, solar thermal energy and ambient heat are supposed to cover about 4% of Bavaria’s total power consumption.

The planned measures depend on financial support, information and incentives in line with the market.

Although solar collectors are technically sophisticated, there is a general need and potential for simplifying the installation in existing buildings. Standardizations and innovative systems solutions contribute to a simplified application. The course of action therefor is to intensify current research and development projects of the Bavarian Center for Applied Energy Research (ZAE) with the Fraunhofer Institute for Building Physics [2].

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
### STRATEGIES

#### Solar Energy

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<tr>
<td><strong>Local Direct Marketing</strong></td>
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<tr>
<td>The regional planning association of Südostoberbayern aims to ensure the public services, to reduce the outflow of financial resources out of the planning region and to strengthen the local economy. Measures to this end are capacity expansions of the renewable energy producers, as well as the local direct marketing of the produced energy. A local direct marketing of solar energy describes a simultaneous use of electrically generated energy on-site, considering the principle of subsidiarity.</td>
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<tr>
<td><strong>(Post-)EEG-Plant Operators as Producers</strong></td>
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<tr>
<td>In Bavaria, the producer organization for energy in Bavaria eG (Erzeugergemeinschaft für Energie in Bayern eG = EEB eG) coordinates all energy farmers in Bavaria and helps marketing the generated power to higher conditions and with equal quality.</td>
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<tr>
<td><strong>Municipal and Local Utilities as Distributors</strong></td>
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<td>The municipal utilities have the competitive advantage, that they are offering regional produced power to the same region, so the local added value is enhanced. Regional authorities without own local utilities have the opportunity to organize themselves in a joint and virtual communal utility and therefor have a share of the electricity market.</td>
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<td><strong>Private Households and Commercial Enterprises as Consumers</strong></td>
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<td>Possible financial advantages result from cheaper electricity rates caused by avoided network charges or reduced EEG-levies. Consumers can also function as “prosumers” (producer and consumer) and market excess quantities of their own solar power production.</td>
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<tr>
<td><strong>Regional Energy Exchange (REX)</strong></td>
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<tr>
<td>REX is an off-market and local trade platform for renewable energies that allows a coordination of production and consumption by means of new technologies from digitization. Equally, it assures the use of distribution channels by the municipal and local utilities. In the future, post-EEG-plant operators offer their product on the platform and municipal and local utilities (existing or virtual) purchase the power for the local consumers. In this context, the digitization (Blockchain 60) guarantees a distinct labelling of the product. Due to clever electricity meter, the user can identify the source of energy and flexible energy costs are enabled. The operators receive a product generator and fill it with individual product features such as plant location or ownership structure. The information is recorded in a digital contract. Programmable bidirectional meters in the meter cabinet assign a digital, forgery-proofed fingerprint to every produced kWh. Following, each kWh as a quality product can be marketed and purchased by the municipal and local utilities on REX.</td>
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**Figure 3** -- Figure showing the parties of local direct marketing in Bavaria. Source: Erzeugergemeinschaft für Energie in Bayern eG
**Example**

**Solar Energy**

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**SOLAR CADASTRE OF ALLGÄU**

A solar potential analysis of the region Allgäu in the south of Bavaria enabled the region to provide a web portal offering a solar cadaster on its own. The user can display the suitability for solar energy of a specific roof organized into different income categories which are indicated by different highlighted colors. The potential outcome is based on the orientation and inclination of the roof and equally the opacity by neighboring buildings and the immediate surrounding was taken into account. Further criteria are the terrain, the course of the sun depending on the time of day as well as the climatic basis data of the region [8].

![Screenshot from www.solarkataster-allgaeu.de showing individual suitability of individual buildings in Oberstdorf, Allgäu](https://example.com)

**“ENERGY VILLAGE” WILDPOLDSRIED**

**“Solar Campaigns”**

Wildpoldsried is a small community in the south of Bavaria that serves as a best-practice example for energetically independence. As part of several “solar campaigns”, Wildpoldsried has built up its stock of solar systems counting more than 2,300 square meters of thermal solar systems and generating 5,350 kWp by photovoltaic plants (2018) [9].

**Achievements:**

- Cipra-competition 2008 “cc.alps”; award for excellent climate protection
- German Solar Prize 2009
- European energy award 2014
- European energy award 2018

![Screenshot from https://pebbles.fit.fraunhofer.de/ showing the daily provided power generated by renewable energies in Wildpoldsried](https://example.com)
## STRATEGIES

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### Wind Power

**Onshore Wind Energy**

In Germany there are 29,213 onshore wind turbines (2018) and indicate the highest growth opportunities [10]. The Government has drafted several goals that are to be realized by the year of 2050. The main objective is the technological development with a focus on standardizations and modularization, as well as the maximum reliability on the mass production. Additional target is the cost reduction by fundamental innovations such as further development of plant engineering and the development of new materials and composites.

In parallel, the aerodynamic, aero elasticity and aero acoustic of the facilities must be optimized by collected experiences and tools of the flow mechanics. Further research topics are the studies concerning wind climatology, identification of locations in complex terrain and energy yield prognosis.

The Government of Germany aims to increase the efficiency of wind turbines by 20% in the year of 2050 and simultaneously halve the noise emissions [11].

**Offshore Wind Energy**

In 2018, Germany recorded 1,305 offshore wind turbines, generating 6,382 MW [10]. The use of offshore wind energy involves additional challenges that arise from larger loads due to wind and sea and the difficult access. Therefore, studies in the fields of innovative concepts for overall systems, regulations and technical reliability, as well as wind and wave characteristics of the offshore use must be conducted [11].
### STRATEGIES

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#### Wind Power

The small share of 5.4% of the gross electricity generation in Bavaria (2017) [12] results mainly from the geographic and topographic circumstances and also from the partially low acceptance of wind turbines. According to trade associations the annual energy yield in Bavaria could reach more than 17 billion kWh by the year of 2021. In terms of figures about 1.4 Mio households in Bavaria could be provided with energy generated by wind turbines.

The Bavarian Government has developed the Bavarian energy concept “Energy innovative” and defined concrete objectives to increase the use of wind energy by the year of 2021 and thereby covering the Bavarian power consumption with 6-10% by wind power stations [2].

**Targets:**

- Providing generally valid information on the approval procedure of the installation of wind turbines under the aspect of immission protection for competent authorities
- Increased use of the wind potential in the Bavarian State Forestry
- Creating a guideline in supplementation of the Bavarian wind atlas, to encourage the financial participation of citizens on common wind farms
- Motivating communal energy supplier to also invest in wind power facilities of inter-municipal cooperation
- Enhancing the compatibility of military radar installations and no-fly zones
- Granting sufficient areas for wind energy use in regional plans
- Reducing the compensatory measures under nature protection law caused by interventions in the landscape by wind turbines
- Standardized search method for suitable locations
### STRATEGIES

#### NATIONAL LEVEL | REGIONAL LEVEL | LOCAL LEVEL

**DONAU-ILLER**

The Government of Bavaria and Baden-Württemberg aims to provide 10% of its electricity generation from local wind turbines by the year of 2020. This energy goal requires extensive areas which are identified by planning law as suitable for wind power systems [13].

The district Unterallgäu is integrated in the Regional Planning Association Donau Iller (Regionaler Planungsverband Donau Ilfer = RVDI). As per the amended treaty between Baden-Württemberg and Bavaria, the regional plan of the region Donau-iller must determine all areas as either preferential or exclusion zones for wind turbines [13].

Based on the recommendation of the State of Baden-Württemberg, all areas with an average wind speed of 5.75 m/s in a height of 140m above ground level were approved as suitable for wind power. In addition, surfaces with an average wind speed of 5.5-5.75 m/s in a height of 140m above ground level were considered. Since a fundamental suitability for the last-named areas cannot be guaranteed, they were only accounted for preferential zones if a prior imprint of the landscape exists. The information of those specific areas is partially obtained from the municipalities and therefore includes the local aspects. Already foreseeable projects were also taken into account [13].

In consideration of aerial and environmental sustainability the regional plan strives to concentrate wind turbines in suitable areas. This also means an appropriate burden sharing among the communities and the installation of wind parks with 3 to 20 regionally significant plants. The regional significance of a wind power plant is defined by its size, by the level of exposedness of its location, as well as by its own originating effects [13].

Conflicting interests of the preferential zones, and defining criteria of the exclusion zones are aspects of regional and infrastructure development, emission protection, nature and landscape conservation and the protection of cultural heritage [13].

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**Figure 8** — Map showing identified preferential zones in Biberach-Winterreute, Unterallgäu. Source: 5. Teilfortschreibung des Regionalplans Donau-Iller
Previous power-to-heat applications such as conventional electric storage heating cannot be sufficiently integrated in the future power system with its partially large surpluses and long-term time bottlenecks [14].

The Bavarian State Office for Environment and its project wind heating 2.0 deals with the described issue: The wind heating 2.0 is an electric heating system that can adjust to the dynamic range of the power supply system. The heating system is tailored for an operation in highly efficient and economical buildings with a long-lasting storage capacity of heat and the direct electric heating is justified [14].

The system is based on a simple principle: In case of an electricity surplus (e.g. due to a winter storm) the heating extracts electricity from the power grid, transforms it into heat and stores it in a water reservoir, in a high temperature rock storage (still to be developed) or by means of component activation in the building’s ceiling or walls. On the contrary, the heating waives a power extraction during shortage of electricity generated by renewable energies [14].

“ENERGY VILLAGE” WILDPOLDSRIED

Civil Wind Farms

Wildpoldsried is a small community in the south of Bavaria that serves as a best-practice example for energetically independence.

The first civil wind farms in Wildpoldsried were built in the year of 2000, whereas by the year of 2018 a number of 9 wind parks was recorded. In total the plants annual (2018) electricity yield comes to 31.324.000 kWh and covers 1/5 of the communities overall consumption.

In 2015 the community cooperated with its neighboring community Kraftisried and set up its first intercommunal wind farm with two wind turbines (figure 13) [10].
Because most hydroelectric power plants with an installed capacity of over 1 MW were built before 1960, the modernization of existing facilities offers the greatest potential for performance increase. Further potential is found in reactivation of facilities which were destroyed in the Second World War or were shut down in the 1960s and 1970s. By means of modern technologies the systems can be put back into operation and offer the possibility of increasing the protection of nature and the waters. The additional potential for expansion of hydropower amounts to an estimated 1000 MW or 3,0 billion kWh/a and therefore is relatively small. A large proportion of the potential (around 80%) lies in the extension and the reconstruction of existing large plants with an installed capacity of over 1 MW [8]. In the year 2013 hydropower made up 3,4 % of the gross electricity generation in Germany and therefor accounts 14,5 % of the electricity generation produced by renewable energies.

Since the hydropower utilization is relatively technically mature, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Economics and Technology set their priorities on research funding in the fields of ecological compatibility. Stricter environmental requirements such as complex approval procedures more and more frequently get in the way of electricity generation from hydropower. In 2013 a new joint project was granted. The proposed research project aims to develop an innovative moving screen for hydroelectric plants which prevents injury to fish in turbines. Studies on prototypes of moving screens in micro-plants allow the conclusion that the technology can be transferred to large plants. This is based on the prerequisite that hydraulic conditions and the integration into the existing plant is clarified [16].

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**Figure 11** – Image showing a model of the drive axle of the moving screen. Source: Erneuerbare Energien: Innovation durch Forschung, Jahresbericht 2013 zur Forschungsförderung

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### STRATEGIES

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#### BAVARIAN ENERGY CONCEPT “ENERGY INNOVATIVE”

The share of Hydropower in the electricity generation from renewable energies in Bavaria is about 60%. Since hydroelectric systems operate regardless of weather conditions and daytime, it is an energy source which is available at any time and can be deployed from base load to peak load. For this reasons hydropower makes a major contribution in the fulfilment of demand and the system stability. Bavaria aims for a greater use of the existent potential and for a rapid, consistent and environmentally compatible growth in the utilization of hydropower. The objective is it to increase the hydroelectric electricity generation to 14,5 billion kWh/a by the year of 2021 [2].

**Targets:**

- Aims of nature conservation and the aquatic ecology as well as of the energy industry must be taken into account while taking an administrative decision on hydroelectric power projects
- Integration of new transvers constructions in existing facilities. Sites of interest for new construction are among others the rivers Lech and Salzach
- Modernization and retrofit of existing plants as far as the pass ability of the waters is improved. Interventions in the Bavarian rivers Danube, Iller, Lech, Wertach, Isar, inn and Main promise an additional power generation of about 700 million kWh/a.
- Administrative proceedings must be accelerated
- Official requirements must be user/cause-based and are limited to a necessary extent.
- The prescribed inspection according to section 35(3) of the Water Resource Act in order to test the feasibility of hydropower utilization at specific locations must be carried out on an accelerated basis.
- Support for novel technologies in the fields of hydropower. In particular the further development and demonstration of the new hydropower concept “shaft power plant” which is supposed to enable small hydroelectric power plants an economic operation at the highest ecological level ought to receive intensive support
- Financial support for new constructions and extensions of innovative and environmentally compatible hydroelectric power plants as far as otherwise an implementation is considered as economically unfeasible and the funding is authorized by the state aid law
### STRATEGIES

#### Hydroelectric Energy

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The potential for hydroelectric energies is well utilized and is an essential pillar of energy use and supply in the regional planning association of Südostoberbayern. Even though the exploitation of the hydroelectric potentials is often related to complex assignments regarding nature conservation and legal approval, still there are existing potentials for extension. The development potential lies especially in interventions at the rivers Salzach and Saalach, as well as existing transvers constructions that are not yet or not anymore used for energy generation and recommissioning of inoperative systems. In addition, there is potential for modernization and efficiency enhancement of existing plant. The total potential for extension amounts to about 360 GWh/a and yields to an increase of 11.5% compared to the actual state (2019). The majority of the expansion potential (95.8%) exists in the counties of Altötting (34.0%), Berchtesgadener Land (39.6%) and Traunstein (22.2%). This is due to the topographic conditions in the districts as well as the immediate proximity of the rivers Salzach and Saalach which both are hardly used for energy generation so far. The river Inn which is the main watercourse in the county of Altötting is almost completely exploited for energetic purposes, but the measure of renewing the power plant Töging represents an expansion potential of 120 GWh/a. By means of raising the maximum water level, increasing the maximum water volume that passes through the turbines and installing three Kaplan turbines, a performance increase of 20-25% is possible.

The greatest obstacle for the expansion of hydropower in the regional planning of Südostoberbayern are the high ecological demands for new construction such as water and fish protection. Therefore, new constructions are almost exclusively feasible at existing barrages. To improve the practicability and acceptance of hydroelectric energies and to meet the requirements, the application of ecological hydroelectric power plants shall be considered. Ecological hydroelectric power plants offer an environmentally compatible alternative to the conventional hydroelectric facilities which often are no longer capable of being approved. Examples of these ecological systems are mobile hydropower plants, shaft power plants, flowing waters power plants and hydroelectric facilities using very-low-head-turbines or (dual) hydrodynamic screws [7].

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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
Due to the expansion goals for renewable energies of the Bavarian energy concept the need for storage capacity in Bavaria grows. Therefore, the Bavarian Council of Ministers decided to conduct an analysis on storage potential and suitable locations for possible pump storage plants in Bavaria. Goal of the study is it to identify sites which show equally a high-performance potential and low potential for conflicts. Thereby a designation of an overall performance of at least 3000 MW is aspired. An essential element is the development of an evaluation matrix with transparent and comprehensible criteria. The matrix serves the computer-supported selection and sequence of potential sites according to the respective suitability for a pump storage plant. 16 technically and economically promising sites showing a low potential for conflicts were selected and formed the basis for rough concepts. In this process, the requirements and obstacles of a realization at the specific location was outlined. The study points out the framework for the feasibility of sites that are relevant from Bavaria’s point of view.

