BALANCING ALPINE ENERGY AND NATURE

2015

Renewable Energy and Ecosystem Services in the Alps

Status quo and trade-off between renewable energy expansion and ecosystem services valorization

recharge green

Alpine SPACE
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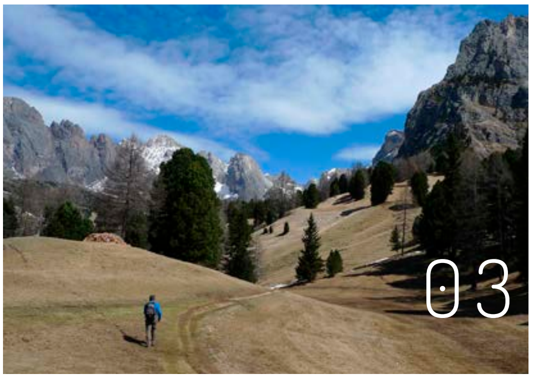
Ecosystem Services in the Alpine Area and in the Pilot Areas

Energy Potential from Renewable Sources



Trade-off and perceived impacts

Editorial

The Alpine Space is a strategic territory both for renewable energy exploitation and for the importance of its ecosystems. Concerning energy production, the Alps have different opportunities to develop Renewable sources of Energy (RE), due to their vast availability of resources, from wood for district heating, to water for hydropower, to sun and wind to develop photovoltaic or wind power. The development of RE is important in order to meet the 20-20-20 target and the 2030 framework for climate and energy policies established by the European Union, through which each European nation should reduce by 40% greenhouse gas emissions, increase by 27% the share of RE, increase by 27% energy efficiency.

On the other hand, developing RE interferes with the surrounding environment, so policy makers have to be aware of these interactions. Exploitation of natural resources creates an impact on the ecosystems that identified and quantified, in order to contribute to sustainable development. The impacts can be positive or negative for the local Ecosystem Services (ESS). Often, management practices do not consider the environment in the proper manner; this is one of the main reason of the wide adoption of non-sustainable actions. This trend is particularly visible in mountainous areas, especially in the Alps. Fragile ecosystems, such as mountain ecosystems, face extreme temperatures and a high level of anthropic pressure that lower the resilience and deplete their capability to regenerate. In particular, the renewable energy (RE) sector can play a negative role in environment degradation, because many conflicts may rise between natural resources conservation and energy use. The utilization of RE cause an impact on the environment, with negative consequences on the quality of the ESS provision.

In order to conciliate the needs of the local communities of producing RE and the need for conserving nature, the partners of the project recharge.green investigated in this report not only the RE potential and ESS in the Alps but possible conflicts that can arise in a complex territory as the Alpine Region.

G. Grilli and G. Garegnani

Ecosystem Services in the Alpine Area and in the Pilot Areas

01

The ecosystem services concept is very important for understanding the entirety of benefits nature provides to humans. We need to recognize that nature and biodiversity protection is also crucial to ensure the wellbeing and welfare of ourselves. The ecosystem services concept is one way to express this idea.

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1.1 The Ecosystem Services

Ecosystem services (ESS) are defined by Millennium Ecosystem Assessment as the "benefits people obtain from ecosystems" (MEA 2005). Human well-being depends on ESS, because most of them are not reproducible artificially, so their preservation and maintenance is a crucial challenge for the future. (Costanza et al. 1998) divided ecosystem services into 17 major categories of ESS such as gas, climate, disturbance and water regulation, water supply, erosion control and sediment retention, soil formation, nutrient cycling, waste treatment, pollination, biological control, refugia, food production, raw materials, genetic resources, recreation and cultural. Successively, (Rudolf S de Groot, Wilson, and Boumans 2002) provided more detailed information, identifying 23 different ESS, important for natural cycles and human daily life maintenance. Specially, these authors introduced new ecosystem functions such as nursery function, medicinal resources, ornamental resources, aesthetic information, spiritual and historic information, science and education. Over the years, this list was modified and, in particular, Millennium Ecosystem Assessment (MEA, 2005) listed a classification of ESS, based on their functions: provisioning services (e.g. food, timber, fodder, water provision), regulating services (e.g. water and climate regulation), cultural services and supporting services (e.g. recreational opportunities, cultural and spiritual values). Subsequently, (De Groot et al. 2010) reclassify ESS replacing supporting services with habitat services (e.g. nursery habitat, gene pool protection).

Despite several classifications, the importance of ESS for human life is widely recognized by both the scientific community and political decision makers. Preserving ESS means preserving life. Often management practices lead to a depletion of ecosystem functioning. This trend is particularly visible in mountain areas, especially in the Alps. A high level of anthropogenic pressure could compromise the functionality and the ability to regenerate of the fragile ecosystems as mountain areas. In particular, the renewable energy (RE) sector could have negative effects on environment, because many conflicts may arise between nature conservation and RE development. The development of different RE (solar, wind, hydropower and wood biomass) could cause an effect on the environment, with negative consequences on the quality of the ESS provision. RE development may cause soil consumption and a loss of biodiversity. Besides, some RE may have a negative effect in terms of the landscape aesthetic beauty. Notwithstanding, effects of RE on the environment are not always negative. For example, the removal of forest residues have positive impacts on tourist attractiveness and ecosystem health reducing fire risk. In other words, if on one hand it is important to reduce the dependence on fossil fuels using RE sources, on the other hand people have to be aware that RE and nature conservation are in a trade-off situation. Fossil fuels should be reduced as quickly as possible, but it should also be noted that RE has the potential to damage the environment; therefore, smart utilization is ideal to reduce environmental degradation. It is not always possible to enhance the quality of ecosystem with a sustainable use of renewable sources of energy.

1.2 Renewable Energy sources and Ecosystem Services in the Alpine Area

The Alps are strategically important for RE in Europe due to their high energy potentials and connotation as a "green battery" by energy companies. According to the Energy Protocol of the Alpine Convention "the Alpine Region will make a long-term contribution to (Hoppichler 2013) meeting Europe's energy needs" (EC 2005) but at the same time, it is essential "limit the negative effects of power plants on the environment and the landscape" (EC 2005, p. 38). Alpine ecosystem is particularly threatened by expanding RE due to their high levels of biodiversity, fragile ecosystems, recreational value and the diversity of cultural identities (Hoppichler 2013). The Alpine ecosystem provides several goods and services such as protection against natural hazards (i.e. landslides, avalanches and rockfalls), carbon dioxide sequestration, fodder, timber, renewable raw material for energy production (bio-energy), tourism and recreation (hiking, biking, hunting, etc..), freshwater and biodiversity (Grêt-Regamey et al. 2008). The number of existing classification regimes highlights the difficulties regarding the exact definition and categorisation of these ESS (Fu et al. 2011, Fisher et a. 2007). Therefore, it is recommended to develop an individual set of most affected ecosystems reflecting both the particular ecosystems characteristics (Alpine ecosystems) and the decision context (expanding RE).

TABLE 1: ALPINE ECOSYSTEM SERVICES CONSIDERED IN THE RECHARGE.GREEN PROJECT

ECOSYSTEM GOODS AND SERVICES	DEFINITION ADOPTED
Provisioning services	
Provision of forest and agricultural production	Products obtained directly from ecosystems such as agricultural products, forest products and aquaculture products. If relevant, could also include extractable products (e.g. mushrooms, natural medicines, peat, etc.).
Provision of fresh or potable water	Provided fresh or potable water including water filter function of soils.
Regulating and maintenance services	
Protection against natural hazards	Mediation/Buffering of flows (mass, liquid, gaseous) for avoiding extreme events (such as floods, soil erosions, landslides, avalanches, storms, rock falls, etc.).
Air quality regulation	Mediation of toxics and other nuisances in the air (e.g. dust) by the ecosystem (this category could also include micro climate regulation and/or abatement of noise pollution).
Carbon sequestration in vegetation and soil	Amount of carbon sequestrated by the ecosystem for regulating the global atmospheric composition.
Ecological habitat quality	This can be regarded as the overall habitat quality for wild plant and animal species and is necessary for the function of ecosystem services mentioned above. Habitat quality is (mutually) dependent on nutrient cycling, seed dispersal and pollination. Also, the long term ecosystem stability (=resilience) and resistance against pests affecting human health and forest or agricultural production are an expression of high ecological habitat quality.
Cultural services	
Aesthetical values	Viewing experience of the natural world (through different media), landscapes as source of inspiration or cultural values and the "sense of place" in general associated with recognized environmental features.
Recreational values	Value for recreation (such as walking, hiking, skiing, climbing, boating, leisure fishing and leisure hunting), possibility for relaxation and silence in general.
Intrinsic values	Value of ensuring the particular character of an ecosystem for future generations.

Source: elaborated from MEA (2005), Sukhdev et al. 2010, European Environment Agency 2013.

Within recharge.green project a list of nine final ecosystem services was developed (Table 1) using the international literature concerning the environmental impacts of renewable energies development (IPCC 2011, Kaltschmitt et al. 2007, Boyle 2012) and the European classification regime of CICES (European Environment Agency, 2013). In contrast to other classification regimes, CICES regards “biodiversity” as total sum of life and a basis for all (biotic) Ecosystem Services and not as an Ecosystem Service itself. Thereby, in the present study the ESS are categorized into three main groups: provisioning, regulating, maintenance and cultural services.

1.2.1 Analysis of different RE sources and their impacts on Ecosystem Services

Based on a literature review concerning the environmental impacts of the renewable energies, forest biomass, hydropower, wind power and solar photovoltaic were scrutinized. From a thematic point of view, we focus on direct impacts at the site of energy production but also on indirect impacts on regional scale such as required infrastructure constructions. Off-site impacts caused by the production, disposal or recycling of power plant elements and lifecycle analyses are not regarded as main part of recharge.green project. It is planned to publish these results in a peer-reviewed scientific journal (Richard Hastik et al. 2014).

FOREST BIOMASS

Forest management strategies traditionally focus on balancing various economic, ecological and social functions (Führer 2000; Stupak et al. 2007). Impacts caused by an increased use of biomass for energy purpose can be regarded in the context of forest-related activities, but also in context of road infrastructure, transport activities and combustion. The extraction of wood biomass from forest is strongly linked to various forest management strategies (Röhrig et al., 2006; Häusler and Scherer-Lorenzen, 2001) and its impacts on ESS (i.e. provision of fresh water and water filtering, habitat, recreation and natural hazards protection) should be carefully analyzed (Avocat et al. 2011; Bürgi 2011; Führer 6; Quadt, Maaten-Theunissen, and Frank). The increased demand of forest biomass needs to be scrutinized from two aspects which are strongly intertwined, but they differently impact ESS. First, the increased demand might promote “traditional” timber extraction on former unmanaged or extensively used forests impacting a wide range of ESS. The second aspect is related to an increased use of residuals (branches, needles and tops). These residues make up a varying proportion of the aboveground woody biomass ranging approximately from 15% (Norway spruce) to 20% (European beech) depending on tree species and age (M Kaltschmitt and Hartmann 2001). Currently, also in mountainous areas difficult to access, the residue use is increasingly simplified by full-tree harvester vehicles (Hofer and Altwegg 2007). However, residue use impacts various ESS particularly such as soil productivity, water filtering and habitat quality.

ESS impacts related to forest biomass need to be differentiated between an increased use of residues, forest management changes (e.g. shorter rotation periods, changed tree compositions) and increased pressures on formerly unmanaged areas. Emphasis must be put on scrutinizing soil characteristics due to their key role for maintaining various provisioning and regulation services. It is yet unclear, if the increased revenues for fuel wood might also favour shifts from monocultures (e.g. Norway spruce forests) focussed on the specific demands of the wood industry to more diverse forests. Some ESS impacts are strongly linked generating co-benefits, such as habitat and carbon sequestration or natural hazards protection and water regulation. Trade-offs could be revealed regarding forest production and carbon sequestration, but also partly regarding material competitions (wood demand by industry). Other trade-offs and co-benefits are not linear but depend on management intensity, such as for natural hazards protection.

HYDROPOWER

Assessing impacts caused by hydropower is a complex task, due to the wide range of different technologies involved ranging from run-of-river, reservoir, pumped-storage, cross-watershed diversion, in-stream diversion, to combinations or multipurpose projects (Egré and Milewski 2002). Assessing downstream impacts without referring to specific projects is difficult due to the high influence of operational management, river derivations, cross-watershed diversions and/or in-stream diversions. Impacts caused by hydropower are mostly regarded in the context of river ecosystems, landscape values and recreational values (International Energy Agency 2000; Platform Water Management in the Alps 2011). Hydropower reservoirs are an additional source of socioeconomic issues such as displacements, but also creating benefits such as irrigation or flood control.

The ecological viability or supporting ESS of a river ecosystem can be scrutinized by different aspects including hydrological character, river connectivity, solid material budget and morphology, landscape and biotopes and biocoenosis (Bratrich and Truffer 2001; Bratrich et al. 2004; Truffer 2010). Any deteriorations regarding these ecological characteristics have to be considered carefully in respect to the EU Water Framework Directive (European Commission 2000). Thereby, loss of biological diversity, barriers for fish migration, impacts on downstream river ecosystems (e.g. alternation of hydrological cycles, loss of areas exposed to regular inundation), reservoir impoundments, alternated sedimentation and water quality modifications play a major role (International Energy Agency 2000). Further impacts might result out of related infrastructure requirements (e.g. roads, power lines).

Energy potentials related to drinking water power plants are particularly high in the Alps (Blanc and Cherix 2014; Möderl et al.) with little additional environmental impacts and therefore not addressed further in the presented work. As most hydropower potentials in the Alps are already exploited, the ecological compatibility of remaining potentials should be considered in detail. Thereby, a focus could be put on watersheds already strongly alternated while prioritising nature conservation in remaining pristine rivers. Further emphasis must be put on evaluating the added value of small hydropower potentials.

WINDPOWER

Guidelines for assessing wind mills encompass impacts on birds and bats, alternated landscape aesthetics, health risks caused by noise, flickering and safety risks (Balaguer et al. 2004; Gilgen et al. 2010; Ministère de l'Ecologie; de l'Energie; du Développement Durable et de la Mer 2010). These impacts can be differentiated from off-site impacts such as construction of road and power line infrastructure.

High wind energy potentials are particularly correlated to exposed terrain, higher altitudes and mountain ridges. However, these high Alpine landscapes are strongly associated as untouched nature, cultural identification and space for recreational activities. Particularly landscapes not containing any anthropogenic constructions are worth of conservation due to their scarcity. Many parts of the Alpine area are characterised by their historical cultural landscapes, a factor which is additionally regarded critically considering wind park developments (Peters and Uwe 2006). Evaluating visual impacts caused by wind power stations is thus regarded as a key task for Alpine Regions (CIPRA 2002).