On the basis of Bavaria’s demand for energy storage, a GIS-based determination of potentials, an analysis of pump storage plant potentials located at lakes and reservoirs, as well as an assessment of expansion potentials on existing pump storage plants, the available pump storage potential in Bavaria is evaluated [17].

The Technical University of Munich (TUM) created an innovative concept for a cost-effective and nature-compatible utilization of run-of-river hydropower that can be transferred to small power plants as well as to large facilities and in addition allows a retrofit of existing transvers constructions [18]. The approach targets to arrange the entire power plant unit underwater and a horizontal plane for the feed of works water. The plant system requires only low construction volume and commands ecological advantages due to the fact that a conclusive fish protection and fish bypass is integrated in the hydraulic design. The system “multiple shafts power plant” was conceived to fit larger sites [19].
### STRATEGIES

**Geothermal Energy**

A crucial prerequisite for a broad application of geothermal energy is the development of procedures allowing cost-effective and safe drilling and increasing economic yield from the deposits. Therefore, the challenge in research is to direct the learning curve towards an economic provision of geothermal energy. For this purpose, in particular so-called Enhanced Geothermal Systems (=EGS) are to be developed. Those systems mainly base on hot water deposits and dry rock formations that exist beyond the volcanic or tectonic active areas. With regard to the exploitable energy, those areas involve more complex conveyor systems and a higher exploration expenditure. Nevertheless, those reservoirs constitute the main part of the deep geothermic potential worldwide and are also available in Germany (figure 6). The objective is to convert and extend the approaches and achievements of the EGS-research into appropriate programs.

In addition, the Government aims to link research and development activities throughout Europe, as well as national competences and funding programs [1].

Particular emphasis will be placed on geothermal technologies that are not limited to particularly favorable areas and consequently can be transferred to similar situations worldwide. Due to existing technological synergies to conventional geothermal systems, most of the research successes are to be expected in the fields of material science and component selection, which enable the market to more export opportunities [1].

[Figure 15](#) — Map identifying Germany’s suitable areas for hydrothermal and petrothermal energy generation. Source: Energiewendeatlas Deutschland 2030; Agentur für erneuerbare Energien
STRATEGIES

Geothermal Energy

NATIONAL LEVEL REGIONAL LEVEL LOCAL LEVEL

Bavarian Energy Concept “Energy innovative”

Deep Geothermal Energy

The energy concept “Energy innovative” published by the government of Bavaria aims to make use of the region’s geothermal potential by 2021 and thereby covering about 1% of the total energy consumption and 0.6% of Bavaria’s power consumption.

The thermal water reserves in the “Malm carbonate” in the south Bavarian region provide the opportunity of a domestic energy source. This area forms the largest directly usable deposit of geothermal energy in Central Europe.

Bavaria aims to promote a simpler application of the market incentive program published by the federal government and to enhance the transparency. An additional target is it to consolidate the federal funding instruments so the security of investment is assured [2].

Measures [2]:

- Increase of the basic remuneration of geothermal energies according to Renewable Energy Act
- Extension of the Bavarian Deep Geothermal Energy Program and enhanced support for the federal Geothermal Energy Program
- Bunching and expansion of the Bavarian geothermal research activities
- Motivating communal energy supplier to also invest in wind power facilities of inter-municipal cooperation

Proposed projects [2];

- A petrothermal energy trial project located in Bavaria
- Further development of the EGS-procedure including a promotion of the studies in the Bavarian community Mauerstetten
- A demonstration plant for the combined use of a solar absorber and a geothermal spiral probe at a Bavarian location

Figure 16 – Map showing the permeability of the upper Jurassic in the Malm carbonate. Source: Tiefe Geothermie: Grundlagen und Nutzungsmöglichkeiten in Deutschland; Bundesministerium für Wirtschaft und Energie
The Southern German molasse basin is one of the three large geothermal provinces in Germany, whereby the use of thermal water is concentrated in the central and eastern region of the Bavarian molasse. Thereby useable is the layer of the Jurassic Malm limestone, in particular in the area of Corallian limestone, open gap systems and karsts.

In the year 2008, the company “Geothermie Allgäu GmbH” realized a 4,080 m TVD (TVD = true vertical depth) long geothermal deep drilling (GT1) in Mauerstetten and therefore initially enabled the use of hydrothermal energy production in the western part of the molasse. However, no significantly scavenging losses occurred and the drilling showed only poor permeability. Also, an acidification could not obtain a sufficient transmissibility. Therefor the lower part of the borehole was given up, cemented and sealed. In the upper part of the bore a sidetrack (GT1a) was drilled into the Upper Malm reaching a depth of 3,763 m TVD, whereby the last 332 m are without a tube. But an “Airlift Test” revealed again only a poor productivity. As a result, the work at the drilling site temporarily came to an end and the borehole was secured and sealed for the moment.

In the course of a research project, influential factors of the permeability structure at the location Mauerstetten are to be explored and measures to increase the storage efficiency have to be spotted. The project includes preparatory laboratory test by means of sample materials and modellings that serve as a basis for adjusted simulation concepts for the site of Mauerstetten. A series of in situ pre-tests in the GT1a are supposed to confirm the general feasibility of this concept and provide the planning of the actual in situ simulation studies with a data pool [20].

Figure 17 – Newly developed laboratory plant to measure the permeability and porosity under high pressure. Source: www.tu-freiberg.de
## Example

### Geothermal Energy

#### NATIONAL LEVEL

**GEOTHERMAL POWER PLANT TAUFKIRCHEN**

The geothermal power plant (figure 9) located in the community of Taufkirchen and Oberhaching in the south of Bavaria has an installed thermal capacity of about 40 MW and an installed electric capacity of 4.3 MW.

Worth particular mention is the additional heat extraction at low temperature (85°C), in order to feed the district heating network in summer while using a low flow temperature without reducing the electricity yield significantly.

The thermal water is transported from the underground in a depth of 3.800 meters up to the earth’s surface showing a temperature of 135°C. In doing so the power plant pumps 120 liter per second. After transferring the heat at the surface, the cooled off water is again pumped into the underground and is reheated by the natural warmth of the interior of the earth [21].

![Image of the geothermal power plant in Taufkirchen/Oberhaching. Source: www.boederal-erneuerbar.de](image)

#### REGIONAL LEVEL

**DEMONSTRATION BUILDING: UNIVERSITY KEMPTEN**

Conventional heat pump systems obtain their energy out of the ground or the ambient air. The University of Kempten serves as demonstration building by taking full advantage of a hybrid system consisting of a solar and a geothermal installation type.

Depending on the current temperature in the ground and in the ambient air, the heat pump can be powered by the energy that is most disposable at the time. This is guaranteed by different switch states: The first switch state (figure 10, first diagram) is chosen during periods of cool outdoor temperatures. Parallel to increasing outdoor temperature the following switch statuses (figure 10, following diagrams) advance toward the state of using mainly the solar energy. In the period of a switched off state of the heat pump, the existing energy in the ambient air can be buffered in the ground and in case of operation it can be used as initial energy [22].

![Diagrams showing the different switch states of a heat pump linked to a hybrid system. Source: www.hs-kempten.de](image)
**Biomass Energy**

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The focal point of the research and development of biomass is the scientifically substantiated assessment of existing biomass potentials as well as biogenic waste with regard to consisting conflicts of use, conservation issues, potential production risks, technological restrictions as well as social, ecological and economic implications of international business with biomass. On a long term, besides the energetic utilization of biogenic waste a cascading use of multiple upstream processes of material use in the fields of biomass cultivation is to be pursued. The combined use of biomass with a high overall efficiency offers a great potential for development. It provides an optimized supply of electricity, heat and fuels by “polygeneration” which also introduces a CO₂-neutral substitution in the transport sector.

A further research topic deals with the handling of local heat networks within the scope of an enhanced expansion of thermal insulations. Germany aims to develop dynamic models that for one thing allow a CO₂-neutral heat supply as an interim solution, then again provide sufficient incentives to implement insulation measures according to a reduction of thermal demand.

On a long term, the Government targets to utilize the existing biomass predominantly for the food chain supply and the material use and only conclusively for the energetic use (e.g. for fuel) [7].
### STRATEGIES

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#### BAVARIAN ENERGY CONCEPT “ENERGY INNOVATIVE”

In Bavaria, nearly the entire mobility based on renewable energies, over 90% of the regenerated heat and about 30% of the renewable electricity result from bioenergy sources (2011). Overall, the share of biomass in the entire renewable energy sources in Bavaria amounts to about 70%. Until 2021 energy generated from biomass could contribute to the primary energy demand with around 50 billion kWh (180PJ). In order to achieve this objective, renewable raw materials must be cultivated on about 500,000 hectares agricultural land (currently about 400,000 hectares. In addition, 1,25 million tones straw as a by-product of the grain production could be used for energetic purpose (matching 25% of the incurring total quantities). Therefore over 15% of the agricultural land (3,2 million hectares) would be used as an energy resource. Whether this development is feasible, depends on the social acceptance and the warranty of a sustainable use. From today’s forestry view (2011), the energetic use of local wood can increase from 4,8 million tons to 5,5 million tons of dry matters. The further-reaching measures of exploitation of energy sources would intensify the usage competition of the material use and additionally accelerate the wood price increase. The currently estimated technical potential of bioenergy in Bavaria is to be exploited from the view of efficiency. This means that in the year of 2021 annually about 8 billion kWh electricity is to be generated by biomass. For this purpose, organic residues and waste materials have to be used in a more efficient way, the utilization potential of straw and wood has to be further encouraged and efficient conversion technologies (inter alia, biomass gasification technology) have to be brought forward.

Furthermore, the Bavarian Government aims to advance the clean fuels among the biofuels. The existing resources (for instance liquid manure which result anyway) for the biogas production are to be used more widely and in a more efficient way. In addition, a higher diversity of energy crop is supposed to be attained in order to realize the pursued development of agricultural land for renewable raw materials environmentally compatible and with public acceptance.

Another aim of Bavaria is it to increase the rate of installations based on the feed of wood pellets in existing building stocks.

By taking these measures, biomass is supposed to cover 9% of the total energy consumption and nearly 10% of the power consumption in Bavaria by the year of 2021 [2].
### Biomass

#### Energy

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<td><strong>USE OF BIOMASS IN THE REGION OF “SÜDOSTOBERBAYERN”</strong></td>
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The use of biomass has a specific feature in the planning region of Südoostoberbayern which is characterized by its rural areas. Whereas the northern districts relies on biomass from agriculture for the biogas production, the southern parts, especially the county of Berchtesgadener Land, source the biomass from forestry.

The exploitable expansion potential of biomass which considers the existing stock of installations amounts in the planning region up to about 1.426 GWh per year for the heat generation and around annual 384 GWh for the electricity production. Thereby 212.000 people in private households could be provided with renewable electricity. According to the estimated potential, biomass is able to cover 96% of the electricity demand in Südoostoberbayern excluding the industries. By exhausting all expansion potentials in the sector of heat, in particular forest wood is able to provide about 60% of the final energy demand of the private households.

Electricity generation based on biomass is of further significance due to its ability to economically compensate fluctuating energy production. More particularly the further flexibilisation of the existing stock of biomass systems and projects with a focus on linking the sectors electricity, heat and traffic substantially promote the efficiency enhancement in the application of energy generated from biomass.

One focal point during the development of project approaches is the identification of clusters with a potential for efficiency enhancement and which follow the principles of regional value creation, contribution to climate protection and energy system transformation as well as technical and economic feasibility. Each cluster combines project approaches which intend to maintain the existing biomass plants in order to ensure the future security of supply in the planning region and to open up an economic perspective for biomass plant operators even after the period of remuneration according to the Renewable Energy Act. The concepts include a local electricity market, the development of an instrument to identify hot-spots for the direct marketing of power and heat, bundling of biogas plants for joint processing and feeding of bio natural gas, consultations for operators of biomass systems and a virtual farm for biomass [11].

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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
Example

**Biomass Energy**

### ONLINE DATABASE FRED

An important tool for enhancing the acceptance for energies generated from biomass is the information transfer. In the course of a joint project of the Bavarian National Office for Environment and the Technology and Resource Center the online database FRED was created to provide information about the material composition of the various solid biomasses. The free search tool is accessible to plant operators, planners, operators of biomass firing installations, environmental authorities and all interested parties. All data sets are reviewed by the Technology and Research Center in terms of quality and are constantly extended. The greater the database of the analytical values for a fuel type, the better a characterization is possible. Further important information provider is the value distribution and are the extreme values. Therefore the records of raw materials can be statistically analyzed. The user can query extent of figures, value distribution, average values, deviations, coefficient of variation as well as minimum and maximum values according to each parameter of fuels (e.g. N, Cl, K, ash content ...). The results can be displayed as individual figures or as a statistical evaluation (figure 8) [14].

### ECO-MODEL ACHENTAL

The eco-model Achental with its nine members (community of Bergen, Grabenstätt, Grassau, Marquartstein, Reit im Winkl, Schleching, Staudach-Egerndach, Übersee and Unterwössen) targets to be self-sufficient in the near future by relying on its own resources to generated electricity and heat. The initial milestone for the intensive discussion on the use of renewable energies in Achental is the participation of the eco-model Achental e.V. in the EU project “RES Integration” (2004-2007). In the scope of this project the potential for the use of local energy sources as well as the suitability of the area as a model region for renewable energies in the rural region is assessed. It was established that the local energy resources based on solar power, hydropower and biomass are sufficient to cover the total energy demand for heating and electricity. This insight forms the basis of the first inter-communal energy concept.

The biomass farm Achental opened in 2007 in Grassau and since then provides further impulses to expand and utilize renewable energies in Achental [6].

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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
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Germany (Bavaria) - RES

**METHODOLOGIES**

List of renewable Energies to be studied

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Renewable Energies

**GERMANY – BAVARIA**

**DELIVERABLE T3.2**

**METHODOLOGIES - CONCLUSIONS**

- **Solar energy vector**

  In Bavaria, the comparably high global radiation is already widely used for energetic purposes and the Government aims to extend the exploitation of solar energy in the years to come. To promote the use of renewable energies the Bavarian Government provides comprehensive information and digital maps via an online platform ([www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to the expected energy demand and to the requirements of supplier and consumer. Therefore, energy saving, efficiency enhancement and a transition to the use of regenerative energy sources can be coordinated [1]. The Bavarian Government as well as the Federal Government aim to increase the use of solar energies. In order to make solar energy more accessible to wider public, the Governments promote the development of innovative technologies as well as the further development of existing technologies. The aim is to reduce the costs for photovoltaic systems and to facilitate the planning, the construction and the operation of PV plants [2; 3]. To further on enable appropriate funding for the use of solar energies, tender procedures were introduced [3].

**Related to Historic Buildings and protected sites**

Monumental protection and climate protection are equal interests and are not mutually exclusive. Due to the fact, that solar energy systems often affect the protected authentic appearance of historic buildings, it is mandatory by law (article 6 Bavarian heritage protection law = DSchG) to obtain approval. This applies to architectural monuments, ensembles of architectural monuments and immediate surroundings of monuments, unless a building permit is required anyhow. As far as serious reasons of monumental protection speak against an installation, the permission can be denied according to article 6 paragraph 2 sentence 1 DSchG. Each decision on authorization related to conservation legislation matters is a case-by-case decision. There is no list of criteria determining the permit of solar systems in connection with monuments. The monument’s value is decisive for the assessment of a possible official permit. In this context the term of division adequacy has developed. This means that the assessment is based on the monument’s category of meaning. For instance, the undisturbed and comprehensive preservation of an art monument is of paramount importance, whereas adjustments in scientific and local history monuments are more likely to receive an approval. 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 solar energy can be resolved, by being sufficiently flexible regarding the design and the choice of location of the solar plant. Processes not requiring planning permission are managed in article 57 paragraph 1 (3) of the Bavarian building regulations. Still the substantive requirements of the Federal State Building Order have to be observed [4].
**METHODOLOGY**

### Solar Energy

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**Energy Atlas Bavaria** [1]

The average of global radiation in Germany is 1.055 kWh/m² (for the period 1981-2010), whereby Bavaria provides favorable conditions to use solar energy. The southern region of Bavaria shows the highest global radiation sum, with a total annual radiation of 1.200 kWh/m² on a horizontal surface.

In Bavaria, photovoltaic plants provide more than 13.3 % of the gross electricity generation (2017). The PV plants are mostly located on building rooftops and to a less degree in open sites along highways and railway tracks. The goal of the Bavarian government is to increase the share of energy generated by solar systems to 22-25% by 2025 [1].

As a result, the Bavarian Government created the web portal EnergieAtlas Bayern ([www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)). The portal offers private individuals, companies and municipalities the opportunity to find information about existing, as well as potentially suitable locations for the solar systems. This is done by means of digital and interactive maps. The global radiation, respectively the sunshine duration can be calculated and files such as planning fundamentals (e.g. stocks or geographic and legal constraints) can be displayed (figure 1).

The map's information is based on data provided by the Bavarian State Office of Statistics and the Bavarian Agency for Surveying. Such as the 3D-model LoD2 (Level of Detail 2) with integrated common shapes of roofs. Building layouts by ALKIS (authoritative real estate cadaster information system) and rooftops recorded by Airborne-Laserscanning, ALKIS 3D building survey, as well as digital surface models based on aerial photographs are taken as a basis of modelling.

By importing external files in a WMS-format and overlapping the own data from the users with the technical data, the solar potential can be specified. Furthermore, the portal users have the possibility to display or to identify vacant surfaces (rooftops or open spaces) and get informed about their potential for solar energy applications (figure 2).

To forecast the individual potential of a location, a mixer console helps simulating various scenarios. Current potentials serve as guidelines to realistic scenarios and provide planning guidance [1].

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**Figure 1** – Screenshot from [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de). The portal allows you to calculate the sunshine duration at any location in Bavaria.

**Figure 2** – Screenshot from [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de). Users can identify vacant open spaces that fit the necessary conditions for PV plants.
Example

Solar Energy

**BAVARIA**

**Solar Potential**

The web portal Energie-Atlas Bayern ([www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)) can be used to estimate the PV potential of a municipality or a county (Landkreis) [1].

The interactive maps offered by web portal Energie-Atlas Bayern display existing photovoltaic systems with their exact location and efficiency in kWp. The shown information refers to facilities, which receive financial support according to the Renewable Energies Law (EEG). The different types of installations are shown separately and are categorized by location (rooftop and ground-mounted systems plus facilities on landfill and contaminated sites). Equally, vacant locations for solar use are visible and the users have access to additional information (e.g. material, dimension, orientation, utilization, contact person and possible shading). Moreover, the user can get an estimate about the amount of remuneration being paid as per the EEG [1].

The case of Trostberg, located in the municipality of Traunstein, serves as an example of how to make use of favorable conditions identified in the Energie-Atlas Bayern. In the course of a roof renovation of the municipal sports hall, the community decided to equip the tin roof with the metal sheets laminated solar modules (figure 4). The result is an annual saving of 46.000 kWh and 27.12 t CO₂ per year [1].

Due to federal and state regulations, new buildings often include solar facilities for heating and electricity. To retrofit an existing building often involves structural interventions including high costs and therefore is rather few in numbers. For historic buildings the Bavarian Office for the Preservation of Historical Monuments published a script which presents first guidelines regarding energy-efficient techniques in relation to historic preservation [4].

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**Figure 3** — Screenshot from [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de). Proportion of overall power consumption (by counties) produced by PV plants from <5%–100%.

**Figure 4** — Renovation of a tin roof with integrated thin-film solar cells. Source: Energieatlas, Bavarian Government
METHODOLOGY

Solar Energy

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Energy Use Plan

The energy use plan “Energienutzungsplan” (ENP) is a strategical planning instrument that provides a comprehensive overview of a municipality’s current and future energy demand and supply situation. Three phases define the ENP: stock and potential analysis, concept development and implementation [5].

In order to perform an analysis regarding the potential of photovoltaic and solar systems, the planners can refer to the 3D-building model LoD2 (figure 5) and the digital surface model DOM40 provided by the Bavarian Agency for Surveying. DOM40 displays the earth’s surface in a grid, including objects on it such as vegetation and buildings. In order to allow an assessment of the solar potentials, the exploitable amount of energy currently produced by solar and photovoltaic systems on existing and suitable rooftops must be determined. Different approaches are conceivable as a method, for instance a rough calculation, aerial photo analysis or the processing of geodata. Listed buildings that are not suitable for installations of solar systems are excluded. Due to various land usage demands, specific recommendations regarding open-site systems are left out [5].

Since generation and consumption of thermal energy is closely linked in spatial terms, this form of energy has a greater role in creating an ENP than the electricity supply. Therefor the heat requirement of a municipality is analyzed in accordance with its distribution in the municipal area. Significant outputs are maps showing the density of heat requirements (figure 6). Actual consumption values, as well as calculated or statistically evaluated requirements can be used to determine the heat requirement of a municipality. Frequently, only a small percentage of the consumption values referring to existing buildings is available, consequently for the majority (in particular residential buildings) the figures have to be estimated. Thereby the buildings type, age, size and utilization have to be considered [5].

Besides the identification of a municipality’s energy-saving potential, the ENP provides concrete suggestions for economical energy projects [5].

Figure 5 – Example of a 3D-building to identify rooftop surfaces (left) and a heat cadaster showing the annual heat requirement. Source: Energienutzungsplan, Landkreis Berchtesgadener Land.

Figure 6 – Map showing thermal density on basis of the heat cadaster. Source: Energienutzungsplan, Landkreis Berchtesgadener Land.
Example

Solar Energy

NERATIONAL LEVEL REGIONAL LEVEL LOCAL LEVEL

BERCHTESGADENER LAND

Energy Use Plan

The county of Berchtesgadener Land aims at becoming a role model in climate protection and local energy production. In order to achieve this objective, an energy use plan has been created.

To determine the solar potential on building’s rooftops in the municipality of Berchtesgadener Land, the annual global radiation of each roof surface was simulated (figure 7). The roof surfaces were mapped using the 3D-building model provided by the Agency for Surveying. With the help of the digital surface model the shading caused by the near surroundings (e.g. buildings or vegetation), as well as by the broad environment (surrounding topography, such as mountains) can be taken into account for the calculation. Based on the simulation of radiation, each rooftops surface that exceeds an annual global radiation of 800 kWh/m² a and is suitable for installations of solar thermal energy or photovoltaic modules, was identified and automatically equipped with modules [5].

The analysis results show the spatial and temporal distribution of direct and diffuse radiation of each rooftop in the county of Berchtesgadener Land. Furthermore, the studies disclose the maximum technical potential in the form of module area and corresponding outputs of solar thermal energy and PV.

To identify the potential of photovoltaic, only PV plants on buildings with an output of at least 1 kWp and a minimum yield of 850 kWh/kWp are considered. The analysis takes into account that the rooftop’s surfaces are manly used for hot water supply by solar thermal energy and therefore the available surface for PV plants is reduced [5].

The potential of expansion by 2030 is calculated with 105.000 MWh/a (figure 8) and measures up to 35% of all rooftops considered as usable [5].

To indicate the solar thermal energy potential, only buildings with a heat requirement (space heating and/or hot water) are considered. The thermal energy demand of each building is compared against the available solar potential and therefore the potential use of solar thermal energy can be identified.

The results show that the solar thermal energy use can increase from 1% (2014) to 3% by 2030 amounting to 16.639 MWh/a [5].
Installing a solar energy plant on a historic building, the compatibility with preservation orders has to be taken into account. Users of the web portal Energie-Atlas Bayern can identify the currently listed facilities with the help of interactive maps (figure 9). The monuments are divided into ground monuments, architectural monuments, ensembles of architectural monuments and landscape shaping monuments and can be shown or hidden at will.

Even in the immediate surrounding of monuments, an energy plant can affect the visual appearance of a monument. Nevertheless, the installation of a solar energy system can mean a contemporary usage of historical buildings. Generally, it is recommended to prove the option of installing the plants on subordinate adjoining structures or not observable surfaces [1].

**Solar Thermal Plants for Water Heating Purposes**

Solar thermal systems for water heating purposes are installed flush with the roof’s surface. Therefore, there are more discreet in their appearance than other roof structures. Under specific conditions, the installation in conjunction with historic monuments is conceivable. Primarily, the existing construction and the appearance of the monument have to be protected. Modules, simulating local elements such as eaves flashing (figure 10), slate cladding or metal sheets, can help preserving the monuments character. Sub-roof installations do not have any visual impact; however, the efficiency is reduced and the historic roof construction could be affected [6].

**Photovoltaic Plant on Historic Buildings**

Due to a much more prominent appearance than solar thermal plants, PV systems are not allowed to be visibly installed on or by historical monuments. However, since production and consumption of solar generated energy is not necessarily linked to each other, the installation of PV plants is not place-bound and in some cases can be moved to locations that are more favorable.

In case of an installation on site, several aspects have to be taken into account. To protect the historical roof construction, the static matters have to be considered (e.g. snow load). The modules are to be reduced to a minimum and various design options have to be taken into consideration. Photovoltaic films offer an alternative to the obvious modules and are suitable for flat roof surfaces and facades [6].
Solar Energy

APPLICATION TO HISTORIC BUILDINGS

MAXIMILANEUM (Munich, Bavaria)

The "Maximilaneum" describes for one thing the scholarship funds founded in 1852, furthermore it’s the naming of the building itself and in addition it forms the residence of the Bavarian State Parliament [7].

In 2004 a photovoltaic system upon the roof of the historic Maximilaneum which houses the Bavarian Parliament was taken into operation. The solar plant is in the hands of Buergerenergie Isar eG, a Bavarian cooperative that takes over the task of planning, financing and administer several renewable energy systems and providing the generated energy to the region [8].

Achievements and factors assessed:

- Annually, the solar plant produces about 18,000 kWh electricity with a total performance of 20,04 kWp
- The solar park feeds five single-family houses with green electricity
- The Maximilaneum being a landmark of Munich serves as a symbolic contribution to the expansion of renewable energies

![Figure 16 – Photovoltaic system on the roof of the Bavarian Parliament. Source: www.greenity.de](image-url)
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

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Germany (Bavaria) - RES

METHODOLOGIES

List of renewable Energies to be studied

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GERMANY – BAVARIA
DELIVERABLE T3.2
METHODOLOGIES – CONCLUSIONS

- Wind energy vector

Due to geographic and topographic circumstances and the partially low acceptance of wind turbines, still only a small share of the gross electricity generation in Bavaria is based on wind power. The Government’s aim is to extend the exploitation of wind energy and therefore created the map series (Bavarian Wind Atlas) as a planning resource. In addition, comprehensive information and digital maps are provided via an online platform (www.energieatlas.bayern.de) [1]. Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to the expected energy demand and to the requirements of supplier and consumer. Therefore, energy saving, efficiency enhancement and a transition to the use of regenerative energy sources can be coordinated [1]. The Bavarian Government as well as the Federal Government aim to increase the applicability and use of wind energies. While on a national level the focus is set to the technological development and further development of plant engineering [2], the Bavarian Government aims to ease the planning process and approval procedures [3].

In Bavaria the so called 10 H-regulation came into force in November 2014. According to Article 82 (1) of the Bavarian Building Regulations wind energy plants must keep a minimum distance of ten times its own height to residential areas to be seen privileged according to §35 (1), point 5 of the building code. A shortfall of the minimum distance is only possible if there is a development plan that determine lower distances. The 10 H-regulation is supposed to help establishing a balance of interests between a turnaround in energy policy and local resident populations [1].
METHODOLOGY

Wind Energy

NATIONAL LEVEL REGIONAL LEVEL LOCAL LEVEL

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**Wind Atlas**

The Bavarian Wind Atlas shows the regional wind power potential and functions as a guidance and planning tool for the spatial management of the utilization of wind power. The atlas allows an initial assessment of the average annual energy output and the suitability of a specific site for wind power plants. In 2014 the Bavarian wind atlas was reviewed and with the help of a calculation model a recalculation of the wind conditions was enabled. The new calculation fits the Bavarian topography which is characterized by its relief and equally observes the various land uses and vegetation.

The published wind maps in the Bavarian Wind Atlas illustrate a general tendency of the economic usability in certain areas. Shown are the possible energy yields and the average wind speed in a height of 100m, 130m (figure 1) and 160m above ground level. By means of a color scale the user can identify a locations medium wind speed.

An energy yield index indicates the risk of fluctuations of the wind conditions over a period of 30 years and captures the expected error occurring in the wind maps.

Bavaria’s wind patterns are shaped by its small-scale topography and therefore the wind situation of adjoining locations can distinguish significantly [4].

**Energy Atlas Bavaria**

The web portal Energie-Atlas Bayern ([www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)) also supplies its users with the wind maps and the energy yield index of the Bavarian Wind Atlas. Besides the mentioned instruments the portal offers further tools to evaluate the wind power potential of a region and fundamental data referring to a wind power plant setup.

The 3D-analysis of wind turbines is a feature that covers planning support by enabling the user to build a virtual wind energy plant and deploying it in a 3D model of Bavaria’s landscape. In combination with distance measurements, simulation of the shadowing and analyses of visibility, the tool’s outcome helps evaluating the feasibility of the wind power system and serves parties involved a neutral and objective basis for discussions [1].

![Figure 1 – wind map showing the wind conditions in 130m height above ground level in Bavaria. Source: Bayerischer Windatlas, Bayerisches Staatsministerium für Wirtschaft und Medien, Energie und Technologie](image1)

![Figure 2 – wind speed responding to changing terrain. Source: Bayerischer Windatlas, Bayerisches Staatsministerium für Wirtschaft, Infrastruktur, Verkehr und Technologie](image2)
Example

### BAVARIA

**Wind Power Areas**

In Bavaria, wind energy turbines provide 5.4% of the gross electricity generation, counting 1,100 facilities with an electricity generation of 4.559 million kWh (2017).

The Bavarian State Office for Environment (Bayerisches Landesamt für Umwelt = LfU) has developed wind power areas as an environmental planning tool for the expansion of wind energy use. The assessment of the sites suitability is based on the Bavarian wind atlas of 2014. The map series in a scale of 1:100,000 shows areas in Bavaria reaching sufficient wind speed and which are most likely suitable for wind energy turbines while not being affected by immission protection and nature conservation requirements.

The wind power areas were first published in 2012 and were based on the Bavarian energy atlas of 2010 and the Bavarian wind energy enactment of 2011. The areas were updated in the year 2016 building on the Bavarian energy atlas of 2014 and the Bavarian wind energy enactment of 2016. Only the surfaces documented in the Bavarian wind atlas of 2014 with a longtime average wind speed of 4.5 m/s in a height of 130 m were taken into account. Those sections were pretested regarding to immission protection and nature conservation requirements based on the guidelines of the wind energy enactment. Therewith, various environmental technical data was evaluated and processed in a geographic information system together with further geographic base data. Nature conservation areas, landscape conservation areas, bird sanctuary areas and further aspects of nature protection were considered, as well as matters of drinking water protection, provision of raw material and seismological service. Settlement were considered areal and provided with protective distances for noise protection. In regards to an efficient preliminary review from a nature conservation perspective distances to traffic routes, high-voltage lines and transformer stations were respected [1].