The impacts of windmills on wildlife are described in the context of rotor collisions, displacements due to disturbance, migration barriers and habitat alternations. A huge number of studies and reviews originating particularly from the United States and Canada address these impacts on birds (e.g. Drewitt and Langston 2008) and bats (e.g. Arnett et al. 2008) with the general conclusion that the impacts strongly depending on site-specific factors (position of power station towards topography, winds and movement routes), species-specific factors and seasonal factors (yearly migration movements). However, these site-specific factors are difficult to evaluate systematically besides basic assumptions such as the importance of Alpine passes for migratory birds (Gilgen et al. 2010) or the proximity to wooded landscape features having an influence on bat mortality (Dürr and Bach 2004).

Consequently, wind power projects should particularly scrutinize impacts on endangered bird and bat species, but also impacts in case of valuable biotopes. Migration models or empiric data might serve as basic information to discuss energy potential constraints. The compatibility of windmills and Alpine landscapes is controversially discussed especially regarding the social acceptance of windmill projects.

PHOTOVOLTAIC

Photovoltaic facilities mounted on buildings and ground-mounted photovoltaic have to be differentiated regarding their ESS impacts. Only minor impacts on the regional environment are reported for building-mounted photovoltaic (and building mounted solar thermal) panels except for aesthetic issues. In contrast, impacts caused by ground-mounted photovoltaic (=GM-PV, often realised as “solar parks”) are manifold including visual landscape alterations, microclimatic changes, reflections and competing land uses (Chiabrando R. 2008; Herden et al. 2009; Torasso 2011; Tsoutsos et al. 2009). Although most GM-PV can be found in low lands bigger facilities were also constructed in the Alps such as in Les Mées (FR) in the valley Großes Walsertal (AT) or Bolzano/Bozen (IT).

Concerns of GM-PV on ecologic impacts are generally low focussing on habitat alternations and plant community changes due to shading effects and microclimatic changes (Wirth and Schneider 2012) (Chiabrando 2008; Herden et al. 2009). No avoidances by wildlife or bird collisions were revealed yet but fences required around facilities are a barrier for various species (Herden et al. 2009). Concerns regarding the loss of productive land can be raised. However, this argument contradicts European targets on reducing agricultural production (Wirth & Schneider, 2012). Besides, modern fundaments reduce soil sealing to less than 5% of an area (Herden et al. 2009) and remaining areas can be used for grazing. Soil impacts (e.g. compaction) might occur during installation phase.

The expansion of building-mounted photovoltaic (and solar thermal) panels is little limited by specific ESS impacts. In contrast, GM-PV strongly depends on assumptions made regarding their impacts on the provision of agricultural products, alteration of habitats and recreational and aesthetic landscape values in Alpine areas. However, these issues are yet less pronounced as technical and economic issues strongly limit GM-PV (e.g. costs, issue of energy storage).

1.2.2 Systematic overview on ESS impacts and RE constrains

Based on the presented findings it is possible to synthesise the potential environmental impacts caused by various RE upon thematic fields or spatial dimensions involved. From a thematic point of view, several main conflicting priorities regarding RE and ESS of were revealed (Figure 1).

	Provisioning Services		Regulating and Maintenance Services			Cultural Services
	Provision of forest-/ agricultural products	Water provision and filtering	Climate regulation	Habitat for flora and fauna	Natural hazard protection	Recreational and aesthetic values
Forest biomass	Impacts on forest products and soil productivity, wood competition with industry	Impacts in case of inadequate management	Trade-off between the replacement of fossil energies and changed forest carbon sequestration rate	Loss of natural forests, habitat disturbances, reduced dead wood values	Benefits or negative impacts depending on forest management	Temporary impacts related to logging activities, long term benefits of infrastructure
Hydropower run-of-river	Loss of productive land possible	Only minor impacts for human use assumed	Impacts in case of inappropriate land-use changes	Riverline alteration, limitation of migratory routes, downstream impacts, collisions	Positive and negative impacts depending on side-measurements	Positive and negative impacts depending on side-measurements
Hydropower reservoir	Loss of poductive land possible	Changed water availability in case of derivations, mitigate of droughts possible	Impacts in case of inappropriate land-use changes	Habitat loss through inundation, temperature shifts, introduction of species	Reservoirs can help to defuse extreme flood events	Positive and negative impacts depending on side-measurements
Hydropower drinking water supply	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed
Wind power	None or only minor impacts assumed	None or only minor impacts assumed	Impacts in case of inappropriate land-use changes	Alternation of habitats/migratory routes of birds and bats, collisions	None or only minor impacts assumed	Visual impacts on landscape composition, emission of noise/flicker effects
PV ground mounted	Competition for agricultural products possible	None or only minor impacts assumed	Impacts in case of inappropriate land-use changes	Only minor impacts assumed, avoidance of important habitats required	None or only minor impacts assumed	Visual impacts on landscape composition
PV building mounted	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	Only minor impacts assumed in case of natural and cultural heritage sites

*) Impacts related to land use and management shifts, lifetime carbon emission savings not included
**) Impacts on ecosystem properties (air composition) assumed as main issue

Source: Richard Hastik et al. (2015), Renewable energies and ecosystem service impacts.

Figure 1: Main dimensions of affected ESS (dark grey = main issues; light grey= further issues; white = side aspects)

It is nowadays acknowledged that conservation strategies do not necessarily imply trade-offs between ESS and economic interests (De Groot et al. 2010). Therefore, both negative impacts and positive co-benefits need to be balanced and scrutinized regarding endogenous development strategies which are particularly important to Alpine Regions (Dax 2001). However, most of these impacts depends on particular management regimes and side-measurements. Thus, it is not possible to valuate these impacts a priori as positive or negative. Nevertheless, it is possible to highlight main conflict dimensions, which require trade-off decisions as highlighted in Figure 1.

Global climate change mitigating goals need to be particularly balanced with local nature protection requirements, which are particularly important in biodiversity-hot spots such as the Alps. Furthermore, industrialised landscapes serving for energy production need to be balanced with the need for “pristine” mountain environments. However, tourism and energy generation can also create co-benefits depending on the individual project and tourism strategies. Also natural hazards protection, crucial for areas characterised by their extreme topography, can be impacted both positively and negatively by expanding RE. RE used in the context of settlement areas (roof-mounted photovoltaic, near surface geothermal energy) are generally of less concern from an environmental point of view.

1.2.3 Hotspot maps

WEB

Jecami (Joint Ecological Continuum Analysing and Mapping Initiative), www.jecami.eu

The assessment of the ESS provisions is not an easy task, many authors pointed out that such analyses should be carried out at a very small scale. For these reasons, it was not possible to make a detailed description of the provision of ESS for the entire Alpine bow, which is too wide for accurate computations, so the partners focused their attention on a qualitative approach. The purpose of the current project was to identify some useful variables to take into consideration, while investigating ESS in the Alpine area. The data collected allows the inclusion of environmental consideration when it comes to estimate the quantity of the natural resources exploitation for energy purposes. Following the Norman Myers' concept of hotspot (Myers 1988), which includes areas of high species richness and endemism, we mapped the most valuable site within the Alpine bow.

In the Alpine area, protected areas of the Alps were provided by E-connect project. The maps considered are with high biodiversity value, namely:

- National Parks,
- Regional Nature Reserve,
- Biosphere Reserve,
- Areas subject to special protection,
- Natura 2000 sites.

Together with the hot spot maps of biodiversity, other important areas were considered as being highly valuable, such as the UNESCO network of cultural heritage sites. These hot spot maps can be considered as constrains to renewable energy production, where the withdrawal of the energy potential should be lower than other areas in order to preserve biodiversity and the related provision of ESS. From maps in Jecami can be observed that area with high biodiversity value are often area with high energy potential.

1.3 Ecosystem Services evaluation in the Pilot Areas

It is a matter of fact that ESS are extremely valuable for human beings, since their functions guarantee the prosecution of life on Earth. On the other hand, it is a matter of fact that ecosystem are facing continuous and increasing depletion of their quality and their capability to fulfil to their functions. Non sustainable practices are always lead by market logics, because people need to use natural resources to producing goods. The consumption of natural resources allows a "marketable" benefit, in the sense that the economic advantage for the exploiter is clearly visible and reflected in the market price and his related income. Moreover, air pollution and damages of ecosystems produce an economic loss for the entire society that is not compensated, as long as the exploiter is not compelled to pay for his damage. This negative externality occurs because natural resources are public goods, which are non-rival and non-excludable, and so their value is not as clear as private and marketable goods. Due to these characteristics, each form of natural resources consumption produces an unbalanced situation between beneficiaries (the private person or company) and the damaged ones (the whole society).

In order to better understand the costs and benefits of natural resources exploitation, an economic approach to ESS valuation appears to be effective, because it allows a profitability analysis where costs and benefits are valued with the same unit of measure. In the energy production context, considering the social costs of exploiting natural resources could highlight the existing trade-offs between RE and ESS. With such information, decision makers may formulate effective strategies about optimal RE location, capable to preserve the environment and efficiently produce RE at the same time.

A working group for the Pilot Areas identified conflicting priorities, in order to create ESS maps for the Pilot Areas. Firstly, a description of each Region is provided. The analysis focuses on four areas: Leiblachtal (AT), Triglav National Park (SL), Mis and Maè Valleys (IT), Gesso and Vermenagna river basin (IT). The first step was the economic evaluation of the ESS by exploiting several methods. Secondly, the ESS are mapped in a geographically explicitly way and possible conflicts between RE expansion and ESS preservation highlighted.

LOCAL CHARACTERISTICS OF PILOT AREAS

Leiblachtal

The Pilot Area Leiblachtal lies in the most northwestern part of Vorarlberg (Austria) on the border to Germany. With a number of five municipalities (Lochau, Hörbranz, Hohenweiler, Möggers and Eichenberg), approximately 15.000 inhabitants and a size of 50 km^2, the Leiblachtal is the smallest Pilot Area scrutinized in this study. The main land uses are as follows: 48.9% forests (2,497 ha), 39.5% grasslands (2,017), 4.1% agricultural crops (208 ha) and 7.5% urban area (381 ha). About forests, the main forest types are Norway spruce, silver fir and European beech mixed forests (75.3%), followed by pure Norway spruce forests (13.6%) and the mixed broadleaves coppices (4.5%). Considering the tree species composition, mixed forests cover 1,880 ha, pure conifer forests cover 429 ha, while pure broadleaves forests cover the remaining 188 ha which can be found in the lower valley area. The Leiblachtal is socioeconomically characterized by moderate tourism, work migration to the nearby urbanized area of Rheintal and forestry and agricultural activities in smaller villages. As in many parts for the Alps, hydropower and biomass are also in Vorarlberg the most important renewable energies. However, in the Region of Leiblachtal only limited hydropower potential is available. Therefore, alternative renewable energy sources such as wind power and forest biomass are under intensive discussion to meet regional energy demands (Seidel et al 2013).

Triglav National Park

The Pilot Area in Slovenia is the Triglav National Park located in the North-East of country close to the Austrian and Italian borders. Triglav National Park (TNP) is the only national park in Slovenia and the current boundaries are established by a National Law of the 1981. The TNP covers 3% of the territory of Slovenia (83,807 ha: 55.332 ha of central area and 28.475 ha of peripheral area) and the main land uses are forests (62%) and managed grasslands (10%). The main forest types are the European beech forests with about 30,000 ha, the dwarf mountain pine forests with more than 11,000 ha, and the Norway spruce and silver fir forests with 4,185 ha.

The climate of the area is continental, the average temperature in the warmest month range from 20 °C in the valley and 5.6 °C in the mountains, and in the coldest month the temperatures range between 0.7 °C and -8.8 °C. The annual average of precipitation is about 1,500 mm.

In reference to the year 2010, TNP incorporates 25 settlements with a population of 2,444 people (1,018 households) for a population density of 0.029 inhabitant/ha (average national density = 98.7 inhabitant/km^2). Besides, TNP is important touristic area with a number of tourist presences more than 580 thousand tourists per year and an average tourists' permanence of 2.5 nights. The park provides a variety of ecosystem services. On the one hand nature conservation, environment and cultural heritage protection as well as recreation and tourism are the most important ecosystem services in TNP; on the other hand agriculture and forestry are important for the people living in the park.

Gesso and Vermenagna River Basin

The Pilot Area Gesso and Vermenagna River Basin is located in the South-West of Italy, in Piedmont Region, close to the Italian and French border. The area is considered in the recharge.green project because it is partially in the regional park “Parco Naturale Alpi Marittime” (PNAM)

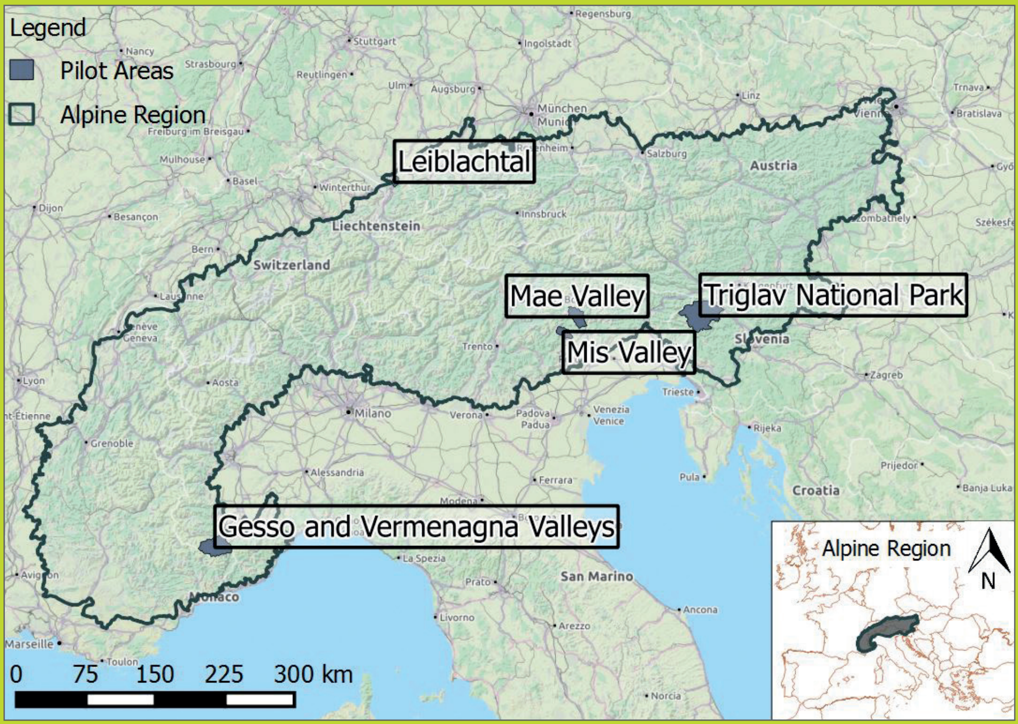
The Gesso-Vermenagna valley includes seven municipalities (Valdieri, Entracque, Roaschia, Roccavione, Robilante, Vernante and Limone Piemonte). The land surface is approximately 51.500 ha. In reference to the year 2010 the population was 10.022 inhabitants with a density of 0,194 inhabitant/ha. About 32.000 ha are situated in protected areas (parks or Nature 2000 sites). Maritime Alps Natural Park and Nature 2000 site Maritime Alps are the most important protected areas of the Pilot Area. The main land uses are forests (42%) and pastures (33%). The main forest types are the European beech forests (11.500 ha) and the chestnut forests (2.700 ha). The principal renewable energy actually used is hydropower. The local economy is based mainly on tourism (about 121,000 tourists per year) and secondarily on agriculture and forestry.