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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
METHODOLOGY

**Energy use plan**

The energy use plan “Energienutzungsplan” [ENP] [2] analysis is a strategic planning instrument that provides a comprehensive overview of a municipality’s current and future energy demand and supply situation. Three phases define the ENP: stock and potential analysis, concept development and implementation.

To identify the wind energy potential in its region, the municipality of Berchtesgadener Land has developed a statistical, high-resolution 3D-wind field model. The model provides information to possible plant yields at each location in the county and if required the district administration can make it available for wind yield assessments.

According to the 3D-model, the municipalities surrounding the mountain Teisenberg can expect comparatively high average wind speed. However, the installation of such called “landscape formative plants” are excluded in the current regional plan of the district. Due to the constraining conditions, two scenarios were considered while determining the wind energy potential of the municipality of Anger.

**Scenario 1:**
The first scenario considers the current legal framework and includes the installation of landscape formative plants which are potentially of economic importance.

*Result:*
On the basis of the present regional plan no expansion potential in the field of wind power was recorded.

**Scenario 2:**
Only if the legal conditions adjust, the development of the detected (additional) potentials in scenario two is conceivable. In general a technical potential for the use of wind generated energy in the surroundings of the Teisenberg exists.

*Result:*
In coordination with the municipality of Anger, two wind turbines and their estimated electricity yield were incorporated in the second scenario and as a result show an additional potential of more than 7.800 MWh/a.

The disclosed potential is simply a rough estimation of the electricity yield and does not replace a detailed yield calculation based on various reference facilities with geographical proximity. Without neglecting the high local variance of the wind power potential, each specific location must undergo a comprehensive analysis [2].
### Example: Wind Energy

#### STARNBERG

**Wind Power Concentration Areas**

The 13 local authorities in the county of Starnberg, as well as the city Starnberg itself manage the general admissibility of wind turbines by means of partial land-use plans. In addition the municipalities developed in 2012 so-called wind concentration areas, which describe suitable location where installations of wind turbines are possible. Even after the introduction of the 10 H-regulation, the partial land-use plans remain in full force and effect.

The Geographical County Information System Starnberg (Geographische Landkreis Informationssystem Starnberg = GeoLIS) is the cross divisional geo-information system of Starnberg’s district administration. It has established itself as a modern system based on maps and has become an important pillar of digitalization and eGovernment. The web portal GeoLIS provides a map showing the wind power concentration areas (figure 7) and is accessible for the users free of charge. The map serves interested parties as an initial guide [5].

According to the web portal Energie-Atlas Bayern, the county of Starnberg records an average wind speed of 5 m/s in a height of 100m above ground level (figure 8) and therefor has the potential of generating energy by wind turbines [1].

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**Figure 7 –** Screenshot from [www.arcgis.com](http://www.arcgis.com). Image of wind power concentration areas in the county of Starnberg.

**Figure 8 –** Screenshot from [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de). Image of the average wind speed in a height of 100m above ground level in the region of Starnberg.
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

References

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Germany (Bavaria) - RES

METHODOLOGIES

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Hydroelectric Energy

Germany – Bavaria

Deliverable T3.2

Methodologies – Conclusions

- Hydroelectric energy vector

In Bavaria, hydroelectric energies are already widely used and the Government aims to extend the exploitation in the years to come. To promote the use of renewable energies the Bavarian Government created online platforms with access to comprehensive information on waters in Bavaria such as the register for stream and river basins in Bavaria and digital maps ([www.umweltatlas.bayern.de](http://www.umweltatlas.bayern.de), [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)) [1; 2]. Furthermore, the Energy Use Plan (Energiennutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to the expected energy demand and to the requirements of supplier and consumer. Therefore, energy saving, efficiency enhancement and a transition to the use of regenerative energy sources can be coordinated [1]. The Bavarian Government as well as the Federal Government aim to increase the use of hydroelectric energies. The focus of the Government’s promotion is the use of existing facilities and the compatibility of hydroelectric systems with nature conservation issues contemplated in the National energy concept 2050 (Energiekonzept 2050, 2010) [3] and a Regional level within the Bavarian energy concept “Energie innovativ” (Bayerisches Energiekonzept “Energie innovativ”, 2011) [4].

Related Historic Buildings and sites

Hydroelectric power plants can be monuments of a technical nature where their value as monuments must be preserved. These templates fact sheet include different examples of application of Hydropower RES energy in Historic Buildings. Besides the retrofit of existing systems, as the installation of turbines in Drinking Water Pipelines (e.g. Thannberg) there is the example of Reactivation of a Historic Hydroelectric Power Plant that was built in 1896, used as spinning mill. In the 1970s it was shut down. The hydroelectric historic installation was reactivated in 2004 with an installed capacity of 120 kW and in the year 2006 it provided 200 households with hydroelectric energy, producing annually 0,7 million kWh with environmental improvements as well. Another interesting example of historic technical monument is the Danube power plant Jochenstein, in Untergriesbach, at the German-Austrian border. The hydropower plant was built from 1952 to 1956. It is the only joint monument of technology of Austria and Bavaria and is listed in Bavaria since 2011 and Austria since 2012.

Other example presented here is a new hydropower plant in an historical protected site, in Kempten. In 2007 a power plant built in the 1958 was demolished and replaced by a new run-of-river power station in Kempten at the River Iller. Alongside the power plant are historic and listed brickwork buildings which were used by spinning and weaving mills up until the middle of the last century.
Hydroelectric
Energy

METHODOLOGY

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BAVARIA

In Bavaria about 4,300 hydroelectric power plants are in operation, producing 12.160 million kWh and serving electricity to 3.8 million households. 94% of the facilities are recorded as small hydropower installations with an installed power of under 1 MW. Generating annually 1,000 GWh, they account 9% of the hydroelectric power in Bavaria [1]. The major share is produced by the large hydroelectric installations with an installed power of over 1 MW. The largest facilities have an installed power of more than 10 MW and yield around one third of the annual hydroelectric electricity [1]. Nevertheless, they only make up less than 2% of all facilities in Bavaria. Mainly, they are located at the alpine tributaries of the River Danube Iller, Lech (and Wertach), Isar and Inn, as well as at the River Main and Danube itself. The greatest potentials lie in the modification of the extent of use, the increase on the efficiency rate and the optimized management in cases of retrofit or modernization of large hydroelectric systems. Even though the opportunities for small facilities are limited, there is still unexploited potential [1].

The hydrographic groundwork of the waters are so far documented analog in the 1978 published register for stream and river basins in Bavaria and in the 1982 published register for lakes in Bavaria. Those listings were examined and revised comprehensively, transformed into a digital version and form an essential component of the digital Bavarian water management index. The register for stream and river basins in Bavaria is an official list containing the official name as well as information on length of the waters and size of the catchment areas. In addition the online tool Umwelt Atlas (www.umweltatlas.bayern.de) allows users displaying the different waters and the catchment areas in an interactive map (figure 2). If needed, further information such as administrative boarders can be added [2].

Additionally, the Bavarian Government created the web portal Energie-Atlas Bayern (www.energieatlas.bayern.de) which offers private individuals, companies and municipalities the opportunity to gather information about the field of hydroelectric energies [1]. With the help of interactive maps the user can identify existing hydroelectric power plants with a potential for modernization and/or retrofit and which have a performance of over 1 MW (figure 1). Furthermore layers showing potentially suitable locations for new transfers constructions can be displayed [1].

Figure 1 – Screenshot from www.energieatlas.bayern.de shows the existing hydroelectric power plants in Bavaria which indicate a potential for modernization and/or retrofit.

Figure 2 – Screenshot from the environment atlas on the web portal www.umweltatlas.bayern.de shows the interactive map listing all stream and river basins in Bavaria

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
Hydroelectric Energy

Example

**BAVARIA**

Expansion Potential of Hydroelectric Power in Bavaria

The two largest hydroelectric plant operators E.ON Wasserkraft GmbH and Bayerische Elektrizitätswerke GmbH conducted the potential study “Expansion potential of hydroelectric power in Bavaria”, demonstrating that the increase of hydroelectric energy contributes to climate protection [6].

In order to calculate the technical potential of the facilities, various parameters such as state of development and drop height were examined [5].

The study describes different methods of increasing and using the potential and discloses them for the region of Bavaria. In the process, a distinction is made between increase of potential by an improvement of the state of development, increase of potential by a short-term raise of the capacity level, increase of potential by enhancing the efficiency rating, increase of potential by new constructions at vacant locations, increase of potential by new constructions at locations with existing transvers constructions, increase of potential by upgrading existing facilities and increase of potential by modernization, retrofit and reactivation[5].

The research results indicate a hydroelectric energy potential of annually 1.035 GWh. Therefor up to 300,000 average private households could be provided additionally with renewable power and furthermore 610,000 tones carbon dioxide could be saved [5].

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METHODOLOGY

Hydroelectric Energy

Energy Use Plan

Referring to hydroelectric energies, the energy use plan aims to identify the ascertainable potentials site-specific. In order to draw up the actual state as precisely as possible, plant operators were questioned and invited to attend a hydroelectric forum open to all interested parties. In addition to specialist lectures, experts in the field of hydroelectric power were present and offered consultation hours. Besides the findings of the participative events, data from the district administration and the water authority fed into the analysis. By merging the knowledge gained the potential for hydroelectric energy was defined and two scenarios developed [6].

The first scenario includes the expansion potential by modernization, conversion, retrofit, as well as new constructions and reactivation. Subject to fulfilling all legal requirements, the potential in this scenario is seen as achievable. The potentials of this scenario are assessed with annually 4.060 MWh originating from optimizing an existing plant, extending an existing plant and creating a new construction with residual water release [6].

The exploitation of the potentials considered in the second scenario are ether uncertain at the moment due to the complexity of the respective project or assessed as merely feasible on the condition of changing framework conditions. At this point in time no potentials of scenario two can be located in the region.

Summarizing there is a total potential for hydroelectric energy of 13.115 MWh/a, though only 9.055 MWh/a are currently utilized (figure 3) [6].

Figure 3 – diagram showing the calculated potential for expansion in the county of Berchtesgadener Land on the basis of data collected in the year of 2014. Source: Energienutzungsplan, Landkreis Berchtesgadener Land
Example

Hydroelectric Energy

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Due to the high altitude of the drinking water reservoir in Frauenau in the Bavarian Forest, the opportunity of planning a network of long-distance water pipelines with a water distribution in free fall occurred. Within the main route several sections showed an energy potential surplus. On the basis of energetic calculations five suitable locations were identified for an installation of turbines. The water pressures of the respective long-distance pipelines with a nominal diameter between 400 and 1000mm are higher than the necessary water pressure for filling the tanks [1].

The aim was to utilize the excess energy without jeopardizing the quality or quantity of the supply reliability. Because of this, pumps which are approved for the drinking water supply were used as turbines (figure 4). Evaluations of the various operating states determine the technical layout of the pumps. Due to the lack of experience with the impact of power cuts on the construction methods, at the beginning mechanically operating brake discs were installed. By doing this, the possibility of a transgression of the allowable rotation speed for conventional pumps is ruled out. Later on the materials of the pumps could be customized to fit the possible maximum rotation speed [1].

The amortization period of the installation account seven to eight years. Currently, about one third of the energy costs of the association Water Supply Bavarian Forest (WBW = Wasserversorgung Bayerischer Wald) can be generated by the own turbines (2010) [1].

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Figure 4 – image of the turbine unit for the high-level tank in Thannberg. Source: [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)

Figure 5 – overview map of turbine units in the counties of Deggendorf, Regen and Freyung Grafenau. Source: [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)
Hydroelectric Energy

**METHODOLOGY**

**RELATED TO HISTORIC BUILDINGS**

** Reactivation of a Hydroelectric Power Plant [4]**

In the south of Baden-Wuerttemberg, at the river Radolfzeller Aach, a hydroelectric power plant was approximately built in the year 1896 and was used by a formally resident spinning mill.

In the 1970s it was shut down. The hydroelectric installation (figure 6) was reactivated in 2004 with an installed capacity of 120 kW and in the year 2006 it provided 200 households with hydroelectric energy, producing annually 0.7 million kWh. Before the reactivation the section between the hydroelectric plant and the channel leading back to the main stream was not passable for fish or microbes. This has a negative impact on the entire living environment of the running waters.

In the course of the reactivation of the hydroelectric power plant a passage of fish and other aquatic organisms and an improvement of the living conditions was made possible. Among other things, this was done by a fish pass [7].

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**Figure 6** – Image showing the reactivated historic hydroelectric power plant at the river Radolfzeller Aach. Source: Erneuerbare Energien 2020, Potenzialatlas Deutschland; Agentur für Erneuerbare Energien e.V.
Example

Hydroelectric Energy

APPLICATION TO HISTORIC BUILDINGS

HYDROPOWER ALONGSIDE A MONUMENT (KEMPTEN)

In 2007 a power plant built in the 1958 was demolished and replaced by a new run-of-river power station in Kempten at the River Iller (figure 7). Alongside the power plant are historic and listed brickwork buildings which were used by spinning and weaving mills up until the middle of the last century.

Kempten called for a new facility that operated at high efficiency on the one hand and on the other hand meets the higher requirements of sound insulation.

Due to the increased development achievement and a better efficiency the electricity generation was increased by about 30%. Annually the new hydroelectric power plant generates about 10.5 million kWh and provides around 3000 households with CO₂-free electricity. With the aid of these measures, approximately 5400 tons of the harmful CO₂ emissions can be avoided [1].

LISTED HYDROPOWERPLANT (UNTERGIESBACH)

The Danube power plant Jochenstein (figure 8) was built from 1952 to 1956 and is located in Untergriesbach at the German-Austrian border. It is the only joint monument of technology of Austria and Bavaria and is listed in Bavaria since 2011 and in Austria since 2012. According to the Bavarian state office for the preservation of monuments especially the power plant Jochenstein is a fine example for the combination of a technical monument and the needs of modern energy generation. The preservation order aims to conserve the monumental essences and equally allow the technology to be updated moderately. This could also include an extension of the power plant to increase the efficiency of the facility [8].

Figure 7 – Run-of-river power plant located at the river Iller in Kempten, Bavaria. Source: www.energieatlas.bayern.de

Figure 8 – Hydroelectric power plant Jochenstein at the German-Austrian border. Source: www.geoportal.bayern.de

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
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Hydrothermal and Geothermal energy vector

Even though the temperature at the earth’s surface in Bavaria is relatively low, shallow-ground geothermal energy is conditionally exploited [1]. Regarding deep geothermic energy, hydrothermal energy is already widely used for energetic purposes and an even higher energy yield is expected for the years to come (Bayerisches Energiekonzept “Energie innovativ”, 2011) [2]. To promote the use of geothermal energies, the Bavarian State Ministry of Economy, Regional Development and Energy created the Geothermal Atlas Bayern which comprises comprehensive information referring to local conditions and expected values [3].