Veneto Region, Mis and Maè Valleys

The Pilot Areas in Veneto Region are located in the Belluno Province, and they correspond to Mis and Maè Valleys. Mis Valley is in the central part of Dolomiti National Park; it covers an area of 11,800 hectares and it is crossed by the 22 km long Mis stream. It includes Sospirolo and Gosaldo Municipalities (3,237 and 762 inhabitants respectively, in 2009), which are characterised by small villages in the northern and southern parts. Forest area covers about 8,347 ha and the main forest categories are hornbeam and manna ash forests (2,420 ha), European beech forests (2,133 ha), dwarf mountain pine forests (1,442 ha) and Norway spruce forests (533 ha). The central part of valley has been abandoned partly for the creation of the artificial Mis Lake in 1962, partly for the great flood event in in 1966, and now it is not fed by electricity. The very few infrastructures of the site use fuel generator to get energy. Mis Valley has recently been affected by a judgment on a hydroelectric power plant within the Park’s boundaries. In fact, both the National Law for natural protected areas (L. 394/1991) and the Plan of the Park do not allow nor to change the hydrological system of streams, nor to build any new construction inside the park area. The artificial lake (110 hectares wide) is used for hydropower production and as a useful reservoir for irrigation of plane areas during the summer season.

Maè Valley is an area of 23,300 hectares around the Maè stream (33 km long). The municipalities of Longarone, Forno di Zoldo, Zoldo Alto and Zoppè di Cadore, account for 7,974 inhabitants in total (year 2009), and there are several collective ownerships as territory management boards. Forest area covers 18,928 ha and the main forest types are: European beech forests (3,963 ha), dwarf mountain pine forests (2,532 ha), mixed forests of Norway spruce and European beech (2,167 ha). Maè valley is largely affected by the presence of protected areas such as Natura 2000 Network and Dolomiti UNESCO sites. The area is important for winter and summer tourism. By the time, the area was also characterised by traditional use of wood for rural building structures, a habit now strongly declined. Nowadays, there are high consumption’s rates of woody biomass for heating related to the households’ traditional activities. Maè Valley shows a traditional use in hydropower and a recent increase in small hydropower derivation requests. The forest biomass is used only in few known power plants, but it can represent a possible alternative source of energy. Its utilization can also guarantee the conservation of grasslands (pastures and meadows), that in last decades have been covered by spontaneous afforestation, causing problems of loss in landscape variety, occurrence of fires, presence of ticks and so on.

Figure 2:
The Pilot Areas of the project.



1.3.1 *The economic evaluation*

In order to estimate the ESS' benefits, several economic valuation methods were exploited. Table 2 summarizes the approach used.

TABLE 2: ALPINE ECOSYSTEM SERVICES DEFINED FOR THE RECHARGE.GREEN PROJECT

ECOSYSTEM GOOD AND SERVICE		DEFINITION ADOPTED	
Provisioning services			
Timber	Market price	Hay production	Market price
Wood for energy	Market price	Livestock	Market price
NWFP (hunting products, berries and mushrooms)	Market price		
Water provision	Market price		
Regulating services			
Protection against natural risks (direct and indirect protection)	Replacement cost method	Protection against natural risks (indirect protection)	Replacement cost method
Carbon storage (living and non-living forest biomass)	Voluntary market price	Carbon storage in living biomass	Voluntary market price
Cultural services			
Outdoor recreation (hiking, walking, pic-nicking, etc..)	Benefit transfer method	Outdoor recreation (hiking, walking, pic-nicking, etc..)	Benefit transfer method

Three categories of ecosystem services were evaluated from the economic point of view (provisioning, regulating and cultural services), while supporting services were not included in order to avoid double counting of value (Hein et al. 2006). The main benefits provided by forest and grassland ES were evaluated using different economic valuation methods (such as market price, replacement cost method and benefit transfer method) and the estimated benefits were made spatially explicit. The economic valuations of all benefits derived from ES have been made in reference to the 2012 year. The spatial distribution of the market and non-marketed benefits supplied by ecosystems provides useful information to support the decision makers (i.e. planners and managers) in the definition and implementation of the landscape planning strategies in the different portions of the territory. In the recharge.green project, the spatial distribution of ESS' benefits will be used to forecast the future positive and negative impacts of renewable energies (i.e. solar, wind and forest biomass) development on the ecosystem services in the study areas.

PROVISIONING SERVICES

The estimated provisioning goods and services supplied by forests were:
1. Timber for construction,
2. Wood for energy (fuelwood and wood chips),
3. Non-wood forest products (NWFP),
4. Water provision.

The timber and fuelwood production were estimated considering the local market price and the annual harvested volume subdivided by forest types.

The NWFP were estimated considering the main products supplied by the Alpine forests: hunting products (meat, trophy and skin), berries (bilberries and raspberries), mushrooms and truffles. The value of hunting products was calculated from the data of annual animals hunted (ungulates, other mammals and birds). Three components of animal were considered, especially meat for all comestible animals, skin for all ungulates, and trophy only for the male of ungulates (e.g. red deer, roe deer and chamois). The quantity of berries and mushrooms collected were accounted taking into account the local household.

Instead, the water provision was evaluated considering the average annual consume of water pro capita taking into account all water uses (agricultural, domestic, energetic and industrial uses) and the average price of water (OECD 2009).

The estimated provisioning services supplied by grasslands were hay production and livestock in managed grasslands. The economic value of hay production was evaluated considering the annual hay production and local prices of hay. Instead, the value of annual livestock grazing in the pasture areas was estimated taking into account the Livestock Units (LUs) per hectare and an average price for each unit.

REGULATING SERVICES

The regulating services estimated for both natural ecosystems were the protection against hydrogeological risks and the carbon storage in forest living and non-living biomass.

The protection against hydrogeological risks - such as soil erosion, landslides, rockfalls and avalanches (Notaro and Paletto 2012; Dorren et al. 2004) - was evaluated through the replacement cost approach (Freeman 2003). This approach assesses the cost incurred by replacing ecosystem services with artificial substitutes (Dixon et al. 2013). Generally, the artificial substitutes are choice considering type and degree of protection (Notaro and Paletto, 2012). In this study, the costs for replacing hydrogeological protection with artificial substitutes were considered distinguishing between direct and indirect protection. According to the third Ministerial Conference for the Protection of Forests in Europe (Lisbon, 1998), indirect protection can be defined as the prevention of soil erosion and regulation of water flow, while direct protection involves safeguarding human life and activities from natural risks (Motta and Haudemand 2000; Notaro and Paletto 2012). From the economic point of view, the total costs of carrying out and maintaining the different artificial substitutes - distinguishing for land use (forest and grassland) and type of protection (direct and indirect protection) - were taken into account to calculate an annual cost per unit area (hectare). In each Pilot Area different artificial substitutes were chosen based on the site characteristics and level of protection (e.g. seeding for the grasslands, hydro-seeding for the indirect protection forests, simple palisade for the direct protection forests).

For the annual cost calculation, a conservative interest rate was chosen and fixed at 2%, according to Freeman's (2003) ranges.

The procedure used to estimate the quantity of carbon stored in forests follows the For-Est approach (Federici et al. 2008), based on the IPCC "Good Practice Guidance for Land use, land-use Change and Forestry" (IPCC 2003). The annual forest's capacity to transform atmospheric carbon into biomass was estimated considering three carbon pools: above-ground biomass, below-ground biomass and deadwood. The other two carbon pools (litter and organic soil) were not considered, as the changes in the annual increment of carbon stock are negligible. The formula used to estimate the value of carbon sequestration in living forest biomass (above-ground and below-ground biomass) is the following:

$$V_c = [(I \cdot BEF \cdot WBD) + (I \cdot WBD \cdot R)] \cdot 0.5 \cdot 3.67 \cdot p_c$$

where V_c is the value of carbon sequestration in above-ground and below-ground biomass (€), I is the annual volume increment (m3/year), BEF is the biomass expansion factor (usually forest volume is referred to stem volume, and the expansion factor accounts for components such as branches, and leaves), WBD is the wood basal density (kg/m3), R is the ratio of roots to shoot, C_c is the coefficient of carbon content equal to 0.5 and p_c is the carbon price of the voluntary carbon market (€/tC).

The capacity of grasslands to act as net carbon sinks may result from the continuous turnover of biomass and stable storage of this organic matter in soil (Schulze et al. 2000). The amount of carbon stored in grasslands depends on climatic condition, site features and management strategies. The value of carbon storage for both natural ecosystems was estimated using mean voluntary carbon market price related to 2012, which is 4.59 €/tC (Peters-Stanley, M. and Yin, D. 2013).

CULTURAL SERVICES

Cultural services were estimated considering the outdoor recreation (e.g. hiking, walking, picnicking, jogging and landscape viewing), through the Benefit Transfer (BT) (Wilson and Hoehn 2006). BT method consists in examining the results of surveys undertaken in specific contexts (study site) and transferring them to similar unstudied situations of interest for policy making defined policy site. The economic value estimated in the study site can be transferred to the policy site either as monetary units (value transfers) or as a function (function transfers) that defines the attributes of an ecological and economic choice setting (Rosenberger and Loomis 2001). The average value transfer method uses a measure of central tendency of all subsets of relevant studies as the transfer measure for the policy site issue. In this study, we used the method of average value transfer choosing study sites as much similar as possible to the policy site (i.e. mountain forests in Europe). The average value of mountain forest studies was collected through a meta-analysis, the detailed methodology is available in Grilli et al. (2014). Outdoor recreational values were estimated and transferred according to forest types (mixed forests, pure conifer forests and pure broadleaves forests) and altitude (above and below 1,000 m a.s.l.).

1.4 ESS maps

The benefits provided by ESS were expressed in a 3-point, 5-point or 7-point rating scale and mapped taking into account the ecological characteristics of each ecosystem service using a Geographical Information System software (GRASS GIS and Quantum-GIS). A set of thematic layers representing a key variable was used. The layers were overlapped in order to analyze the spatial distribution of ecosystem services' values.
The used key variables were:

1. land uses;
2. forest types (forest tree species composition);
3. altitude (distinguishing between areas above and below 1000 m a.s.l.);
4. forest tracks and paths network;
5. river and stream network.

The land use was employed to distinguish the areas to be evaluated (forests and grasslands) by others (urban areas and agricultural crops). Also according with the categorization of ecosystem services shown in Table 1 (provisioning, regulating and cultural services), thematic layers were combined by using an overlay procedure. The resulting map is characterized by a number of polygons which express the values of the ecosystem services supply. The spatial distribution of the provisioning services accounted the values of timber and wood energy production, and water provision for all the forest areas. Regarding to the NWFP (non-wood forest products) we considered all forest area for the hunting products, mushrooms and truffles, while the bilberries and raspberries values were attributed only to the forest types with Vaccinium myrtillus (L.) and Rubus idaeus (L.) in the shrub layer.
The regulating services value of forests was mapped assigning a value per forest type. The value of indirect protection against natural risks was assigned taking into account type and level of protection. Regarding the grasslands, the value of protection against natural risks was assigned to the whole area. While the value of carbon storage in living biomass was assigned distinguishing between pasture, managed meadow and unmanaged meadows. Regarding the cultural services, the value of outdoor recreation is assigned taking in to account both differences among the forest types and the altitude of forest area. The results were mapped for each Pilot Area (see www.jecami.eu).

WEB:

grass.osgeo.org
www.qgis.org

ECOSYSTEM SERVICE

See the paper "Mapping the value of ecosystem services: A case study from the Austrian Alps" www.afrjournal.org/index.php/afr/article/view/335

LEIBLACHTAL

The spatial analysis of the ecosystem service shows higher values for the provisioning services. Especially, the productive forests and the managed meadows close to the urban areas have the highest values, while the lowest values are found in the high mountain areas. Besides, meadows have a higher value than pasture and mixed protection forests have the highest value among forests.

TRIGLAV NATIONAL PARK

Triglav National Park have a different situation of the weight of the groups of ESS within its territory. This difference is mainly given by the fact that the land is completely protected, so the contribution of provisioning services to the TEV (Total Economic Value) is considerably lower, because of the legal limitation to the exploitation of natural resources. In addition, the local prices used for the calculations are lower in Slovenia than in Austria. On the other hand, cultural services are slightly higher, due to the fact that the TNP is a more touristic area than Leiblachtal.

Provisioning services in forests vary considerably from very low values to very high values. This range is due to the differences among tree species and quality of wood in different parts of the Triglav National Park. Regulating services and cultural services, on the other hand, seem to show less differences in the quantification. Concerning the regulating services, we observed three classes of values. In this circumstance, the higher differences in the value are given by the forest dedicated to protection against natural hazards. Of course, protective forests show considerable greater values than non-protective forests. Finally, cultural services have a distribution of the value based on the tree species composition, which is the variable used to map the recreational activities. As well as the findings in the regulating services, three classes of values are found for the cultural services. Grassland ESS have just one class for each typology of service, because it was impossible to find differences in the land management, so the whole portion of grassland was treated as meadow.

GESSO AND VERMENAGNA VALLEYS

The results of the economic analysis highlight medium-high values, on average, for provisioning services, although the highest values are concentrated in specific areas of the valley. Forests is a good source of biomass for energy purposes, in particular firewood and woodchips, while the timber production is less important, due to the high share of coppices and the small number of local sawmills. The highest valuable areas are the chestnut tree forests, thanks to the intense withdrawals of their edible fruits. Grasslands are also very important for the provision of natural goods, especially for pasture products. Two municipalities, i.e. Limone Piemonte and Vernante, seem to be particularly suitable for cow grazing thanks to their accessibility and their morphology.

Concerning regulating services, a common feature to all the Pilot Areas is the great contribution of the forests protection against natural hazards. Even in this case, this particular service is the most valuable among the set of considered services. Forests contribute considerably also for what concerns carbon sequestration, which is also an important function for the managed meadows in the low lands. Meadows and pastures is focused only on tackling superficial soil erosion phenomena.

Finally, data about the number of tourists, due to the presence of infrastructures and sky resorts close to Limone Piemonte, affect the value of recreational service.

MIS AND MAÈ VALLEYS

The University of Padua carried out the spatial analysis of ESS in the valleys of Veneto Region, in the north east of Italy. Thanks to the three maps described in the box "ESS evaluation in Mis and Mae valleys", we can have a general idea of which seems to be the function having a major weight in the analysed areas, therefore obtaining an estimation of the value of the ecosystem services supplied by the environment. If we overlay the results for the Mis Valley, we can appreciate a prevalence of the landscape-touristic value, which almost homogeneously covers a large area within the boundaries. While the ecologic and protective services are less but comparably distributed. This could be due to the important presence of the Dolomites National Park, which covers a huge part of the watershed. The Maè Valley seems to be more fragmented: the functions are heterogeneously distributed even if there is a slight predominance of the land-

ESS EVALUATION IN THE MIS AND MAÈ VALLEYS

The Land, Agro & Forestry System Department of the University of Padova together with Veneto Region analysed the ESS in relation to power generation based on the use of hydroelectric resources and woody biomass, within the Pilot Areas of the Belluno Province.

In general, the approach of the University of Padova follows the steps:

1. Literature review,
2. ESS identification, analysis and mapping,
3. Identification and implementation of the suitable economic evaluation method.

A deepened bibliographic research has been carried out. The ESS represent currently a hot topic, therefore, the various sources of information retrieved, were selected in accordance with the principle of reliability. Mainly through the online research, we gathered scientific articles, ad hoc studies and different types of publications related to the broad theme of the ESS. Guidelines and handbooks for the identification and analysis of the ESS were examined and online tools relating to the Evaluation and Payment for Ecosystem Services (PES) have been consulted. Where a merchantable value could be attributed, the databases of the official related organizations where consulted (i.e.: timber prices for the different essences → National Institute of Statistics ISTAT online database; forest dry biomass carbon content → Forests and Carbon National Inventory INFC). Unfortunately, the ESS to which an effective economic value can be given are few, therefore a lot of similar case studies where investigated in order to get a proxy value attributable to our situation.

Starting from the list of the ESS edited by the recharge.green project partners, and thanks to the survey conducted with the local experts, 10 categories of ESS emerged for having a major importance for the Pilot Areas of the Veneto Region:

- Provisioning services,
- Water related services,
- Carbon sequestration,
- Air quality,
- Water quality,
- Protection from hazards,
- Habitat conservation,
- Landscape services,
- Recreation services,
- Intrinsic value.

Each category has been analyzed, in order to find out the relevant ESS for the Mis and Maè areas. For example, in the first category of the "Provisioning" ecosystem services we could point out that, relating to forest biomass, we have to consider timberwood, fuelwood production as well as non-wood forest products.

According to the different levels from which we can address the ESS' analysis, both monothematic and multi-thematic maps are produced. The first ones describe one of the components of the analyzed ES (i.e. the potential chromatic value of the different forest types contributes to the global landscape value of the valley). For example, considering mushrooms provisioning, the methodology proposed by the Italian Institute for Environment Protection (ISPRA) was adopted, i.e. some specific Corine categories were considered, a certain value of land slope and distance from roads, combined together to obtain the accessibility for mushrooms.

Another example can be represented by fishing as a recreational ecosystem service. The basis is the fish map provided by the Province of Belluno, where the streams are classified considering their usability in fishing activities. A numeric value was given to each of these classes and then translated into a qualitative index of "sporty value", from "null" to "very high".

Multi-thematic maps aim to the description and mapping of the whole service's category and they have been produced through the model elaborated in the C3Alps project (Alpine Space Programme 2007-2013) by the

Land, Agro & Forestry System Department itself. The maps represent Landscape-Touristic, Ecologic and Protection ESS: landscape and touristic services are displayed together in one map, since common indicators were employed for both the categories and there was the necessity of avoiding the repetition of items in the Decision Support System (DSS). In order to obtain the maps, several indicators were combined together. For instance, some of the indicators for the landscape value are: distance from streets and paths, distances from rivers and lakes, presence of National Parks and Natura 2000 areas, distance and visibility from mountain lodges, presence of UNESCO sites, etc. Maps are related both to biomass and hydropower sources, therefore, indicators concerning forests, soil and water are considered. The model has been used for forest typologies as unit of reference, covering entirely forest area and also for grasslands and meadows.

scape-touristic value, the ecologic and protection services are widely present and equally distributed, as in the Mis Valley.
Some of the previously described maps will be employed during the discussions with the local stakeholders, with the aim of weighting the values and the location given in the maps thanks to the stakeholders' point of view. For example, the map localizing the areas dedicated to the game fishing activities – which is part of the landscape-recreational value of the valley – will be separately submitted to the stakeholders, in order to calibrate the values given to the different fishing sites.

1.5 Conclusion

The Renewable Energy expansion is symbolic of a positive paradigm shift, since it allows a considerable reduction in GHG emissions and contribute to a cleaner environment. Policy makers have to be aware that REs produce also several impacts on the environment. The project partners analyzed the current situation and the expected trade-offs between RE and ESS, identifying the main sources of conflicts for each RE. The recharge.green project aims at considering all the possible conflicts that may occur while planning development trajectories for a territory, testing a methodology to analyze the problem with an approach that is most comprehensive. The project foresees two-scale levels. The broader project territory coincide with the Alpine bow, while a smaller one correspond with the width of the five Pilot Areas. Different approaches to the ESS assessment were undertaken, considering the scale of analysis.
The existing characteristics of the ESS at the Alpine level were analyzed to identify the spatial and quantitative distribution of natural areas and the land-use of the Alpine Region. Moreover, natural reserves, Natura 2000, biotopes and the UNESCO Network were considered, in order to understand the quality of such natural areas and the status quo of biodiversity. These variables provide a useful indicator about the constrains that should be included in the estimation of the energy potential of the Alps, in order not to affect the provision of ESs for human being in a negative way.
The Pilot Areas were surveyed in detail, with an economic approach and thematic mapping of the ESS was undertaken, based on a series of spatial data provided by the Pilot Areas. The Pilot Areas showed different contribution of each ecosystem service to the total economic value of the ecosystems. Typically, the protection against natural hazards provided by forests is the most influential and valuable ESS, since without it damages to humans, roads and infrastructure may be very substantial. The results of the project are in line with the literature, highlighting very high value for the protective function. This information is very important and should be considered during policy making, meaning that, protective forest should be left as much natural as possible, in order to avoid the risk of avalanches, landslides or other natural hazards. Except for protection, the other ESS have different importance, based on the specific local context. In particular, great differences are highlighted between protected and non-protected areas. Protected areas have several restriction to land and resources use, so the provisioning services do not have much importance for the territory, but they have a big influence on the cultural services. On the other hand, non-protected areas are allowed to exploit more natural resources, so the provisioning services are more valuable. Despite several differences among the Pilot Areas, the provision of goods such as timber and non-wood products are important, so the development strategies should also aim at maintaining the current level of good provisioning in order not to affect negatively the income of local inhabitants.
Quantifying the monetary amounts of each ESS is important in order to understand the costs and benefits of RE expansion with the same unit of measure. Furthermore, an economic evaluation allows the ranking of the ESS based on their value. The joint adoption of the economic approach and the spatial analysis provided by GIS tools is particularly

effective. The spatial location of the economic values of the ESS allows an effective siting strategy. GIS modeling make possible the computation of the most important sites from the ecological point of view, which should be kept uncontaminated in order not to lose value. At the same time, through GIS analysis it is possible to highlight the portions of the ecosystem with less value, exploitable for energy purposes. Anyway, a final evaluation of the sites should take into consideration not only economical and energy aspects but also qualitative information and social acceptance, as highlighted in the Chapter 3.

Energy Potential from Renewable Sources in the Alpine Area and in the Pilot Areas

02

Identifying the "real" potentials for renewable energy in the Alpine Space is a matter of finding an optimal compromise between the right technology/renewable energy type applied to the right place, and at the same time protecting the environment and ecosystem services.

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EURAC

EURAC research - Institute for Renewable Energy: www.eurac.edu/en/research/technologies/renewableenergy/researchfields/Pages/Energy-strategies-and-planning.aspx

WEB:

www.alpconv.org/en/AlpineKnowledge/database/default.html?AspxAutoDetectCookieSupport=1

In this chapter, the theoretical potential maps are presented. The map showing the potential of forest biomass for energy has been developed by *IIASA* (Vienne, AT), while the hydropower, solar (photovoltaic) and wind potential maps were developed by *EURAC* research centre (Bolzano, IT). The maps developed by EURAC research were derived by using an extension of GRASS GIS.

In order to use a common terminology, we adopted the following definitions (Resch, et al., 2008):

- Theoretical potential: is the upper limit of what can be produced from a certain source, based on scientific knowledge;
- Technical potential: takes into account technical, structural, legal and ecological restriction. The technical potential must be seen in a dynamic constant, it would increase if, for example conversion technologies improve.

In this report, we calculated the theoretical potential for wind, solar, forest biomass and hydropower. For each RE, we computed a theoretical-physical potential based on the physical limits of energy conversion and a theoretical-technical potential based on the theoretical limits of the existing technology.

In addition, to assess the energy potential, we introduce the concept of capacity factor. For each RE, we compute a theoretical-physical potential based on physical limits of energy conversion and a theoretical-technical potential based on existing technology theoretical limits.

For each RE, the capacity factor is defined as the ratio of the annual energy production to the hypothetical maximum possible, i.e. running full time at rated power. It can be expressed in percentage or hour/year. Notice that a higher capacity factor is generally better and, especially, more economical for a given technology. You cannot compare different renewable energies only depending on the capacity factor. Usually, wind capacity factor are 20-40% (Wind Energy Center, University of Massachusetts Amherst). Compared to wind and hydro, solar energy has an additional limitation: there is absolutely no energy production during night-time.

For all the maps, the Alpine perimeter refers to the Alpine Convention database (Alpine Convention – SOIA DATABASE, 2014).

GRASS

GRASS is a free and open source Geographic Information System (GIS) software suite. The Geographic Resources Analysis Support System (GRASS) supports the creation, modification and processing of 2D and 3D raster and vector layers. It provides a topological vector model and true three dimensional coordinates for vector features. GRASS is characterized by stability, an efficient application programming interface (API) written in C, and a large number of GIS functions and modules. GRASS provides many models and algorithms that, after substantial testing and trouble shooting, have proven to be very reliable. Its capabilities to process geographical information have been testified by many research and technical papers.

Source: Neteler, M., Bowman, M. H., Landa, M., & Metz, M. (2012). GRASS GIS: A multi-purpose open source GIS. Environmental Modelling & Software, 31, 124–130. doi:10.1016/j.envsoft.2011.11.014

2.1 Forest Biomass

DATA COLLECTION

The Global Forest Model (G4M) estimates the impact of forestry activities on carbon sequestration and supply of biomass in the Alps. It uses maps showing countries, ecoregions, elevation, forest cover, forest type, gridsize, irrigation, land and water share, temperature and precipitation, primary forest share, slope, soil and current stock. The maps showing country, ecoregion, elevation, irrigation, land and water share, temperature and precipitation and soil are used as they provided free on the web. The slope was calculated by using the information of the global 3” digital elevation map. The grid size for the 30” grids was calculated using some GRASS GIS functions. The forest cover map is a combination of the Modis continuous field forest cover maps for the years 2005, 2006, 2007, 2008, 2009 and 2010. The regions covered by the forest map from JRC for the years 2000 and 2006 are used from those maps. The primary forest share was estimated by using numbers given in FRA 2010 and downscaling them by using the forest cover map and a human activity map from CIESIN. The forest types evergreen needle-leaved, evergreen broadleaved, deciduous needle-leaved, deciduous broadleaved in combination with the four regions Boreal, Temperate, Tropical, Subtropical was estimated by using land classifications form Modis and ecoregions from FAO. The forest stock was estimated on a 30” resolution using the method described in Kindermann et al. 2008.

METHODOLOGY

The forest growth model can estimate site-specific increments for different rotation times. Typical rotation times beside the current rotation time are those that will maximize either forest increment or maximize stock.

The most important point in modelling forest growth is a method to estimate the yield level of a site. For a specific stand, this is done typical by either using the ground vegetation or using dominant tree height, age and a yield table. In the global forest model temperature, precipitation, soil, latitude and altitude are used to estimate site productivity as the net primary productivity (NPP) with the following equations:

$$NPP = F \sum_{m=1}^{12} D_m \, A_m \, B_m \, E$$

where

$$A_m = max\left[0, c_s\left(\frac{1}{1+e^{c_0+c_1\,t_m}} + \right.\right.$$
$$\left.\left. -c_2 - \frac{1}{1+e^{c_3+c_4\,t_m}}\right]$$

$$B_m = max0, 1+$$
$$-\frac{2}{1+e^{\frac{sw_m+p_m-max(0,t_m\,wl)}{max(1,t_m\,c_5)}}}$$

$$E = \frac{c_6}{1+e^{c_7+c_8 CO_2}} + c_9$$

$$F = c_{10} + c_{11}\,nn + c_{12}\cos(lat) +$$
$$+c_{13}\,nn\cos(lat)$$

$$wl = \frac{c_{14}}{c_{15} + \frac{1}{1+e^{c_{16}+c_{17}\,CO_2}}}$$

The input variables of the system of equations are m number of the month of the year, t_m monthly average temperature [°C], p_m precipitation [mm in 30 days], nn altitude [m], lat latitude [°], wl is Walter and Lieth relation (6), swd soil water decay rate equal to 0.8 and CO_2 is the CO_2 concentration [ppm] equal to 0.038.