In addition, the Bavarian Government provides further information and digital maps via an online platform (www.energieatlas.bayern.de). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to the expected energy demand and to the requirements of supplier and consumer. Therefore, energy saving, efficiency enhancement and a transition to the use of regenerative energy sources can be coordinated [4]. The Bavarian Government as well as the Federal Government aim to increase the use of geothermal energies. Therefore, the Governments promote the development of innovative technologies especially for systems based on hot water deposits and dry rock formations. In order to reach the established goals on a national as well as on a regional level, special attention is paid to technologies which are transferable to similar situations worldwide, to the combined use of different renewable energy sources and to funding programs promoting the use of geothermal energies contemplated in the National energy concept 2050 (Energiekonzept 2050, 2010) [5] and a Regional level within the Bavarian energy concept "Energie innovativ" (Bayerisches Energiekonzept “Energie innovativ”, 2011) [2].

At the federal state level focus is mainly set on the domestic energy source in the “Malm carbonate” in the south Bavarian region, which forms the largest directly usable deposit of geothermal energy in Central Europe [2].

Related Historic Buildings and sites

The research project "eCO2centric" [8] conducted by the university of Biberach was presented in this template fact sheet. The use of waste water and heat recovery, hydrothermal or geothermal energy was considered to develop energy efficient options for urban development, taking the listed building stock into account.
METHODOLOGY

Hydrothermal
Geothermal

<table>
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<th>BAVARIA</th>
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According to various estimations, the earth’s core has a temperature of 4,800 °C to 7,700 °C. Based on the temperature gradient between the interior of the earth and the earth’s surface, geothermal heat is constantly carried upward from the depth. In Bavaria, this heat flow reports about 60 to 80mW/m² [3].

**Shallow-Ground Geothermal Energy**
The average temperature at the earth’s surface in Bavaria is around 7 to 12 °C; therefore, the temperature level of surface zones is relatively low. Nevertheless, there is a wide scope for small and medium sized decentralized facilities providing thermal energy or cooling in those temperature levels. Usually, those low levels of temperature can only be used by means of a heat pump [1].

**Deep Geothemic Energy**
There are two ways in using the geothermal energy of the deep underground: hydrothermal energy generation (using the hot water aquifer) and petrothermal energy generation (Hot-Dry-Rock = HDR; using the retained energy in rocks). Whereas the hydrothermal energy generation is successfully applied in Bavaria, the petrothermal systems currently are still in experimental practices. The so far exploited hydrothermal potential reports about 300 MW used for heating and additional 25 MW for electricity generation. The full development of the south Bavarian’s potential promises around 1.800 MW for heating and about 300 MW for electricity generation. Including innovative procedures for the petrothermal energy generation to the theoretical geothermal potential, a power generation of about 3.000 MW is to be expected.

Due to the slow dissipation of heat in the underground, the explored deposits of geothermal energy can be used over the long term. Model calculations assume an availability of 100-150 years [2].

**Geothermal Atlas Bavaria**
The Bavarian State Ministry of Economy, Regional Development and Energy created the Geothermal Atlas Bayern as a guidance and planning tool for communities, cooperation association and private investors. Interested parties have the opportunity of gathering information concerning favorable conditions for hydrothermal energy generation in Bavaria and which drilling depth and temperature is to expect [6].

In Addition, the web portal Energie-Atlas Bayern (www.energieatlas.bayern.de) offers interactive maps allowing to display specific data such as rock distribution, thermal conductivity or fault zones [5].
## METHODOLOGY

### Geothermal Energy

<table>
<thead>
<tr>
<th>NATIONAL LEVEL</th>
<th>REGIONAL LEVEL</th>
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<tbody>
<tr>
<td>Energy use plan</td>
<td>The energy use plan “Energienutzungsplan” (ENP) is a strategical planning instrument that provides a comprehensive overview of a municipality’s current and future energy demand and supply situation. Three phases define the ENP: stock and potential analysis, concept development and implementation [7]. To identify the shallow-ground geothermal energy potential in its region, the municipality of Berchtesgadener Land falls back on the hydrogeological data of the geological office of the State Office for Environment. The potentials were precisely elevated from each plot in the community. Therefore, first the principal land availability for ground heat collectors or borehole heat exchanger on the particular plot was evaluated and the legal framework of drilling was examined. Subsequently, the usable heat in theory on land parcels was calculated and related to the heat demand of its buildings. Besides the hydrological suitability and the legal framework of drilling, the energetic condition of a building as well as its thermal output system (e.g. underfloor heating) determine the eligibility for shallow-ground geothermal energy. Figure 4 illustrates the fact that an increasing standard in renovations of the existing buildings would raise the number of real estates in the county of Berchtesgadener Land that come into question for the use of shallow-ground geothermal energy use. Due to the geological conditions in the county Berchtesgadener Land the use of deep geothermic energy can only be considered in few subsections in the region [7].</td>
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</table>

**Figure 3** – the images show the site suitability for shallow-ground geothermal energy (left) and the thermal conductivity in a depth to 100m (right) in the county of Berchtesgadener Land. Source: Energienutzungsplan, Landkreis Berchtesgadener Land

**Figure 4** – graphic showing the supply potential by borehole heat exchanger in the county of Berchtesgadener Land. Source: Energienutzungsplan, Landkreis Berchtesgadener Land
The research project "eCO2centric" conducted by the university of Biberach [8] deals with the topic of sustainable urban. The project takes an integrated and interdisciplinary approach on improving the carbon footprint in the historical center of the city. In cooperation with civil, industrial and research partners the university evaluates the carbon reduction potential in the old town. Besides developing mobility concepts and examining measures on energy saving, the options of energy generation are assessed. For instance use of waste water and heat recovery, hydrothermal or geothermal energy. Aim is it to develop energy efficient and climate-friendly options of action for urban development, while taking the listed building stock into account. On this basis further city centers are to be studied and the collected findings serve as database for a guideline yet to be developed [8].

Figure 5 – Potential assessment on the options of thermal renovation in the context of preservation order. Source: www.hochschule-biberach.de
<table>
<thead>
<tr>
<th>References</th>
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<tbody>
<tr>
<td>[1] Oberflächennahe Geothermie; Bayerisches Landesamt für Umwelt (LfU); 2013</td>
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<tr>
<td>[3] Bayerischer Geothermieatlas; Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie; 2019</td>
</tr>
<tr>
<td>[5] Energiekonzept 2050: Eine Vision für ein nachhaltiges Energiekonzept auf Basis von Energieeffizienz und 100% erneuerbaren Energien; ForschungsVerbund Erneuerbare Energien; Juni 2010</td>
</tr>
<tr>
<td>[6] Erdwärme – Die Energiequelle aus der Tiefe; Bayerisches Landesamt für Umwelt (LfU); 2016</td>
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<tr>
<td>[7] Energiennutzungsplan: Markt Berchtesgaden; Landkreis Berchtesgadener Land; 2017</td>
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</table>
List of renewable Energies to be studied

**Renewable Energy Systems (RES)**

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<tbody>
<tr>
<td>1</td>
<td>![Solar icon] Solar (Photovoltaic &amp; Solar thermal)</td>
</tr>
<tr>
<td>2</td>
<td>![Wind icon] Wind power</td>
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<tr>
<td>3</td>
<td>![Hydroelectric icon] Hydroelectric</td>
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<tr>
<td>4</td>
<td>![Hydrothermal icon] Hydrothermal</td>
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<td>5</td>
<td>![Geothermal icon] Geothermal</td>
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<tr>
<td>6</td>
<td>![Biomass icon] Biomass</td>
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</table>
Biomass Energy

Germany – Bavaria

Deliverable T3.2

Methodologies – Conclusions

- Biomass energy vector

In Germany, biomass energy is already widely used for energetic purposes and an even higher and more sustainable energy yield is expected for the years to come [1]. To promote the use of biomass fuel, the Bavarian Government provides comprehensive information and digital maps via an online platform (www.energieatlas.bayern.de). Furthermore, the Energy Use Plan (Energienutzungsplan = ENP) is a helpful planning instrument for municipalities in Bavaria. The ENP supports communities to customize the individual energy supply to the expected energy demand and to the requirements of supplier and consumer. Therefore, energy saving, efficiency enhancement and a transition to the use of regenerative energy sources can be coordinated [2]. The Bavarian Government as well as the Federal Government aim to increase the use of biomass energy. The focal point of the research and development of biomass lies, inter alia, on organic residues and waste materials. Furthermore, the Governments promote the installation of systems based on biomass in existing building stocks. At best, the intervention is linked to insulation measures in order to reduce the overall thermal demand [3; 1].

Related Historic Buildings and sites

Nowadays, the utilization of renewable energies such as biogas is no more bound directly to a building structure. Certified pipeline-bound energies can be purchased on the trading market. The question of biogas plant setups is mainly posed in rural regions. During construction of large facilities and related interventions in the soil with a possibility of discovering archeological findings, the issues of preservation of historical monuments affect the archeological heritage. The excess planning of archeological monuments is to be avoided. The conservation of the visual appearance and surroundings relate to the preservation of architectural monuments. In cases of internal consumption of biogas, the intervention has no further impact on the monument than other condensing boilers [4]. Biogas plants in the immediate proximity of an architectural or art monument can have a negative impact on the historic image. In order to perform an individual assessment, an approval procedure according to Article 6 of the Bavarian heritage protection Law is mandatory. Sites in the area of ground monuments or upon surfaces that indicate a ground monument require an approval procedure according to Article 7 of the Bavarian heritage protection Law [5].

Examples of local heat network taking advantage of Biomass exploitation in Lupburg where the center of the network is the heating plant based on biomass boilers and a cogeneration with a 30 kWp PV system are presented in these fact sheets. Another example, in Bad Alexander regards a listed property supplies the municipal biomass plant.
### METHODOLOGY

#### Biomass Energy

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### BAVARIA

**Energy Atlas Bavaria**

With a share of 23%, fuel wood is the second main forestall product and the most important bioenergy in Bavaria. The far greater portion of the logged wood is still used for raw and building material or for pulpwood. Only at the end of its service life it is utilized for energy generation in firing plants for waste wood or in waste-to-energy plants.

In 2008 a total of about 1.8 million tons organic waste were recorded and processed in over 330 composting and fermentation plant. In addition approximately 50% of the around 3 million tones waste which are transferred to energy in waste-to-energy plants in Bavaria are of biogenic origin, e.g. food scraps, sanitary waste, textiles, wood or cardboard.

The energetic use of biogenic waste and residual material contributes to the avoidance or reduction of potential acreage competition for the production of nourishments and animal feed, raw material, energy crop as well as conservation measures or organic farming.

The web portal Energie-Atlas Bayern ([www.energieatlas.bayern.de](http://www.energieatlas.bayern.de)) offers users the possibility of gathering information about the current use of biogenic energy sources in Bavaria and their potentials. Interactive maps show the ownership structures of the forests (figure 1) and the annual usable energy potentials (figure 2). The potentials apply solely to wood which has an aboveground wood mass over 7 cm including the bark. The evaluation of the potentials was surveyed for each municipality and refers to various remote sensing data, modeling tools and inventory data. The maps do not provide information to which extent the potentials are used so far or whether they can be exploited at all. However the maps include a layer that identifies the stock of biomass plants, municipal treatment plant and landfills [2].

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**Figure 1** – Screenshot from [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de). Ownership structures of Bavaria’s forests.

**Figure 2** – Screenshot from [www.energieatlas.bayern.de](http://www.energieatlas.bayern.de). Energy potential generated by solid wood from the forests.
Example

Biomass Energy

<table>
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<th>NATIONAL LEVEL</th>
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**BAVARIA**

**Biogas Guide Bavaria**

Biogas plants can have a sustainable and significant impact on energy supply, climate protection and on the utilization of biological waste. According to the Agricultural Institute of the State of Bavaria in 2013 2330 biogas plants with an installed electrical rated output of 732 MW and an additional installed methane feed-in power of 11600 standard cubic meter per hour were operated in Bavaria. The main amount of the facilities use exclusively farm manure (slurry/dung) and/or regenerative raw materials (mainly maize).

The Bavarian Ministry of the Environment and Consumer Protection commissioned the Bavarian National Office for Environment to create a biogas guide for Bavaria in cooperation with the respective specialized body and in accordance with the professional association biogas [2].

The guide includes examples, checklists as well as detailed instructions concerning the framework that has to be observed and gives answers to all fundamental questions about biogas. A focal point is the chapter 2 “approval procedures”, which provides assistance to planners, operators of biogas plants as well as to approval authorities. Aim is it to simplify, standardize and accelerate the proceedings and thereby meeting the requirements of environmental, health and consumer protection [6].

Figure 3 – Distribution of biogas plants in Bavaria. Source: [www.lfu.bayern.de](http://www.lfu.bayern.de) [7]

Figure 4 – number of plants, electrical rated output and feed of methane according to years (status as of June 2019). Source: [www.lfu.bayern.de](http://www.lfu.bayern.de) [7]
### METHODOLOGY

#### Biomass Energy

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<th>LOCAL LEVEL</th>
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**Energy Use Plan [9]**

A substantial part of the county of Berchtesgadener Land is forested (about 53%). For reasons of sustainability, the annual harvesting of wood in the public forests is far below the amount of wood regrowth and there is no economical logging in the entire area of the national parks. In order to further ensure the sustainability and equally use most of the logged wood for material use, the respective parties came to the conclusion that there is no significant expansion potential for energetic utilization of solid biomass in the public forests. Meanwhile the private forests show high wood reserves and promise an enhanced utilization potential in the medium term by destocking or forest modification measures. In practice the mobilization of wood is often not possible due to the ownership structures.

In the course of creating the energy use plan for the county of Berchtesgadener Land an analysis on efficiency enhancement of existing biogas plants was conducted. Due to the current legal and economic framework only few potentials can be identified. For instance the establishment of small biogas plants on the basis of high usage of slurry.

In addition the potentials for cogeneration systems in district were determined. The evaluation for the expansion potentials for the electricity generation based on solid and liquid biomass refers to concrete projects in the municipal territory. However due to the current basic conditions the installation of new cogeneration systems does not offer an economic prospect [8].

![Figure 5 – diagram showing the existing and the expandable potential for biogas in the municipality of Anger. Source: Energienutzungsplan Gemeinde Anger](image)

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
### Example

<table>
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<tr>
<th>NATIONAL LEVEL</th>
<th>REGIONAL LEVEL</th>
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**LUPBURG**

**Renewable Local Heat Network [9]**

Lupburg is a small community in the district of Neumarkt and accommodates 2,300 inhabitants. In cooperation with the citizens a concept for a local heat network was created. Center of the network is the heating plant. The boiler house shelters a wood carburetor cogeneration unit, three biomass boilers and two large buffer storages with a volume of 20,000 liters each. Daily 2.5 tones pellets from the region are heated up in the wood carburetor. Thereby on part of the used heat for the local heat network is emitted. However, the large share results from the combustion of wood gases in the cogeneration plant, whereby a six-cylinder engine is powered. The heat waste warms the water. In addition three heating boilers with a thermal output of 160 kW each and fueled by wood chips or wooden pellets, supply energy to the local heat network in times of higher heat requirements. A photovoltaic system with 30 kWp is placed on the roof of the heating station and generates energy that primarily is used directly in the boiler house. In addition, a power-to-heat-system is operated with a performance of 183 kW. If required, the installation converts the produced power of the cogeneration unit into heat and thereby improves the efficiency of the system. The plant is of particular value, if for example the responsible network operator blocks the electricity feed due to a superset of wind or solar power in the network. Since power-to-heat systems are especially suitable for short-term operation modes and frequent circuits, they offer the opportunity of participating in the balancing energy market and promoting the integration of renewable energies in the market. In case of excess quantities in the electricity distribution network, the cogeneration plant can be disconnected from the network without shutting down the unit. Thereby it continues generating electricity which is converted to heat by the power-to-heat system and is stored in a buffer tank. The local heat network guarantees calculable heating costs over the long term and 220,000 liters heating oil are saved per year. Furthermore, the community benefits of the additional commercial tax income and the commissioning of local companies for the construction and maintenance of the object promotes the regional value creation [9].