The value of sw_m is estimated for each month as

x =

For l = *m-5 to m-1:*

x = $min \{whc, max\ [0, x+p_i$

$-max(0,t_l)\ \ wl]swd\}$

sw = x+groundwater+irrigation

By using forest specific coefficients, the NPP for different forest types can be estimated. The coefficients c_0, c_1 ... c_{15} are estimated by using the global NPP map from Modis (Running et al. 2004) and selecting only grids that are covered by forests. The soil type is taken from FAO (2012). Also the water holding capacity is estimated by using the given available water storage capacity per meter and making the assumption that the usable soil depth is 1.5 meters. Areas with irrigation were taken from Siebert et al. (2010). Monthly precipitation and temperature was taken from Hijmans et al. (2005). Altitude was used from USGS (2008) and the Ecological Zones are taken from FAO (2000).

Figure 3 shows how temperature and precipitation determine NPP.

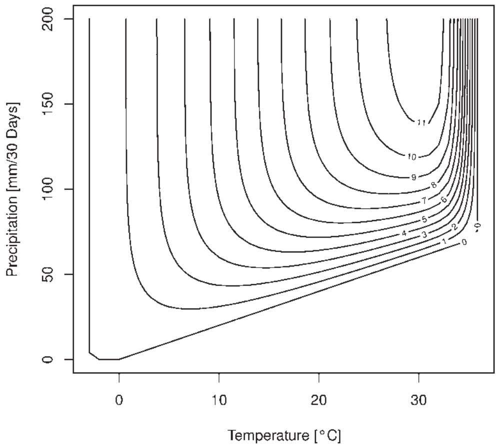


Figure 3: NPP [tC/ha/year] described by temperature and precipitation. For coefficients of forest, no soil water, soil factor cs=0.07, altitude=0, latitude=0, CO2=0.038 ppm. Temperature and precipitation is kept constant for all 12 month.

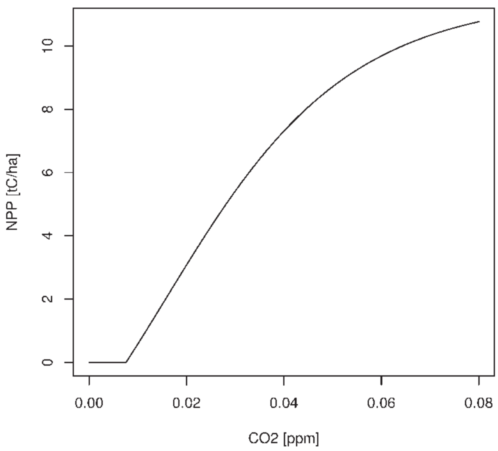


Figure 4: NPP [tC/ha/year] described by CO2. For coefficients of forest, no soil water, soil factor cs=0.07, altitude=0, latitude=0, temperature=20°C and precipitation=70 mm/30 days is kept constant for all 12 month.

An increasing temperature and an increasing precipitation result in higher NPP. Temperature shows a peak where higher temperatures result in lower NPP. This peak can either be determined by precipitation, or if precipitation is high, than by respiration. An increasing CO_2 concentration results in a non-linear increasing productivity rate (Figure 4). The estimated NPP will be used to describe the yield level. For the g4-Model described in Kindermann et. al (2013) this npp needs to be converted to a maximum mean annual increment of stem wood (MAI). This is done by assuming that 35% of the NPP is stored in stem wood until the age when MAI is reached. As long as only the potentials at the current situation are of interest, nothing else is needed as the MAI is already the potential stem wood increment, which can be reached. Many factors will reduce this potential like disasters, disease or losses during harvest. To describe the way from the current situation to this potential, the current forests need to be described. The forest type (species), stand density and age distribution need to be known. For the simulation, a management system (thinning, final harvests) has to be defined and some assumptions on environment changes need to be made. These environment changes will influence e.g. the type of forest, which will be reforested after final harvest.

For the current increments, the current forest situation needs to be estimated. This is done by using information about forest area, species share and age-class distribution or stocking biomass. In addition, the stand density also determines the current forest situation. For this investigation, the starting stand density is set to a yield table stocking degree of one.

RESULTS

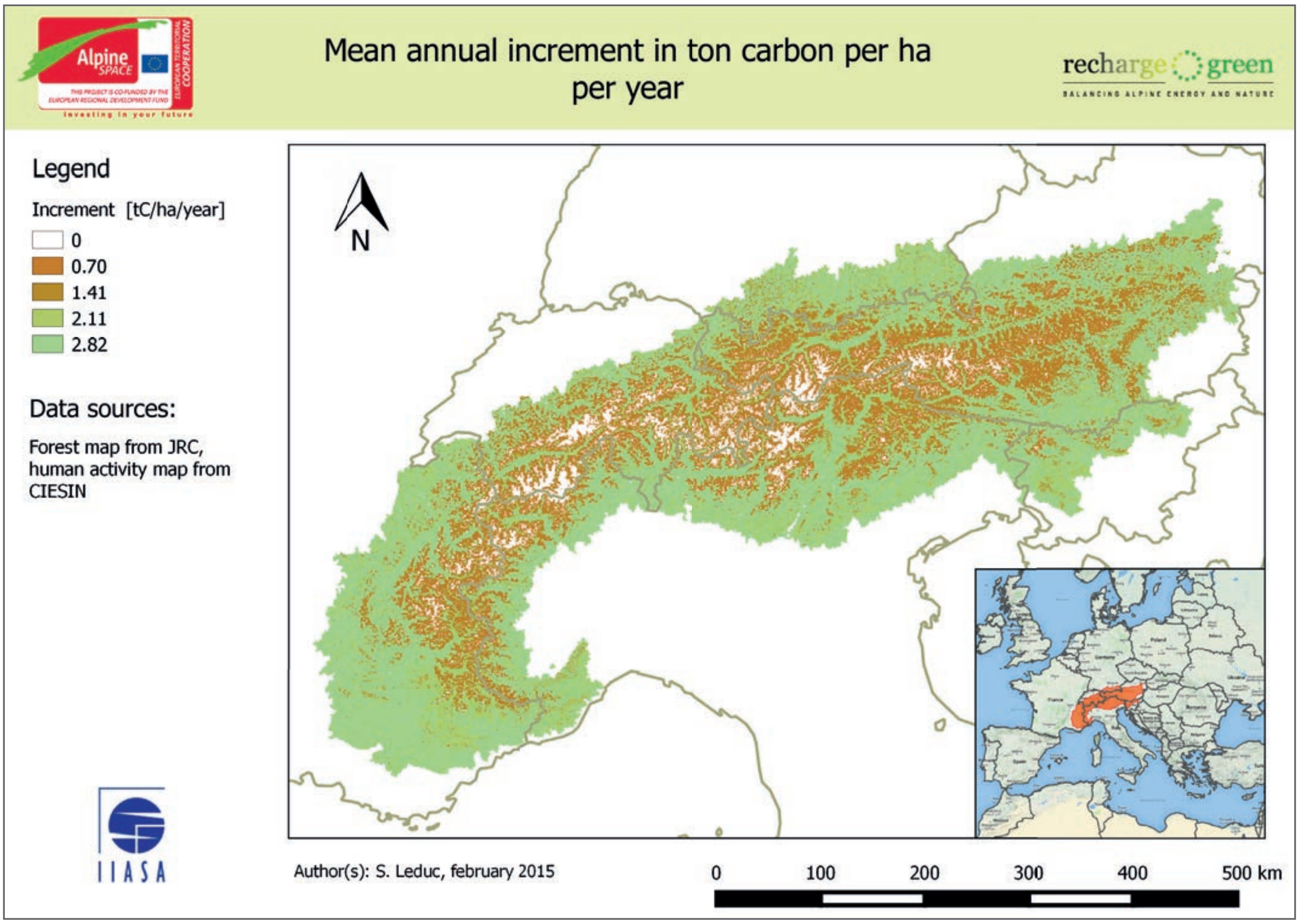
Two scenarios were created by variations in the rotation time and forest management: the maximization of carbon stock in the forest scenario (S1) and maximization of biomass production scenario (S2). In the carbon sequestration scenario (S1), the forest rotation period is increased (on average about 200 years instead of 100 years in S2) such that a maximal amount of carbon is being stored in the forest, considering that damage to forest increases with the age of the trees. In the biomass production scenario (S2), the forest rotation period is decreased such that the forest growth is maximized, leading to a high availability of biomass for energy purposes. About the double amount of harvesting potential is available under this scenario (S2, 23 Mt C/y) compared to S1 (11 Mt C/y). On the other hand, the carbon stock is almost twice as much under scenario S1 than under scenario S2 (see Table 3). Note that both scenarios lead to sustainable forest management and no forest degradation, deforestation, nor afforestation. Figure 3 presents a geographic explicit overview of the results from the G4M model.

TABLE 3: HARVEST POTENTIAL AND CARBON STOCK FOR THE SCENARIOS S1 AND S2

	S1: Carbon sequestration	S2: Biomass production
Harvest potential (MtC/year)	900	44
Carbon stock (MtC)	800	48

Notice that the stock difference of 480 MtC between the scenarios will be leveled out with increment in approximately 40 Years (e.g. the harvested increment is stored in furniture and buildings instead of storing the increment in the forest). After this 40 years a "win" in the scenario S2 (Maximization of biomass production) of about 11.5 MtC per year will be gained compared to the scenario S1. So, if carbon is "stored" (in furniture etc.) instead of burned for bioenergy, the "intensive management" scenario (S2) outperforms the "low intensive management" scenario (S1) after 40 years.

MAPS



2.2 Hydropower

WEB:

www.euro4m.eu

DATA COLLECTION

The maximum potential is the energy that can be produced under the assumption that all the water resource is used. The theoretical potential does not consider the environmental flow and alternative uses of water (aqueducts, irrigation, etc.).

In order to compute the hydropower potential data about precipitation and elevation are collected.

The rainfall dataset (Isotta et al., 2014) has been provided by the federal office of meteorology and climatology MeteoSwiss and was developed as part of EU project EURO4M. The daily precipitation is derived from a pan-Alpine high resolution rain-gauge dataset of More than 8500 time series in total, approximately 5500 measurements each data. The precipitation [mm] considers rainfall plus snow water equivalent. The cover period is January-December, 1971-2008. The resolution is grid spacing 5x5 km, but the effective resolution is approximately 10-20 km, depending on local station density. The rainfall data have been used together with discharge data were measurements were available.

For the digital elevation model, we use a dataset derived from the USGS/NASA SRTM data. CIAT (Jarvis, Reuter, Nelson and Guevara, 2008) has processed this data to provide seamless continuous topography surfaces.

METHODOLOGY

Firstly, rivers and watershed basins in the Alpine area are computed by processing elevation data (Ehlschlaeger, 1989). The algorithm is available as a GRASS extension r.watershed. We set the threshold parameter equal to 10,000.

Then, the exploitable potential is computed in each basin as:

$$P = g\ \eta\ Q\ (H_{mean} - H_{clos})$$

with P is the mean annual power, g gravity acceleration, η energy efficiency equal to 0.8, (H_{mean}-$H_{closure}$) gross head equal to the difference between the average elevation of the basin H_{mean} and the elevation at the river basin closure H_{mean}, $conv$ conversion factor.

Following Mari et al. (2011) we do not consider only the own power of the catchment but also the interaction we upper basins as shown. The discharge coming from upper basins can be used to produce energy in the lower basin. This can be done by means of a system of weirs and reservoirs. In this case the potential related to the base unit and due to the upper discharge is equal to:

$$P_{i,up} = \sum_{j \in UP} g\ \eta\ Q_{j,clos}\ (H_{j,clos} - H_{i,clos})$$

where UP is the set of the upper basin and i is the reference basin.

The energy effeciency η is assumed to be a theoretical limit, because conversion technologies cannot go beyond it and the current technology already reached its upper value.

The limit of this approach are:

- We consider mean value for the gross head and especially for the discharge we do not take into account the flow-duration curve,
- The environmental flow, irrigation and domestic water use are not considered.

RESULTS

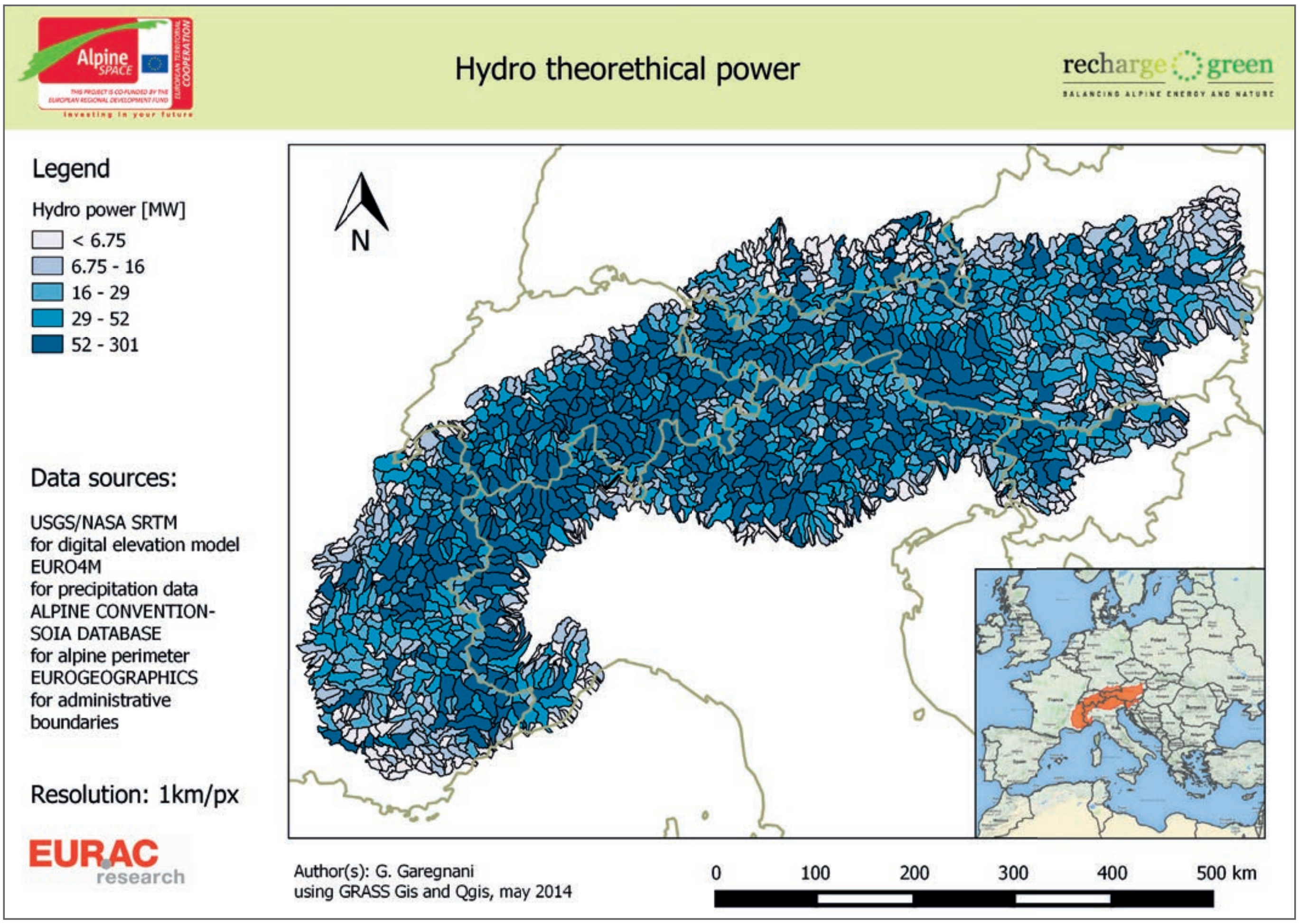
In order to compute the annual discharge in each river basin from EURO4M dataset, we assume apply the following equation:

$$Q_{annual} = \sum_{i=1}^{N} A_i \times p_i \times cd$$

where A_i is the cell area, p_i is the rain precipitation in the i-th cell and N is the number of cell in the each basin.