[Figure 6 – heating center of Lupburg, Oberpfalz. Source: www.kommunal-erneuerbar.de](#)

[Figure 7 – heating center of Lupburg, Oberpfalz. Source: www.kommunal-erneuerbar.de](#)

### APPLICATION TO HISTORIC BUILDINGS

**SOLAR THERMAL DRYING OF CHOPPED WOOD**

**Listed Property Supplies Municipal Biomass Heating Plant**

In Bad Alexandersbad the owner of a listed property dries biomass with the help of solar power [2]. In order to provide the municipal heating plant with biomass, 4.5 hectares short rotational plantations were cultivated in the year of 2006. The service was able to start in 2010. Annually a total of 9 tones absolutely dry wood is obtained per hectare [2].

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
References

[1] Energiekonzept 2050: Eine Vision für ein nachhaltiges Energiekonzept auf Basis von Energieeffizienz und 100% erneuerbaren Energien; ForschungsVerbund Erneuerbare Energien; Juni 2010


[8] Energienutzungsplan Gemeinde Anger; Landkreis Berchtesgadener Land; 2017

6.3 Annex 3: Templates Austria (Vorarlberg)
### AUSTRIA

#### Strategies

**Solar (PV & ST)**
- National Level
  - BDA – brochure (National level)
- Regional – Local Level
  - Energy subsidies by State of Vorarlberg

**Wind power**
- NO INFORMATION

**Hydroelectric**
- NO INFORMATION

**Hydrothermal (surface waters, groundwater, sewage)**
- NO INFORMATION

**Geothermal**
- NO INFORMATION

**Biomass**
- National Level
  - BDA – brochure (National level)
- Regional – Local Level
  - Energy subsidies by State of Vorarlberg

#### Methodologies

**Solar (PV & ST)**
- Regional – Local Level
  - tool USI
  - Heizrechner (Heat calculator)
  - VOGIS – online tool (solar potential)

**Wind power**
- No data

**Hydroelectric**
- No data

**Hydrothermal (surface waters, groundwater, sewage)**
- No data

**Geothermal**
- No data

**Biomass**
- Regional – Local Level
  - Heizrechner (Heat calculator)

#### Application to HB - Examples

**Solar (PV & ST)**
- Application to HB:
  - Example PV (House Breuer)
  - Example ST (House Nenning Hittisau)

**Wind power**
- Application to HB:
  - No data

**Hydroelectric**
- Application to HB:
  - No data

**Hydrothermal (surface waters, groundwater, sewage)**
- Application to HB:
  - No data

**Geothermal**
- Application to HB:
  - No data

**Biomass**
- Example Biomass and District Heating
  - Old School Lech – Kindergarten
  - Elementary School, Lauterach
  - Tow Hall, Zwischenwasser
Austria (Volarlberg) - RES

STRATEGIES & METHODOLOGIES

List of renewable Energies to be studied

<table>
<thead>
<tr>
<th>Renewable Energy Systems (RES)</th>
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<tbody>
<tr>
<td>1 Solar (Photovoltaic &amp; Solar thermal)</td>
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<tr>
<td>2 Wind power</td>
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<td>3 Hydroelectric</td>
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<td>4 Hydrothermal</td>
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<td>5 Geothermal</td>
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<tr>
<td>6 Biomass</td>
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</table>
### CONCLUSIONS

In the state of Vorarlberg mainly three different renewable energy sources are used and are supported with strategies and methodologies. 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).

The following methodologies and strategies are relevant to spread the renewable energy sources in Vorarlberg in historic building:

- **METHODOLOGIES (National -Regional – Local Level) & Examples**
  - SUSI - Online-Tool for electrical energy balance of a building
  - Heizrechner - Online-Tool for comparison of heating systems
  - VOGIS - Online-Tool for solar potential calculation / visualization
  - BDA-brochure - Brochure of the monument office for energy efficiency
  - Energy subsidies by State of Vorarlberg
  
  ➢ **APPLICATION TO HISTORIC BUILDINGS & Examples**
    - See examples House Breuer, House Nenning, Old School Lech, School Lauterach and Town Hall Zwischenwasser

- **STRATEGIES (National -Regional – Local Level) & Examples**
  - BDA-brochure - Brochure of the monument office for energy efficiency
  - Energy subsidies by State of Vorarlberg
  
  ➢ **APPLICATION TO HISTORIC BUILDINGS & Examples**
    - See examples House Breuer, House Nenning, Old School Lech, School Lauterach and Town Hall Zwischenwasser
In Vorarlberg

- **Solar energy vector**
  Thermal solar energy and PV systems are used widely, but not so often in historic buildings.

- **Wind power energy vector**
  Wind power is not present; there is also no political will to change it.

- **Hydroelectric energy vector**
  Not relevant for municipalities in Vorarlberg (everything is organized and managed by the national energy provider, owned by the state of Vorarlberg).

- **Hydrothermal (surface waters, groundwater, sewage) energy vector**
  Not relevant for municipalities in Vorarlberg – no hydrothermal sources in Vorarlberg.

- **Geothermal energy vector**
  Not relevant for municipalities in Vorarlberg – no geothermal power plants (only geothermal uses are heat pumps which are very often not possible in historic buildings due to the need of high temperature for heating system).

- **Biomass energy vector**
  Biomass as single heating system or district heating is very common and supported by subsidies.
## METHODOLOGY

### Solar Energy

#### NATIONAL LEVEL

**VOGIS – online tool**

*Online-Tool for solar potential calculation / visualization*

The VoGIS (Vorarlberger Geographisches Informationssystem) is the GIS system of Vorarlberg – available at [http://vogis.cnv.at](http://vogis.cnv.at). It procures, creates, maintains and publishes geographical data for the Vorarlberg provincial administration and the individual citizen. In organisational terms, VoGIS is integrated into the Landesamt für Vermessung und Geoinformation (Landesvermessungsamt Vorarlberg).

The tool enables to get information about the solar potential, the solar radiation and the sun pathway for every single hour in the year.

This information helps e.g. the owner of a building to plan the PV or solar thermal system precisely.


**Figure 1 – Screenshot of “VOGIS” ([http://vogis.cnv.at](http://vogis.cnv.at))**

**Figure 2 – Screenshot of “VOGIS” ([http://vogis.cnv.at](http://vogis.cnv.at))**

**Figure 3 – Screenshot of “VOGIS” ([http://vogis.cnv.at](http://vogis.cnv.at))**
SUSI – Online-Tool

Online-Tool for electrical energy balance of a building

SUSI - the grid independence simulation – available at (https://www.energieinstitut.at/tools/susi/)

SUSI helps to find out whether a battery for a PV system pays off and how large it should be. Further on SUSI shows the amount of electricity consumption a PV system can provide and how much electricity can be self-consumed and draw from the grid in the individual months. In addition, SUSI calculates the profitability of a PV system with or without an accumulator. This makes SUSI more than just an energy calculator.

In a few simple steps, SUSI can map the electrical energy balance of a house: electricity requirements for electrical appliances, lighting and - if available - hot water, comfort ventilation and an electrical heating system as e.g. a heat pump or direct electrical heating.

SUSI only needs a few details on electricity consumption and building services. If known, the exact consumption can be entered. This will give you as accurate a result as possible. But even with the default values, an estimation can be made for analyzing the effect of a battery storage device, for example.

Clear graphics on the degree of utilisation and self-sufficiency, the electricity balance, the coverage ratio over the course of the year or the CO₂ balance show the effect of various components and dimensions on the overall system. Try out how much the size of a battery storage unit affects efficiency and independence. With default values you can get an overview - or with exact figures of an existing offer and your PV subsidy contract you can calculate as accurately as possible.
### Renewable Energies

**Heizrechner (Heat calculator) – Online-Tool**

**Online-Tool for comparison of heating systems**

Full cost comparison of heating systems – available at ([https://www.energieinstitut.at/tools/HeizrechnerV4/](https://www.energieinstitut.at/tools/HeizrechnerV4/))

The online tool "Heating Calculator" offers a full cost comparison of two heating systems of your choice, tailor-made for your building.

In case of searching for the most cost-effective and low-emission heating system for a residential building, the “Heizrechner” (heat calculator) is the right tool. Here an overview of costs and CO₂ emissions as well as a comparison of amortization between two heating systems of your choice can be found.

The costs used for the calculations refer to a heating system in a new detached house and are average values. In the case of significantly different buildings (e.g. multiple dwelling houses, renovations), it is advisable to obtain quotations from your trusted installer and use the prices in accordance with the quotation.

The energy prices are usually the average value of the last year (sources: Land Vorarlberg, Illwerke-VKW, Ländle Pellets). All values can be changed if necessary.

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**Figure 7** – Screenshot of “Heizrechner” ([https://www.energieinstitut.at/tools/HeizrechnerV4/](https://www.energieinstitut.at/tools/HeizrechnerV4/))

**Figure 8** – Screenshot of “Heizrechner” ([https://www.energieinstitut.at/tools/HeizrechnerV4/](https://www.energieinstitut.at/tools/HeizrechnerV4/))
STRATEGY

METHODOLOGY

Solar
Energy

NATIONAL LEVEL
REGIONAL LEVEL
LOCAL LEVEL

BDA - brochure

Brochure of the monument office for energy efficiency

The present guideline comprises the principles of the Federal Monuments Office with regard to energetic refurbishment of architectural monuments. In this way, it is intended that all those involved to be able to reach an amicable agreement more quickly in the future to arrive at solutions. It was published in the 1st version of March 17th 2011 available on the website of the Federal Monument Office (www.bda.at/downloads) and in accordance with the progressing findings are updated by subsequent versions.

The Directive constitutes a guide to the assessment of those measures, which are connected to a monument within the framework of the energetic remediation (being justifiable or, as the case may be, are not justifiable). Those ways are described, which in the consideration between the possibilities of an energetic improvement on the one hand and preservation on the other hand of the substance, the traditional appearance and the artistic effect of the monument on the other side are to be walked on. These guidelines should be applied to all considerations at the beginning of a project and for concrete planning apply.

The Directive on Energy Efficiency of Monuments and Sites is split into a first overview section with two checklists (basic rules, action overview), the detailed second part on the individual measures on the shell of the building or the building services engineering (measures in detail) as well as a concluding third part with additional legal and technical information (licensing procedure, legal basis, verification methods, glossary, sources).

Only methods are dealt with that are supported by structural changes effects on the substance, structure and appearance of a monument. Beside these hard factors play criteria such as service life, location or ecology for the energy balance and sustainability of a building plays an equally important role. This so-called “soft” and often difficult to measure sizes are not executed within this framework, may be used in the assessment, whether energetic refurbishment measures are efficient and goal-oriented, but cannot be overlooked.

Source: www.bda.at/downloads
Example

Solar Energy

APPLICATION TO HISTORIC BUILDINGS

House Breuer

Full-surface, integrated PV and solar thermal modules

The full-surface arrangement of the integrated PV and solar thermal modules gives the roof a uniform appearance, which is additionally supported by choosing non-reflecting modules with a dark background and metal frame.

The solar thermal panels provide the hot water heat demand in the summer months and a part of the room heating demand in spring and autumn. The logwood heating system is thus relieved. The electricity produced by the PV panels cover a part of the domestic electricity, especially in the summer months. The installation of full surface, integrated PV and solar thermal modules is not compatible with the conservation approach because the modules replace the existing roof covering completely to achieve the uniform appearance of the new roof.

By installing solar thermal panels, the end energy demand of the heat generator, in this case the logwood heating system is reduced, because the panels cover the hot water heat demand in the summer months and a part of the room heating demand in spring and autumn. Furthermore, less electricity has to be taken from the grid, because the produced electricity of the PV panels covers a part of the domestic electricity, especially in the summer months.

The existing roof covering is completely replaced by the full surface, integrated PV and solar thermal modules, which is a disadvantage from the conservation point of view. Nevertheless, it is possible to remove the panels without damaging the original roof structure and replace them by a roof covering similar to the original one.

The southeastern surface of the pitched roof is fully equipped with integrated PV and solar thermal modules. The roof pitch of 35 ° and the orientation of this building make this half of the roof an ideal energy source. Thus, about 200% of the electricity demand and the majority of the hot water and heating demand can be produced locally. One month in winter, the building is in the shadow of the horizon. At this time, a log combustion heating system supplies with the needed heat. A ventilation system with heat recovery ensures low heat losses and sufficient air circulation.

References: Energieinstitut Vorarlberg

Figure 11 – House Breuer, Montafon - full-surface, integrated PV and solar thermal modules

Figure 12 – Detail of roof integrated PV-modules
Example

Solar Energy

APPLICATION TO HISTORIC BUILDINGS

House Nenning Hittisau

Roof-integrated solar-thermal modules

The landmarked farmhouse from the end of the 17th century is situated in Hittisau in the “Bregenzer Wald” (Bregenz Forrest). As the owner of the building is also the owner of a carpentry, he respectively his company did the construction work itself.

The building was renovated and “divided” into three separate useable parts (vertical division) between 2017 and 2020 (work is still in progress). The size of the three building parts are now 210, 90 and 180 m² treated floor area. Before —until the end of the 20th century—the building was used as a farmhouse.

The focus of the landmark status lies on the sliding windows, the old paneled ceiling and the walls.

The heating of the building is realized with a geothermal heat pump system combined with a central wood stove and a roof integrated solar-thermal system (see picture on the right side).

So that building is a very good example how to use renewable energy with new machines and technologies in historic buildings.

References: Energieinstitut Vorarlberg

Figure 13 – House Nenning, Hittisau

Figure 14 – Detail of roof integrated solar-thermal

Figure 15 – Old and new material
**METHODOLOGY**

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| **Heizrechner (Heat calculator) – Online-Tool** |

**Online-Tool for comparison of heating systems**

Full cost comparison of heating systems – available at [https://www.energieinstitut.at/tools/HeizrechnerV4/](https://www.energieinstitut.at/tools/HeizrechnerV4/)

The online tool "Heating Calculator" offers a full cost comparison of two heating systems of your choice, tailor-made for your building.

In case of searching for the most cost-effective and low-emission heating system for a residential building, the “Heizrechner” (heat calculator) is the right tool. Here an overview of costs and CO\(_2\) emissions as well as a comparison of amortization between two heating systems of your choice can be found.

The costs used for the calculations refer to a heating system in a new detached house and are average values. In the case of significantly different buildings (e.g. multiple dwelling houses, renovations), it is advisable to obtain quotations from your trusted installer and use the prices in accordance with the quotation.

The energy prices are usually the average value of the last year (sources: Land Vorarlberg, Illwerke-VKW, Ländle Pellets). All values can be changed if necessary.

Figure 16 – Screenshot of “Heizrechner” (https://www.energieinstitut.at/tools/HeizrechnerV4/)

Figure 17 – Screenshot of “Heizrechner” (https://www.energieinstitut.at/tools/HeizrechnerV4/)

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
### Renewable Energies

#### Energy subsidies by State of Vorarlberg

**Heat from renewable energies**

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 is supporting 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. There are no restrictions on the size of the house. The systems must be installed as central heating in buildings that are the main residence all year round.

Source: vorarlberg.at

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**Figure 18** – Screenshot of “Energy Subsidy Brochure” (Vorarlberg.at)

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This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
Example

**Biomass Energy**

**APPLICATION TO HISTORIC BUILDINGS**

**Alte Schule Lech (Old School Lech) - Kindergarten**

**Thermal insulation, ventilation and biomass district heating**

In 1937, this building was constructed for use as both an elementary school and a residential building. Since the 1970s, the “Alte Schule”, or Old School, has been used as a kindergarten and residential building. In the course of Lech’s new zoning development, the building was completely renovated and renamed “Haus des Kindes”, or House of the Child.