In the EURO4M (Isotta et al., 2014), the daily precipitation is derived from a pan-Alpine high resolution rain-gauge dataset of More than 8500 time series in total, approximately 5500 measurements each data. The precipitation considers rainfall plus snow water equivalent. The cover period is January-December, 1971-2008. The resolution is grid spacing 5km/px, but the effective resolution is approximately 10-20 km, depending on local station density. Since we do not know the runoff coefficients cd of each basin in the Alps, we set them equal to 0.5.We report the potential maps obtained by considering the whole potential energy. Maps should be considered as an indication of the energy potential.

MAPS



2.3 Windpower

WEB:

windharvest.
meteotest.ch

DATA COLLECTION

Data of wind velocity at different elevation (50m, 70 m, 100m) are provided by the Alpine Space project Alpine Windharvest. In the project, they use a statistical modeling methodology to compile wind map based on climatological data collected by 592 permanent elevations or temporary meteorological stations in the area of interest (Schaffner and J., 2005). Regarding the accuracy of the data, they test the interpolation for 14 randomly chosen station and the standard deviation of this test is ±1.5ms^(-1). The computed values can underestimate the wind speed but big overestimations, which might be of concern, do not occur. The resolution is 250m x 250m.

In the Alpine area, difficulties to access limit the size of turbines. We consider two different elevation 50m and 70m.

We choose two sample wind turbines with about 800-900 kW rated wind generator (ENERCON, 2014). The power curves of wind energy converters and the technical specification are reported in Table 4.

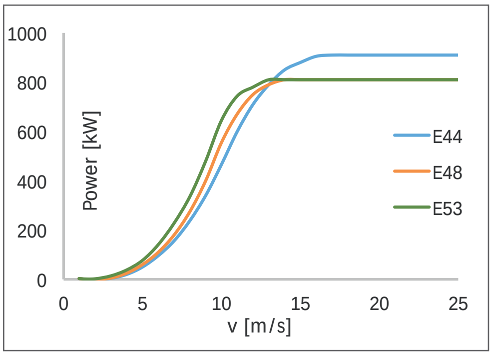


Figure 5: Computed power curve of ENERCON for E44, E48 and E53 wind energy converters.

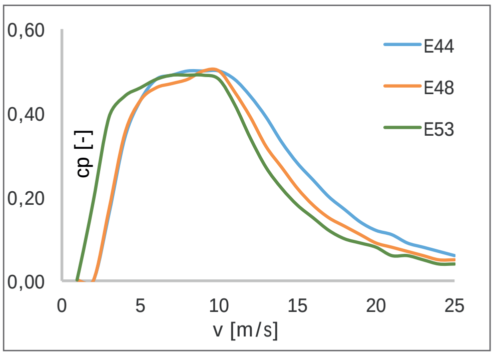


Figure 6: Power coefficient c_p of ENERCON for E44, E48 and E53 wind energy converters.

TABLE 4: TECHNICAL SPECIFICATIONS OF WIND ENERGY CONVERTER

	Rated power [kW]	Rotor diameter [m]	Hub height [m]	Swept area [m²]	Cut-out wind speed [m/s]
E44	900	44	45, 55, 65	1521	28-34
E48	800	48	50, 60, 75, 76	1810	28-34
E53	800	52.9	60, 73, 75	2198	28-34

In Figure 6, we report the power coefficient of the three turbines. The power coefficient c_p is the ratio of power extracted by the turbine to the total available in the air in the absence of actuator disc (Burton, Sharpe, Jenkins and Bossanyi, 2001).

METHODOLOGY

The mean power production for a wind turbine assuming 100 percent availability is equal to:

$$E = \int_0^\infty P(v)\,\varphi(v)\,dv$$

where P(v) is the power curve of a wind turbines and $\varphi(v)$ is the statistical distribution of the wind velocity v.

The shape of the velocity distribution it is very important in order to compute the energy production. We assume a Weibull distribution with shape parameter k equal to 1.5 (Casale, 2009):

$$\varphi(v) = \frac{k}{\lambda^k} v^{k-1} e^{-\left(\frac{v}{\lambda}\right)^k}$$

while the scale parameter λ can be calculated from the following equation:

$$\overline{v} = \lambda\Gamma\left(1 + \frac{1}{k}\right)$$

with Γ gamma function and $\bar{v}$ mean yearly velocity.

The power P(v) of a wind turbine is equal to:

$$(v) = \frac{1}{2} c_p \rho A v^3$$

where c_p is the power coefficient, ρ the air density, A the swept area and v the wind velocity. The power coefficient has a theoretical maximum value of 0.593 (the Betz limit). The wind turbine converts 70% of the Betz limit into electricity. Consequently, the wind turbine converts the 41% of the available wind energy into electricity. In Figure 7, we compare the theoretical potential at various speed with the actual power of E44 wind turbine.

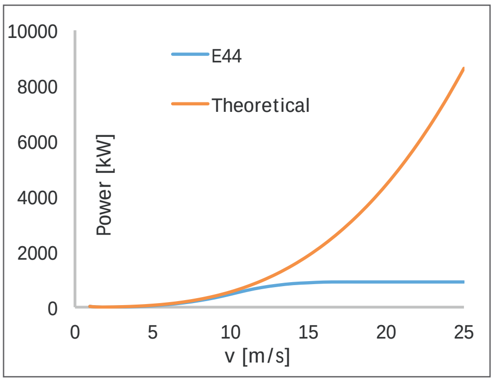


Figure 7: Theoretical vs real power of ENERCON E44

The spacing between turbines is at least 7-8 times the rotor diameter. The resolution of the final map is 350m x 350m (about 7 times the rotor diameter). Such resolution, although being rather low, is suitable for the purposes of the study. In fact, the aim of this map is not to give a tool to compute a detailed analysis, as for example the calculation of the optimum distance among turbines. For this reason, the choice of this map resolution seems to be justified. Available area and logistic questions should be considered in the technical potential.

Notice that it is important to know the operating hours of the wind turbine. We calculate the equivalent operating hours or capacity factor as the rate of the power production to the nominal power of the wind turbine.

RESULTS

The final map refers to the mean value obtained for the three different turbine at different elevation 50m and 70m. In the Attachments, mean potential maps are reported. We obtain three different maps depending on:

- the wind maximum theoretical potential (Betz limit);
- the current potential;
- the turbine equivalent operating hours or capacity factor [hours/year].

The theoretical potential map only considers the Betz limit in agreement with the definition herein reported of theoretical potential (a physical limit), while the second map is obtained by considering the actual power (a technical constrain).

Notice that the higher potential the higher the altitude above the sea level, as shown in Figure 8.

The capacity factor indicates the real efficiency of the wind plant. If we consider only sites with more than 1750 of full load/year (20% of efficiency), we will obtain only the 5.5% of the Alpine territory.

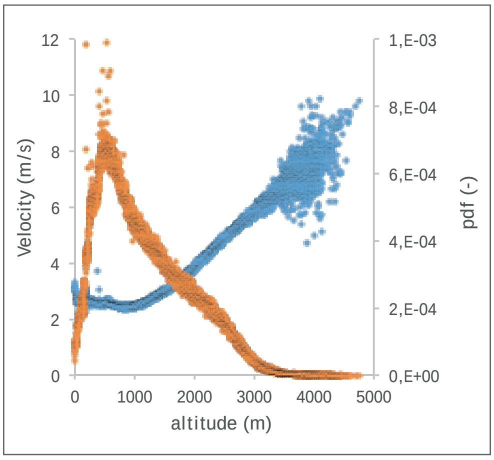
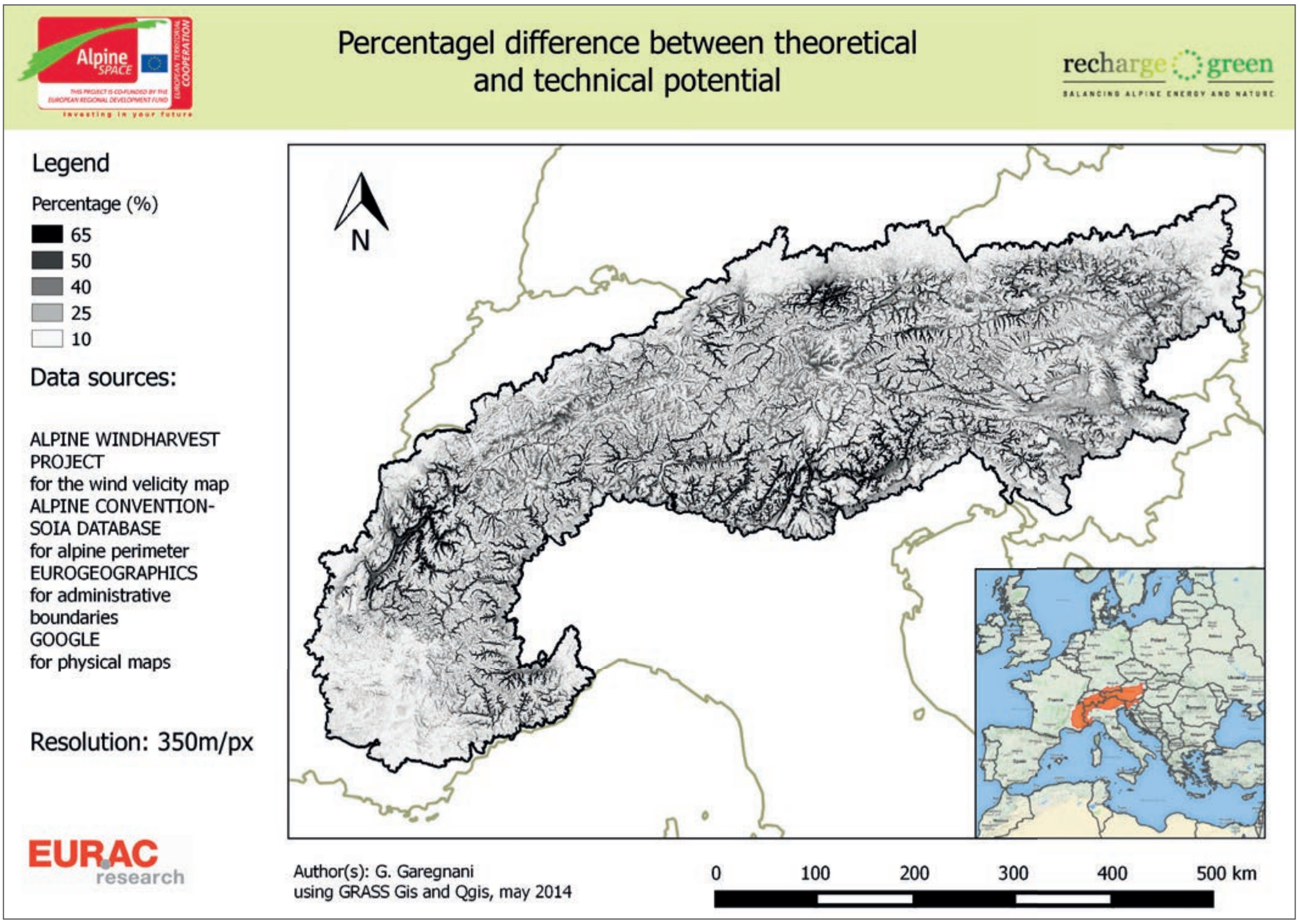
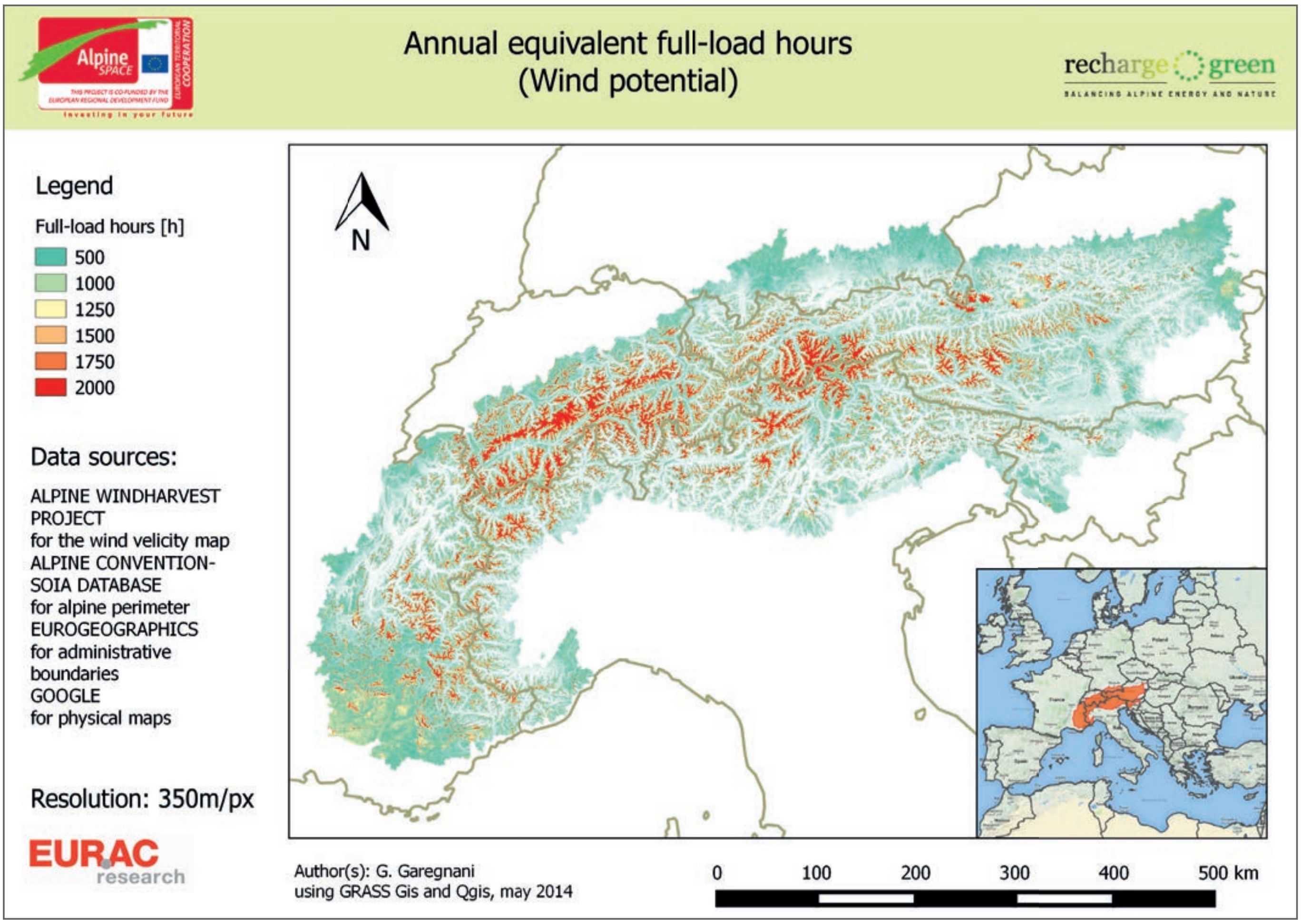


Figure 8: Wind velocity distribution versus altitude distribution.

MAPS


Alpine SPACE
Percentagel difference between theoretical and technical potential
recharge green
BALANCING ALPINE ENERGY AND NATURE
Legend
Percentage (%)
65
50
40
25
10
Data sources:
ALPINE WINDHARVEST PROJECT
for the wind velicity map
ALPINE CONVENTION-SOIA DATABASE
for alpine perimeter
EUROGEOGRAPHICS
for administrative boundaries
GOOGLE
for physical maps
Resolution: 350m/px
N
EURAC research
Author(s): G. Garegnani
using GRASS Gis and Qgis, may 2014
0
100
200
300
400
500 km


Alpine SPACE
Annual equivalent full-load hours (Wind potential)
recharge green
BALANCING ALPINE ENERGY AND NATURE
Legend
Full-load hours [h]
500
1000
1250
1500
1750
2000
Data sources:
ALPINE WINDHARVEST PROJECT
for the wind velicity map
ALPINE CONVENTION-SOIA DATABASE
for alpine perimeter
EUROGEOGRAPHICS
for administrative boundaries
GOOGLE
for physical maps
Resolution: 350m/px
N
EURAC research
Author(s): G. Garegnani
using GRASS Gis and Qgis, may 2014
0
100
200
300
400
500 km

2.4 Photovoltaic

DATA COLLECTION

The data of solar irradiation are provided by the Photovoltaic Geographical Information System (PVGIS). They develop a database for the Europe that allows to compute the solar potential for the Alpine area.

METHODOLOGY

According to European norm EN 15316-4-6 for the solar photovoltaic, the electricity produced by the photovoltaic system is

$$E = E_{sol} \frac{P_{pk}}{I_{ref}} f_{perf}$$

where E_{sol} is the annual solar irradiation on the photovoltaic system, P_{pk}, the peak power, represents the electrical power of a photovoltaic system with a given surface and for a solar irradiance of 1 kW/m^2 on this surface (at 25°C); f_{perf} is the system performance factor; I_{ref} is the reference solar irradiance equal to 1 kW/m^2. With actual technologies, the performance factor f_{perf} can reach value of 0.80 (European norm EN 15316-4-6).
The annual solar irradiation on the photovoltaic module can be calculated as:

$$E_{sol} = E_{sol,hor} f_{tilt}$$

where f_{tilt} is the tilt and orientation conversion factor.
Most solar cells on the market are based on silicon wafers with typical efficiency of 10-15% (P_{pk}=100-150 W$_p$/m^2). Conversion efficiency needs to be increased in the future. According to the aim of the article, the upper theoretical limit has to be considered. The Shockley and Queisser (1961) studies this limit for or a standard solar cell. An optimal cell with a band gap of 1.3 eV is limited by transmission losses of photons to 31% (310 W$_p$/m^2).
According to thermodynamic law, by considering the sun as a black body at 5760 K and a solar cell as another black body at 300 K the conversion efficiency is related to the Carnot efficiency limit, which is nearly 95 % (Green 2002). Notice that the Carnot limit is only a theoretical limit and cannot be built in practice. The large difference between the Shockley-Queisser and thermodynamic (Carnot) limits arises from the fact that a single material is characterized by a single energy gap, whereas the solar spectrum contains photons with a wide range of energies. Several methods have been studied to increase the power conversion efficiency of solar cells and Razykov reviews the future prospect of photovoltaic devices.
In the Table below, we try summarize the theoretical and technical limits and possible future scenarios.

WEB

http://re.jrc.ec.europa.eu/pvgis

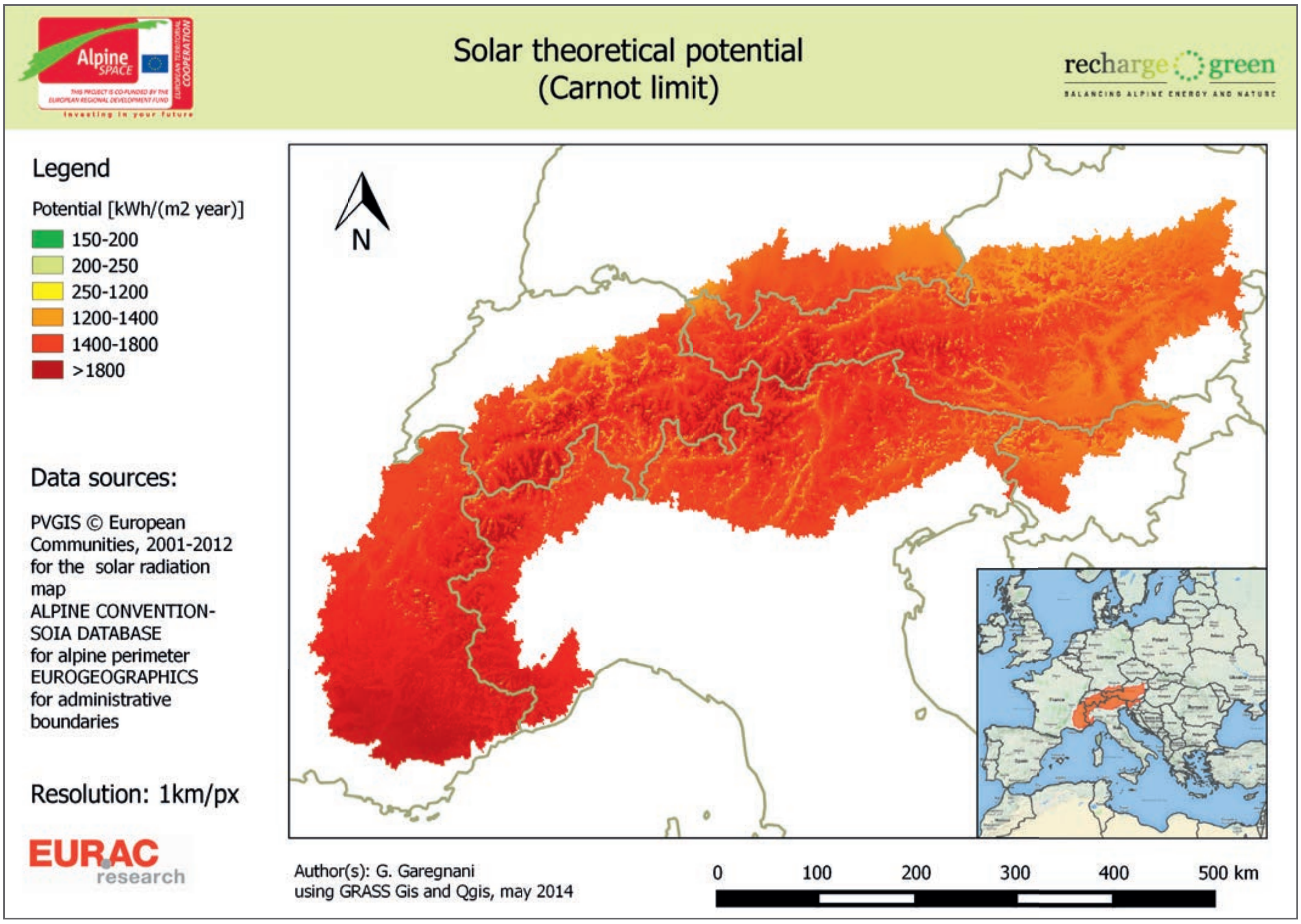
TABLE 5: VALUES OF PEAK POWER COEFFICIENT BY NORMATIVE, THEORETICAL AND FUTURE FORECAST

Type of photovoltaic module	$\frac{P_{pk}}{I_{ref}}$ [–]	f_{perf} [–]
Mono crystalline silicon	0.12 to 0.18	0.8
Multi crystalline silicon	0.10 to 0.16	0.8
Shockley and Queisser limit	0.31	1
Carnot limit	0.95	1

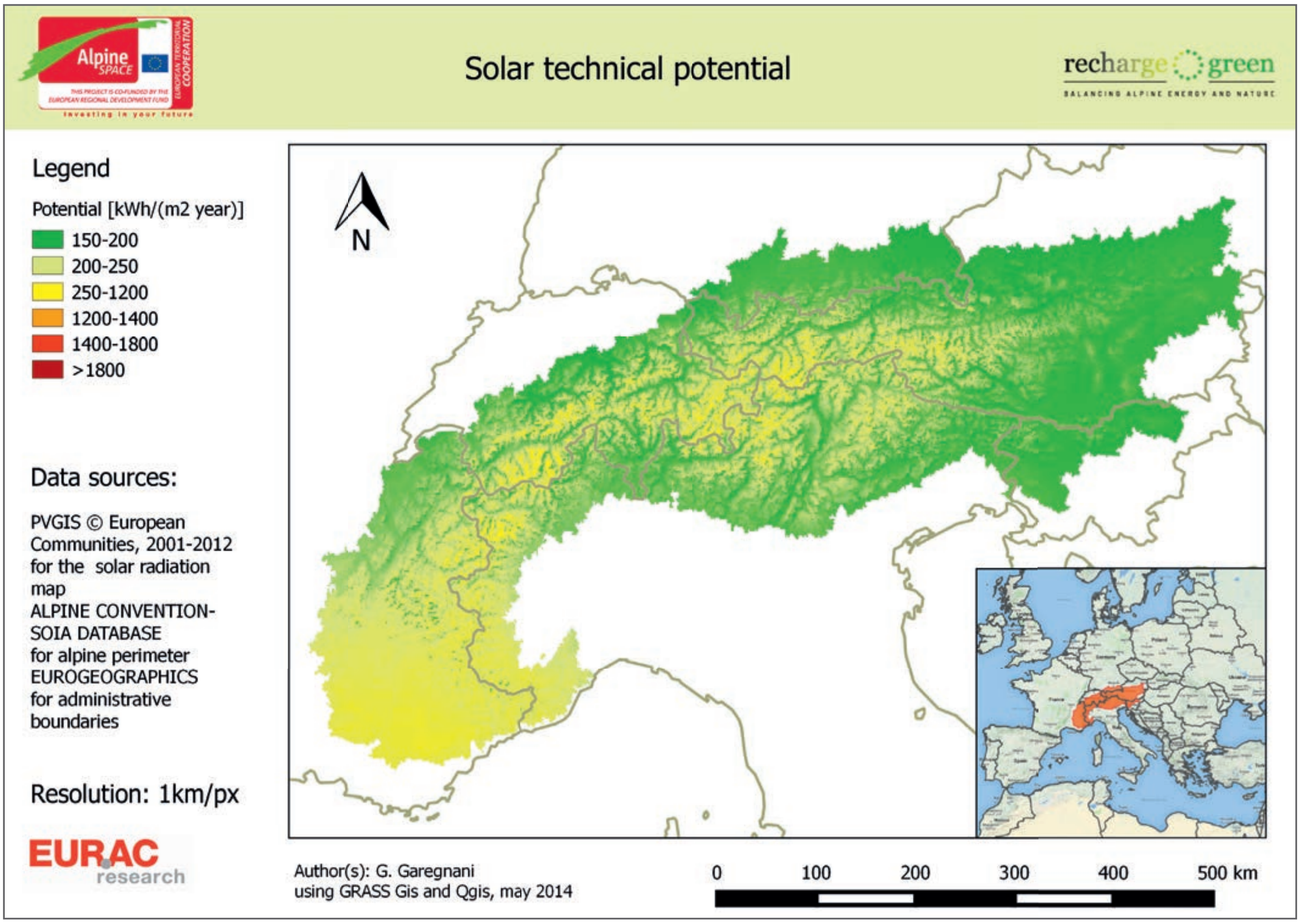
RESULTS

The maps are calculated for both horizontal and optimally-inclined surface. We report the actual potential under the assumption of an efficiency equal to 0.15 and f_perf equal to 0.8 in the case of optimally-inclined surface. Finally, the two limits are considered in order to develop future scenarios. The mean capacity factor of the Alpine area is 14%.