Careful handling was the most important aspect of renovating a protected historical building. Almost no changes were made to the outer appearance. Unique windows with historical charm were left in the facade and renovated. Other windows were reproduced to look like the originals. In order to achieve a high level of thermal insulation, a silicate airgel system was used for the first time in the Alpine region on three sides of the building. This consists of permeable, pure mineral, insulation mats, that function three times better than equally thick mineral wool or polystyrene plates. The historical facade, which was worth preserving, was expertly restored, whereas this area also received insulation on the inside of the building’s shell.

The necessary energy required for heating comes from Lech’s own district biomass heating network. Heat is distributed throughout the building via radiators, floor heating and a controlled ventilation system with a heat recovery rate of 80%. The ventilation system is controlled by air quality sensors. Because this is not a residential building, the hot water requirement is relatively low. Warm water is provided by decentralized hot water tanks.

Renovation of the former school building used environmentally acceptable and sustainable materials. In order to provide emission-free, indoor air quality, building materials containing volatile, organic ingredients, formaldehyde, PVC, halogens and HCFC were avoided. Over 90% of the usual construction-related chemical emission could be avoided.

References: Energieinstitut Vorarlberg
Example

### Biomass

Energy

**APPLICATION TO HISTORIC BUILDINGS**

#### School Building Lauterach

**Thermal insulation, ventilation and district heating**

The spatial and pedagogical orientation into a future-oriented educational institution, and space requirements were the decisive reasons for the Renovation and extension of the elementary school Dorf.

The Classroom wing and the gymnasium from the 1950s was demolished and replaced by a new building. The main building worthy of preservation remained and was energetically upgraded. This included not only thermal insulation but also the use of a ventilation system with heat recovery.

The construction measures were carried out in three construction stages (summer 2016 to spring 2018). The new building was constructed according to a spatially pedagogical Concept. Room dividers have been dissolved, and instead a space continuum with corners and niches and centrally defined propagation possibilities offered.

Also, in the outside area many seats and niches to the interior design concept and enable the a smooth transition between interior and exterior. The variety of differently sized areas is part of the concept. The “clusters” (islands of education) are to receive individual support, work in different group sizes, self-organized and open learning as well as team and project teaching to make this possible.

Besides the use of ecological building materials such as solid wood and insulating materials from renewable raw materials a consistent renunciation of PVC is also implemented. With the products used and through a very consistent chemicals management, the Indoor pollutants reduced to the minimum will be. Heating is provided by district heating via the floors. Automatic Night cooling is achieved with fanlights and Windows.

References: Energieinstitut Vorarlberg

![Figure 22 – School Lauterach before extension](image)

![Figure 23 – School Lauterach with news extension](image)

![Figure 24 – School Lauterach - map](image)
**Example**

**Biomass Energy APPLICATION TO HISTORIC BUILDINGS**

**Gemeindeamt Zwischenwasser (Town hall)**

**Thermal insulation, ventilation and district heating**

The town hall built in the 1930s was structurally still in a good condition. It existed the desire to enhance the external appearance.

Through precisely implemented measures the house with regard to the existing qualities for a contemporary use for the administration of the community was adapted.

Inside, the building was divided floor by floor into areas of use structured and spatially and technically adapted to the needs of today. Through the lowering of the entrance and the eastern ground floor at street level, a threshold-free accessible citizen service point is created.

The new workplaces and club rooms are bright, communicative and show a high flexibility of use.

On the upper floor the formerly numerous partition walls gave way an open one, with glass walls and shelves flexible zonable office structure. On the top floor, formerly used by kindergarten and male voice choir, is now the new Boardroom and rehearsal room. Through a foyer with bar this level is suitable as infrastructure for Events of various kinds, while archive, storage and technical equipment were housed in the basement.

The building was insulated on the inside. Calcium silicate boards were used, which were installed on the room where covered with a clay plaster.

The demands on ecology and energy efficiency were high. In addition to comfort ventilation, a climate control concept with heat recovery, night cooling and Cross-ventilation is implemented. Besides the reduction of the heating energy demand by about 75%, special attention was paid to the use of ecologically harmless and low-pollutant materials.

The municipal biomass power plant and the photovoltaic system on the roof of the neighboring building supply the house with energy.

References: Energieinstitut Vorarlberg

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*This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.*
6.4 Annex 4: Templates Slovenia (Soča)
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.

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<td>National renewable energy action plan</td>
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Slovenia (Soča)- RES

STRATEGIES & METHODOLOGIES

List of renewable Energies to be studied

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<td>5 Geothermal</td>
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<td>6 Biomass</td>
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RES in Slovenia
Slovenia has a goal set forth, namely by 2020 achieve 25% share of RES in gross final energy consumption. 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.

Reference to historical buildings
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. At the moment the most used public funding is the one offered by the Slovenian environmental fund that 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.

Strategies / Methodologies
All Slovenian strategic documents related to energy production, renewable energy sources and efficient use of energy are covering the national level. As Slovenia doesn’t have a regional administration, also the majority of grant/subsidy systems are based on the national level.

In Soča valley there are three RES that are mostly used at the moment and still show potential.
1. Solar (many small production sites, national approach of subsidies)
2. Hydroelectric (a combination of large and small plants)
3. Biomass (individual and district heating systems)

In the document we focus only on national legal framework with subsidy/grant scheme [1 - 3]. 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 [4].

We describe also a case of water use planning in order to avoid conflicts [5] and one example where it was possible to construct a small hydropower plant within the protected area [6]
This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
**Renewable Energies**

### NATIONAL RENEWABLE ENERGY ACTION PLAN 2010-2020

Slovenia set itself a range of targets for increasing the share of RES in energy consumption back in 2004 in the Resolution on the National Energy Programme. As part of the EU climate and energy package, new targets have been agreed upon to promote renewable energy sources. Slovenia’s target for 2020 is a 25-percent share of RES in final energy consumption and at least a 10-percent share of RES in transport.

The NREAP therefore covers:
1. the national policy of renewable sources of energy;
2. expected gross final energy consumption in the period 2010-2020;
3. targets and trajectories regarding renewable energy sources;
4. measures for achieving binding target shares of renewable energy sources;
5. estimates of the contribution of individual technologies to achieving the target shares of renewable energy sources and estimates of the costs of carrying out measures and of impacts on the environment and on job creation.

The plan was updated in 2017 also with a vision towards 2030.

The objectives of Slovenia’s energy policy for renewable energy sources are:
- ensuring a 25% share of renewable energy sources in final energy consumption and a 10% share of renewables in transport by 2020, which under current predictions will involve a doubling of energy generated from renewable sources relative to the baseline year of 2005,
- halting the growth of final energy consumption,
- implementing efficient energy use and renewable energy sources as economic development priorities,
- in the long term, increasing the share of renewable energy sources in final energy consumption up to 2030 and beyond.

**Measures of support:**
- improvement of energy efficiency of buildings and construction of net zero energy buildings;
- substitution of oil for heating with biomass and other renewable energy sources;
- district heating systems based on renewable energy sources and heat and power cogeneration;
- replacing electricity for producing sanitary hot water with solar energy and other renewable energy sources;
- generation of electricity from renewable energy sources,
- increasing the share of railway and public transport,
- introducing biofuels and other renewable energy sources in transport and farming and introducing electric vehicles;
- developing distribution networks for incorporating dispersed electricity generation, including the development of active/Smart networks;
- developing industrial production of technologies for efficient energy use and renewable energy source.

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**Figure 1 –** Slovenian energy production in 2016 (Source: SORS).

**Sources:**
[2] [https://www.agen-rs.si/documents/54870/68629/a/78774b68-dbfc-415e-ab88-8826525558f94](https://www.agen-rs.si/documents/54870/68629/a/78774b68-dbfc-415e-ab88-8826525558f94)
**METHODOLOGY**

### Renewable Energies

**NATIONAL LEVEL**

**EKOSKLAD (Slovenian environmental fund)**

Ekosklad is an independent legal entity, with the Ministry of the Environment and Spatial Planning, being represented as majority in the Supervisory Board.

**Purpose and goals**

Eco Fund’s main purpose is to promote development in the field of environmental protection. It is the only specialised institution in Slovenia that provides financial supports for environmental projects. The financial assistance is offered mainly through soft loans from revolving funds and since the year 2008 through grants. In comparison with commercial banks, Eco Fund’s principal advantages in the market for environmental financing are that it provides soft loans at lower interest rates than prevailing commercial market rates and it is able to lend for significantly longer periods than commercial banks. Recent evaluations of the effective interest rates of Eco Fund’s loans on the one hand, and those of commercial banks, on the other, have shown that a total of 15% of the cost of an investments can be saved when opting for Eco Fund’s loan.

**Activities**

To fulfil its mission Eco Fund made use of the following loan or grant financing programmes:

- **Loans to legal entities** (municipalities and/or providers of public utility services, enterprises and other legal entities) and sole traders for investments in environmental infrastructure, environmentally sound technologies and products, energy efficiency, energy saving investments, and use of renewable energy sources;
- **Loans to individuals** (households) for conversion from fossil fuels to renewable energy sources, energy saving investments, investments in water consumption reduction, connections to sewage system, small waste water treatment plants, replacement of asbestos roofs;
- **Grants to individuals** (households) for investments in electric cars and for investments in residential buildings (energy efficiency and use of renewable energy sources);
- **Grants to legal entities** (municipalities and/or providers of public utility services, enterprises and other legal entities) for investments in electric cars and buses for public transport on compressed natural gas or biogas;
- **Grants to municipalities** for investments in buildings where public education takes place (schools, kindergartens, libraries etc.), newly constructed as low energy and passive buildings or renovated in passive standard.

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**Figure 2 – EKOSKLAD (Slovenian environmental fund). Source:** [https://www.ekosklad.si/english](https://www.ekosklad.si/english) [3]
The guidelines for the energy renovation of cultural heritage buildings were created in the context of the implementation of the European Cohesion Policy 2014-2020, which also states among the key objectives the improvement of energy efficiency in the public sector. As the proportion of buildings protected under the rules of cultural heritage protection in the segment of state buildings is very large, it was found that these buildings, as bearers of Slovenian identity, need special treatment, and therefore guidelines for their energy renovation were formulated.

However, the guidelines are not intended solely for the renovation of public sector buildings, but are an important professional basis for the design and implementation of energy renovation of all buildings, whether privately or publicly owned. It is also reasonable to use them in buildings that do not have the status of cultural heritage, but exhibit quality design and, due to their professional construction or architectural approach, this quality is worth maintaining.

The guidelines are the result of a research assignment that included an overview of Slovenian legislation and documents, an overview of guidelines and good practices in the field of energy renovation of buildings in Slovenia and abroad, and an overview of measures, materials and technologies suitable for the energy renovation of buildings. Experts in the field of construction, mechanical engineering, architecture and urbanism and experts in the field of cultural heritage participated in their creation, in close cooperation with the Ministry of Infrastructure, the Ministry of Culture and the Institute for the Protection of Cultural Heritage of Slovenia.

Source: [4]


Figure 3 – Slovenian guidelines for energy retrofitting of historical buildings [4].
METHODOLOGY

Suitability of (different) water uses

Methodology to plan and crosscheck different water uses

Description

The main objectives and starting points considered during method and approach development were: introduction of contemporary management of watercourses and riparian areas; support of management of water courses and riparian areas on local, regional, national and also international levels; harmonising of the final solutions with active stakeholder involvement; stimulation in bringing forward integrated knowledge and an approach that gathers different expert knowledge; development and introduction of concrete methods and informatics tools. In order to provide objectivity, transparency and robustness, a multi criteria analysis approach (MCA) was selected as a starting point for method development. In the first stages, MCA requires selection of alternatives (division of analysed watercourses and riparian areas on segments with the same length and areas with the same size respectively) and determination of the main aspects: attractiveness for selected water use, vulnerability of environment and landscape. In the next steps, supporting criteria, the scoring method, determination of performance functions with regard to each criterion and weight assignment should be provided. The spatial extent of the application and testing of the method in the pilot area was determined on watercourses or their parts with a catchment size larger than 10 km².

The developed method and tools provide a transparent platform for decision making on the strategic planning level about which watercourses or their parts are most suitable for water use development on the one hand or conservation on the other. They can also support the process of harmonising different sectoral objectives and, based on the recognition of overriding public interests and sustainable development principles, the process of justifying the breach of certain sectoral objectives. To provide assessment regarding the sections of watercourses or riparian areas that should be conserved and that are suitable for certain water uses, it is essential that stakeholders competent for targeted objectives actively participate and collaborate in the whole process, from the beginning of model development, relevant parameter determination and verification.

Figure 1 – Steps of the process (Source: IZVRS)

Source:[5]
### Example

**Suitability of (different) water uses**

**The case of upper Soča catchment**

The described method was tested on 37 water-courses and their riparian areas of the upper part of the Soča River basin with a total length of about 300 km. Based on the water use trend analysis and interviews with the representatives of relevant local communities, the following water uses were selected to be modelled and analysed: hydropower, fish farming, fishery infrastructure and bathing sites. The supporting criteria were also determined on the basis of expert and stakeholder discussions and on the basis of data availability, representativeness and redundancy.

The GIS analysis and additional field surveys provided relevant data (e.g. statistical discharges, environmental flow, road network, slopes, catchment sizes, spawning sites, sightseeing points, land cover, erosion hazard, etc.) to calculate performance values for the alternatives by all selected supporting criteria (e.g. hydropower potential, distance to the nearest spawning site or road, available discharge, visibility from sightseeing points, erosion risk, etc). Separate scores for the main aspects and the overall suitability score were calculated for each alternative by applying the selected scoring method and assigned weights and defined based on the recognised relevancy of selected criteria. These final results provide quantitative information on whether selected watercourse segments or watercourse riparian areas are suitable for selected water use on a common commensurate scale.

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</table>

#### Figure 2 – HE - technical potential (source: Sašo Šantl, IZVRS) [5]

#### Figure 3 – HE – ecological vulnerability (source: Sašo Šantl, IZVRS) [5]
# Hydropower

## Example

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<th>NATIONAL LEVEL</th>
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### Small hydropower in Trenta

**Small hydropower built and owned by a cooperative of inhabitants (economic, social and environmental aspects)**

Trenta is the upper part of Soča Valley with small settlements and remote farms. It was first mentioned in 14th century. For over 200 years it was mined for iron ore till 1778 when the mine was closed. Extensive agriculture and some tourism were the only incomes for inhabitants and this led to severe depopulation after the second world war. In order to keep rural areas populated and give inhabitants an opportunity for better life they decided to establish a cooperative.

One of the main reasons and tasks was also to secure a stable energy supply and an income for the locals. The idea of building a small hydropower plant within the area of a national park was very controversial. The main pro argument that is still considered as such is that the investment was done by the locals and not by an investor that is only interested in making profit. After a long process and many discussions, they were able to build the hydropower plant in 1996 that is nowadays after more than 20 year still fulfilling its mission. The valley has its own renewable energy source, they even get some profit back from the investment and it also connects the locals for common missions. The cooperative was able to use the profit to invest it into reopening of the local shop. It is also very important that the plant was built in a way that it is almost not visible and with high standards to maintain the environment as close to its natural state as possible.

Inhabitants have nowadays the possibility to combine green electricity with local biomass and other RES to be sustainable in terms of energy consumption.

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### References

2. Slovenian energy production in 2016 (Source: SURS). [https://www.agen-rs.si/documents/54870/68629/a/7874b568-d8c4-115e-ab88-8862525558d9](https://www.agen-rs.si/documents/54870/68629/a/7874b568-d8c4-115e-ab88-8862525558d9)
3. EKOSKLAĐ (Slovenian environmental fund). Source: [https://www.ekosklad.si/english](https://www.ekosklad.si/english)
6. Small hydropower in Trenta, [www.zens.si](http://www.zens.si)
6.5 Annex 5: Templates Italy (Trento - South Tyrol)
### METHODOLOGIES

**List of renewable Energies to be studied**

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<td><strong>5</strong> Geothermal</td>
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<td>6 Biomass</td>
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**Deliverable T3.2**

**Conclusions**

- **Geothermal energy vector exploitation in the Alpine Space**

Space heating and cooling has the largest share of finally energy demand in the European Union. **Shallow Geothermal Energy (SGE) systems** represent an effective and sustainable technology for heating or cooling buildings without using natural gas or fossil fuels. These systems exploit the natural heat source that is available ubiquitously at “shallow” depths to heat up or to cool down buildings of different sizes and utilizations (residential, commercial, industrial, etc.). Heat extraction (from the underground to the building) or heat injection (from the building to the underground) can be undertaken throughout groundwater wells, vertical boreholes, special foundations, or even through broad superficial excavations. Less commonly, shallow geothermal energy can also be exploited throughout the direct use of the energy stored by natural water springs or surface waters (lakes, sewages, drainage water, etc.). Shallow Geothermal Energy applications are part of the geothermal domain, more precisely of the “low-temperature” (or “low enthalpy”) one. Below a first superficial level (about 20 m depth) where seasonal temperatures are affected by solar radiation and weather variations, temperatures remain generally stable all the year round. Therefore, the whole underground (rocks or sediments, and groundwater) can be seen as a huge heat reservoir, quite similarly like a lake represents a water reservoir. Geothermal heat pumps are an established technology that uses shallow geothermal energy, the heat stored beneath the earth surface, to supply space heating and cooling and sanitary hot water. They are very versatile and can be used in different kind of structures, from small, residential houses to large individual buildings or complexes of buildings (including historical and heritage building exploitation, if allowed).

**GRETA Project, Near-surface Geothermal Resources (NSGE) in the Alpine Space** [1], aim demonstrate the potential of NSGE in the Alpine Space and to share its knowledge to foster the integration of this technology into future energy plans in the area at different administrative levels. This approach will help to reduce total CO2-emissions in environmentally sensitive regions using renewable energy sources which are very widely available, thus establish transnationally integrated low carbon policy instruments. The main results of the project are decision support tools (geothermal potential maps, guidelines for energy planning), legal and technical guidelines for the utilization of NSGE, based on an exchange of best practices. These results will encourage the implementation of NSGE into policy instruments (such as energy plans) at different administrative levels and will raise the awareness of the potential of this low carbon energy source among different stakeholders. Complex geological structures, highly populated vs remote areas and very different SGE market development are characteristic for the Alpine space. Regulations are country-specific, or even region or municipality specific; however, challenges of regulations are the same across borders, i.e. sustainable utilization of the resources, legal certainty and equal opportunity. Underground interference maps and different steps in the procedures for granting new licences are described and presented in WebGIS tool (Figure 1) and as flow charts in a transnational comparable version. By this aid decisional authorities can better compare different regulation procedures and easier decide how to improve actual practices. Technicians can better manage legal constraints.
Furthermore, the GRETA project seeking to foster diffusion of the Ground Source Heat Pump (GSHP) in the alpine area, and promoting its inclusion in energy and strategic planning. The GRETA project focuses on GSHP systems based on the soil and groundwater properties, is to have an almost constant temperature up to 100m below ground surface. This property can be exploited both for heating and cooling purposes: this means that the ground/groundwater is used as a heat source or a sink, respectively. The GSHPs can work with either heat-carrier fluids (closed-loop systems or GSHPs, Ground-Source Heat Pumps) or water directly withdrawn from the aquifer (open-loop systems or GWHPs, Ground-Water Heat Pumps). Pilot areas and case studies were selected to highlight common issues and solutions and foster the use of best practices in using shallow geothermal energy (Figure 2). Further information is presented in the templates.
GRETA research project is a European Union regional development fund project funded by the Alpine Space Program [1]. The aim of GRETA project is to demonstrate the potential of Near Surface Geothermal Energy (NSGE) in the Alpine region and to foster its integration into future energy plans at different administrative levels. A large-scale map viewer was conceived to show the broad applicability of NSGE systems in the Alpine territories by displaying the areas not suitable to NSGE installations, causing over-costs, authorization problems or particular technical precautions. Even if NSGE is considered as a safe and low impact technology, in the past problems occurred to some plants and a few accidents were caused by the installation of Ground Source Heat Pumps (GSHPs). These issues are often due to the insufficient knowledge about the territory or to installation errors. For this reason, the GRETA partners have identified and mapped geological, hydrogeological and anthropic pre-existing conditions able to produce interferences with the installation of GSHPs in the Alpine areas.

EXAMPLE: ITALIAN REGIONS, workpackage 4: Assessment and mapping of potential of NSGE

All the Italian regions involved in GRETA project (Valle d’Aosta, Piemonte, Lombardia, Veneto, Friuli Venezia Giulia, Liguria and Trentino-Alto Adige) own their own geoportal and online database. Where regional detailed data were not available national databases were used, in particular the OneGeology project was useful for the identification of areas affected by the presence of evaporites or limestones. The Trentino Alto Adige region is composed of two autonomous provinces: Trento and Bolzano. Detailed data of karst presence were not available, thus on the underground interferences map all the limestone areas are shown. Locally anhydrite layers are indicated in the same areas as limestones, due to the fact that the database used (OneGeology) considers sedimentary formations with multiple lithologies included, both anhydrites and limestones. Landslides, DSGSDs and areas susceptible to landslides or landslide-prone areas are shown on Greta WebGIS for the Trento Province (Figure 3). Regarding Bolzano, its landslides database is less dense than in other regions and the features are mainly bigger areas. Abandoned quarries, mines and natural caves are shown only Trento area. Landfills, contaminated sites, artesian aquifers and water protection areas are not mapped. Furthermore, the Trento autonomous province developed a map of limitations to the installation of Borehole Heat Exchangers (BHE) (Figure 4). Three kind of interferences are mapped on this WebGIS: Water protection areas (springs, wells and surface waters), landslides, areas which may contain medium-high enthalpy sources, thermal or mineral water resources.

References


This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space program.
6.6 Annex 6: Templates Alpine Space
Alpine Space - RES

METHODOLOGIES

List of renewable Energies to be studied

<table>
<thead>
<tr>
<th>Renewable Energy Systems (RES)</th>
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<tbody>
<tr>
<td>1 Solar (Photovoltaic &amp; Solar thermal)</td>
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<tr>
<td>2 Wind power</td>
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<td>3 Hydroelectric</td>
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<td>4 Hydrothermal</td>
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<td>5 Geothermal</td>
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Renewable Energies in the Alpine Space

Specific data sheets have been added for the entire Alpine area related two interesting research projects carried out with the collaboration of different countries in the Alpine arc and related the promotion and greater use of renewable energy sources.

The first template fact sheet, concerns an initiative based on a research project related to the development of an European database to collect examples, projects and best-practice that use renewable energy in all EU countries, the REPOWERMAP project [1], an interactive and digital map where all the detailed information of the projects that use every type of RES is located and where it is also possible to find examples of the use of renewable energy in historic buildings.

The second detail fact sheet for the Alpine area concerns the large-scale geothermal implementation methodology based in the GRETA Project [2] described below.

- Geothermal energy vector exploitation in the Alpine Space

Space heating and cooling has the largest share of finally energy demand in the European Union. **Shallow Geothermal Energy (SGE) systems** represent an effective and sustainable technology for heating or cooling buildings without using natural gas or fossil fuels. Shallow Geothermal Energy applications are part of the geothermal domain, more precisely of the “low-temperature” (or “low enthalpy”) one. Below a first superficial level (about 20 m depth) where seasonal temperatures are affected by solar radiation and weather variations, temperatures remain generally stable all the year round. Therefore, the whole underground (rocks or sediments, and groundwater) can be seen as a huge heat reservoir, quite similarly like a lake represents a water reservoir. Geothermal heat pumps are an established technology that uses shallow geothermal energy, the heat stored beneath the earth surface, to supply space heating and cooling and sanitary hot water. They are very versatile and can be used in different kind of structures, from small, residential houses to large individual buildings or complexes of buildings (including historical and heritage building exploitation, if allowed).

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and easier decide how to improve actual practices. Technicians can better manage legal constraints. Furthermore, the GRETA project seeking to foster diffusion of the Ground Source Heat Pump (GSHP) in the alpine area, and promoting its inclusion in energy and strategic planning.

Figure 1 – Screenshot of GRETA WebGIS tool and example of different GSHPs, Ground-Source Heat Pumps systems: BHE (Borehole Heat Exchanger) - GWHP (Ground-Water Heat Pumps) - SHC (surface heating and cooling) and water level; (Source: http://greta.eurac.edu/)
A European map for promoting renewable energies and energy efficiency

repowermap.org [2] is a non-profit initiative to promote renewable energies and energy efficiency by making visible real-world examples and related local information. To this objective, an interactive map is developed jointly by a large network of organizations, institutions, regional and local authorities and other energy actors. The idea of the initiative is to encourage people to use renewable energies and energy efficiency, by making them aware of concrete examples in their region, their city and in their own neighborhood. The information presented on the map furthermore aims to facilitate information exchange and the spread of innovative technologies at local level and across borders. The examples and the accompanying information inspire others to take action as well and help them to take the first steps.

The map gathers information about a big number of RES implementation examples (Figure 2 and Figure 3), from technologies such as: Solar Electricity; Solar Thermal; Geothermal Heat Pump; Aerothermal or Hydro-thermal Heat Pump; Other Geothermal Energy; Energy Efficient Buildings; Biogas Energy; Wood Energy; Other Bioenergy; Hydro; Ocean Energy; Wind.

Individual people, local authorities or regions, organisations and companies could participate in the initiative to promote renewable energies and energy efficiency by making visible local examples, uploading the information to make installations and plants or buildings visible on the map to inspire other people and to motivate others to use these technologies as well.

Figure 2 – Screenshot of the digital interactive map repowermap [source: repowermap.org]

Figure 3 – Map of all RES installations divided by technologies and categories, with detailed information of each best practice example [source: repowermap.org]
REPOWERMAP PROJECT

A European map for promoting renewable energies and energy efficiency

On the map (Figure 4) there is an overview of the solar systems installed in Switzerland. The repowermap.org initiative was founded in Bern in 2008 with the support of the European Union and the Swiss Confederation and since now has already been applied in different countries. Since 2011, the initiative aims to promote the use of renewable energies also in developing countries by facilitating know-how exchange and contributing to capacity building, in particular in Central America and West Africa.

From 2012 to 2014, the initiative has been supported by the European Union within the framework of the Intelligent Energy Europe Programme, as an initiative to promote renewable energies and energy efficiency by creating synergies in awareness raising between various energy actors and by facilitating information exchange for the related technologies. In the project IEE/11/098 REPOWERMAP, the repowermap.org initiative was built up in ten European countries. The IEE action focused primarily on ten European countries: Austria, Belgium, Bulgaria, Italy, Finland, France, Germany, Liechtenstein, Poland, and Slovakia. Organisations, local authorities, regions, companies and energy actors from more and more countries are participating in the initiative.

Figure 4 – Map of solar installations. The map is developed as part of the non-profit initiative repowermap.org with the support of a vast network of organizations, cantons, municipalities, regions and other actors in the energy sector. Source: Swissolar / repowermap.org
Near-surface Geothermal Resources in the Territory of the Alpine Space (GREA research project)

GREA is an Interreg Alpine Space project (Figure 5, [1]) aiming at fostering the diffusion of Ground Source Heat Pumps (GSHP) in the alpine area and promoting their structured inclusion in energy and strategic planning. GSHPs are used to exploit geothermal energy between the surface and 200 meters depth, the so-called NSGE. GSHPs principle is based on the characteristic of soil and groundwater to have an almost constant temperature in depths below ground surface (starting from approx. 5 m). This property can be exploited both for heating and cooling purpose, as well as the awareness of its advantages and its high theoretical and technical potential.

**TASK 5: Integration of NSGE into Energy Plans**

Within the GREA project numerous aspects of NSGE have been explored, in order to illustrate how Near-surface Geothermal Energy (NSGE) can be integrated within the development of energy strategies and energy planning procedures. The final results of this project are based on previews studies analyzing the main principles on legislation and regulation, the most important technical and operative criteria, how to assess the spatial energy potential, and how to match this potential with the spatial energy demand of the residential sector at local and regional scale in order to include NSGE into urban and regional energy strategy and plans. Following the methodology defined within GREA project, it emerges that NSGE can cover a relevant ratio of the energy demand of a region/municipality, i.e. a percentage of the energy demand that ranges from the 20% to 40%. For this reason, NSGE can play an important role in reducing the consumption of fossil fuels used to supply the thermal energy demand and in reducing the related CO₂ emissions. Furthermore, NSGE can contribute to the electrification of the energy system, increase the energy independency and reduce the local emissions of other common air pollutants, particularly PM and NOx. The favorite audience of this project deliverables are decision and policy makers, technicians and experts of the sectors, who could find indications on how to include NSGE in energy strategies and energy planning activities, but also citizens who could appraise the feasibility and convenience of installing a GSHP, through the web tool developed in the project (Figure 6).
**Example**

**GRETAsc RESEARCH PROJECT**

**Near-surface Geothermal Resources in the Territory of the Alpine Space**

Case studies were identified in a wide range of contexts within the Alpine Space region to highlight common issues and solutions and foster the use of best practices in using shallow geothermal energy (NSGE, Figure 7).

The GRETA project has six case studies within the Alpine Space region, namely: District of Oberallgäu in Germany, Parc de Beauges in France, Val d’Aosta Region in Italy, Davos Municipality in Switzerland, Saalbach-Leogang tourist area in Austria, and Cerkno Municipality in Slovenia (Figure 8). The six case studies are used in the GRETA project to identify, verify and test possible regulation issues and operative criteria, and to map the energy potential of Near Surface Geothermal Energy (NSGE).

It was developed a methodology and procedure to assess the main financial figures of the NSGE closed-loop (Borehole Heat Exchangers, BHEs) and open-loop (Groundwater Heat Pumps, GWHPs) systems. The methodology has been applied in 3 pilot areas: Val d’Aosta (Italy), Sonthofen (Germany), and Cerkno (Slovenia). The methodology estimates the energy demand at building level, defines the system size and characteristics of the supply system, estimates the main costs, and identifies which buildings can effectively use the NSGE source. The analysis allows to evaluate whether or not a certain technical solution in a specific position in space might be of economic interest. Besides, the methodology developed considers the energy demand of the building and the main ground properties of the terrain. On this basis, the economic and financial feasibility of the system for each building have been estimated. To assess the potential at urban and regional scale, the evaluation of a single building is not enough and it was necessary to include the spatial constraints and cumulative effects caused by installation of several systems on the same zone, in order to identify the possible suitable area for the GSHP system (Figure 9).

The methodology developed and applied for the spatial financial evaluation of NSGE potential at building level is functional to the aggregated assessment of the capacity of the NSGE to cover the thermal energy needs of a specific area. This information, together with analysis of the local legislative and economic context, is needed for supporting the inclusion of NSGE, both in strategic planning development and in the elaboration of sustainable energy action plans.

**References**


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