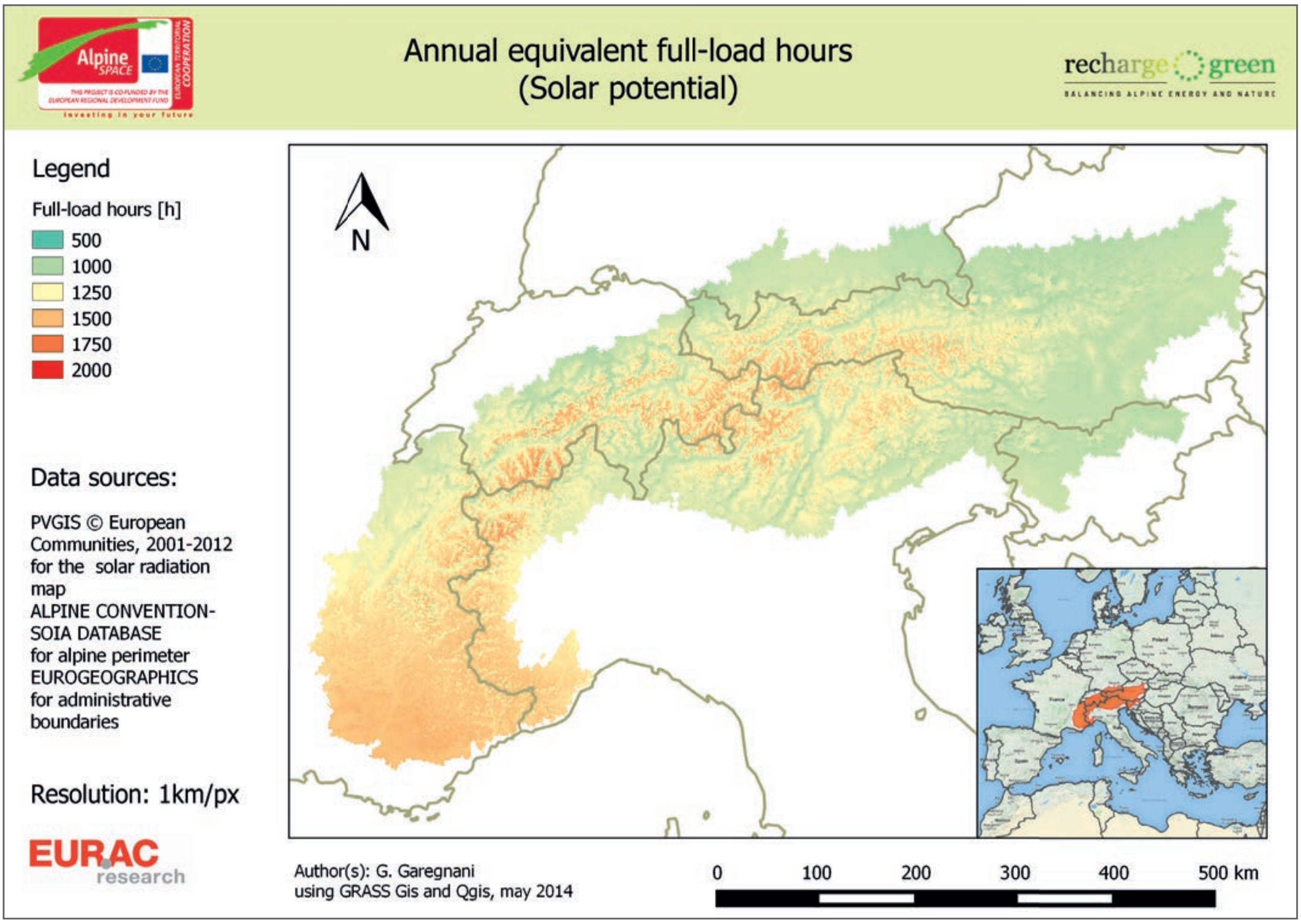
MAPS



Alpine SPACE
THIS PROJECT IS CO-FUNDED BY THE EUROPEAN REGIONAL DEVELOPMENT FUND
EUROPEAN TERRITORIAL COOPERATION
Investing in your future
Solar theoretical potential
(Carnot limit)
recharge green
BALANCING ALPINE ENERGY AND NATURE
Legend
Potential [kWh/(m2 year)]
150-200
200-250
250-1200
1200-1400
1400-1800
>1800
N
Data sources:
PVGIS © European Communities, 2001-2012 for the solar radiation map
ALPINE CONVENTION-SOIA DATABASE for alpine perimeter
EUROGEOGRAPHICS for administrative boundaries
Resolution: 1km/px
EURAC research
Author(s): G. Garegnani
using GRASS Gis and Qgis, may 2014
0
100
200
300
400
500 km



Alpine SPACE
THIS PROJECT IS CO-FUNDED BY THE EUROPEAN REGIONAL DEVELOPMENT FUND
EUROPEAN TERRITORIAL COOPERATION
Investing in your future
Solar technical potential
recharge green
BALANCING ALPINE ENERGY AND NATURE
Legend
Potential [kWh/(m2 year)]
150-200
200-250
250-1200
1200-1400
1400-1800
>1800
N
Data sources:
PVGIS © European Communities, 2001-2012 for the solar radiation map
ALPINE CONVENTION-SOIA DATABASE for alpine perimeter
EUROGEOGRAPHICS for administrative boundaries
Resolution: 1km/px
EURAC research
Author(s): G. Garegnani
using GRASS Gis and Qgis, may 2014
0
100
200
300
400
500 km



INFOBOX

STATUS QUO OF THE ALPINE PRODUCTION FROM RENEWABLE ENERGY

Authors: G. Garegnani, S. Pezzutto, R.Hastik, S. Biscaini, F. Miotello, G. Curetti, D. Vettorato

A right planning of RE exploitation has to start from data collection about the existing production. The recharge.green project aims to study the trade-off between energy exploitation and ecosystem services for the whole Alpine Region and for 4 Pilot Areas. The analysis and the data collection consider both the Alpine area and the Pilot Areas. Obviously, the details reached by the analysis are different.
The actual RE production and consumption in the Alpine area (8 countries) is extremely difficult to gather due to missing spatial explicit data. Data, on other energy sources and energy demand, are easily available only on national scale including non-Alpine areas. For this reason, we collect data based on NUTS3 and NUTS2 units starting from several national and local sources. We mainly consider data from 2009 to 2014 in order to have an estimation of the current situation of the Alpine area. In the following Table, we summarize the main sources for each country and RES.

TABLE 6: SOURCES FOR RES PRODUCTION

COUNTRY	NUTS3	YEAR	NUTS2	YEAR
Hydro power				
Austria	G. Stanzer et al., REGIO Energy Regionale Szenarien erneuerbarer Energie-potenziale in den Jahren 2012/2020	2010	Statistik Austria, Energiebilanzen	2012
Switzerland	Schweizerische Eidgenossenschaft, Statistisches Lexikon	2014	Schweizerische Eidgenossenschaft, Statistisches Lexikon	2014
Germany	Deutsche Gesellschaft für Sonnenenergie, EnergyMap.info	2014	Deutsche Gesellschaft für Sonnen-energie, EnergyMap.info	2014
France	Ministre de l'écologie du développement durable et de l'énergie, observation et statistique	2012	Réseau de transport d'électricité, Bilan électrique 2013 et perspectives, Provence-Alpes Côte-d'Azur Observatoire de l'énergie et des gaz à effet de serre de Rhône-Alpes, 20% de production d'énergie renouvelable dans la consommation d'énergie, 2014	
	2013-2014			
Italy	GSE, Impianti a fonti rinnovabili, 2013	2012	GSE, Quota regionale - settore regionale, 2014	2009
Liechtenstein	Liechtenstein, Aus nationaler Sicht, 2011 Universität Liechtenstein, Erneuerbares Liechtenstein, 2013 S. D'Elia et a., Energiestrategie Liechtenstein 2020, 2012	2010		
Slovenia	Statistical office of the Republic of Slovenia, Renewables and wastes, 2014 National Renewable Energy Action Plan 2010-2020 (Nreap) Slovenia, 2010 ECN, Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, 2011	2010 - 2011		

PV Ground mounted				
Austria	EPIA, Global market outlook, 2014	2014	EPIA, Global market outlook, 2014	2014
Switzerland	EPIA, Global market outlook, 2014	2014	EPIA, Global market outlook, 2014	2014
Germany	Deutsche Gesellschaft für Sonnenenergie, EnergyMap.info, 2014	2014	Deutsche Gesellschaft für Sonnen-energie, EnergyMap.info	2014
France	Ministre de l'écologie du développement durable et de l'énergie, observation et statistique	2012	Réseau de transport d'électricité, Bilan électrique 2013 et perspectives, Provence-Alpes Côte-d'Azur Observatoire de l'énergie et des gaz à effet de serre de Rhône-Alpes, 20% de production d'énergie renouvelable dans la consommation d'énergie, 2014	2013 - 2014
Italy	GSE, Rapporto Statistico 2012 Solare Fotovoltaico, 2012	2011	GSE, Quota regionale - settore regionale, 2014	2009
Liechtenstein	-	2010		
Slovenia	EPIA, Global market outlook, 2014	2010-2011		
Wind power				
Austria	G. Stanzer et al., REGIO Energy Regionale Szenarien erneuerbarer Energie-potenziale in den Jahren 2012/2020, 2010	2010	Source: Statistik Austria, Energiebilanzen, 2012	2012
Switzerland	Bundesamt für Energie, Schweiz, Windkrafta-nalagen,2014	2014	Bundesamt für Ener-gie, Schweiz, Wind-kraftanalagen,2014	2013
Germany	Deutsche Gesellschaft für Sonnenenergie, EnergyMap.info, 2014	2014	Deutsche Gesellschaft für Sonnen-energie, EnergyMap.info	2014
France	Ministre de l'écologie du développement durable et de l'énergie, observation et statistique	2012	Réseau de transport d'électricité, Bilan électrique 2013 et perspectives, Provence-Alpes Côte-d'Azur Observatoire de l'énergie et des gaz à effet de serre de Rhône-Alpes, 20% de production d'énergie renouvelable dans la consommation d'énergie, 2014	2011

Italy	GSE, Impianti a fonti rinnovabili, 2013	2012	GSE, Quota regionale - settore regionale, 2014	2009
Liechtenstein	Liechtenstein, Aus nationaler Sicht, 2011 Universität Liechtenstein, Erneuerbares Liechtenstein, 2013 S. D'Elia et a., Energiestrategie Liechtenstein 2020, 2012	2010		
Slovenia	Statistical office of the Republic of Slovenia, Renewables and wastes, 2014 National Renewable Energy Action Plan 2010-2020 (Nreap) Slovenia, 2010 ECN, Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, 2011	2010 - 2011		
Wood Biomass				
Austria	-	-	Statistik Austria, Energiebilanzen, 2012 http	2010
Switzerland	Amt für Verkehr und Energie, Sachplan Energie, 2002 St. Gallen, Biomasse, 2014 Appenzell Ausserhorn, Energiestrategie 2008-2015, 2008 Kanton Bern, Energiestrategie 2006, 2006 GEO Partner AG, Energieholzpotential-studie AR + AI, 2012 Züricher Hochschule für angewandte Wissenschaften, Energieverbrauch der Schweizer Kantone, 2014 Kanton Glarus, Energierichtplan Kanton Glarus, 2012 Amt für Energie und Verkehr Graubünden, Stromproduktion aus erneuerbaren Energien ohne Grosswasserkraft, 2011	2002 - 2014	BAK Basel Economics, MARS Report 2005, 2005	2004
Germany	Deutsche Gesellschaft für Sonnenenergie, EnergyMap.info, 2014	2014	Deutsche Gesellschaft für Sonnen-energie, EnergyMap.info	2014

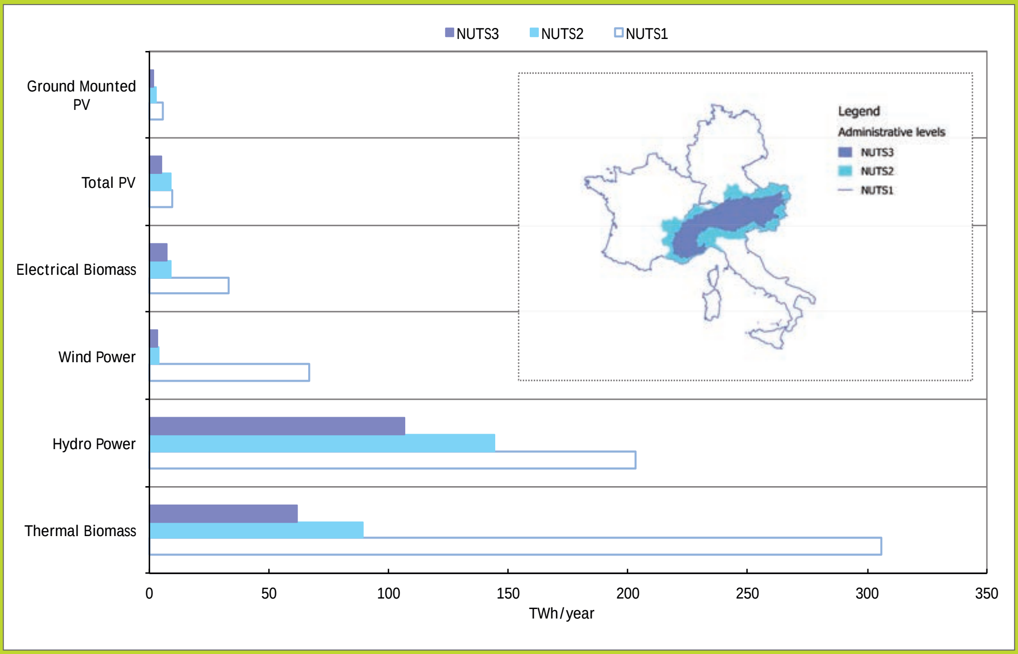
France	Ministre de l'écologie du développement durable et de l'énergie, observation et statistique	2012	Réseau de transport d'électricité, Bilan électrique 2013 et perspectives, Provence-Alpes Côte-d'Azur Observatoire de l'énergie et des gaz à effet de serre de Rhône-Alpes, 20% de production d'énergie renouvelable dans la consommation d'énergie, 2014	2011
Italy	GSE, Impianti a fonti rinnovabili, 2013	2012	GSE, Quota regionale - settore regionale, 2014	2009
Liechtenstein	Liechtenstein, Aus nationaler Sicht, 2011 Universität Liechtenstein, Erneuerbares Liechtenstein, 2013 S. D'Elia et a., Energiestrategie Liechtenstein 2020, 2012	2010		
Slovenia	Statistical office of the Republic of Slovenia, Renewables and wastes, 2014 National Renewable Energy Action Plan 2010-2020 (Nreap) Slovenia, 2010 ECN, Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, 2011	2010 - 2011		

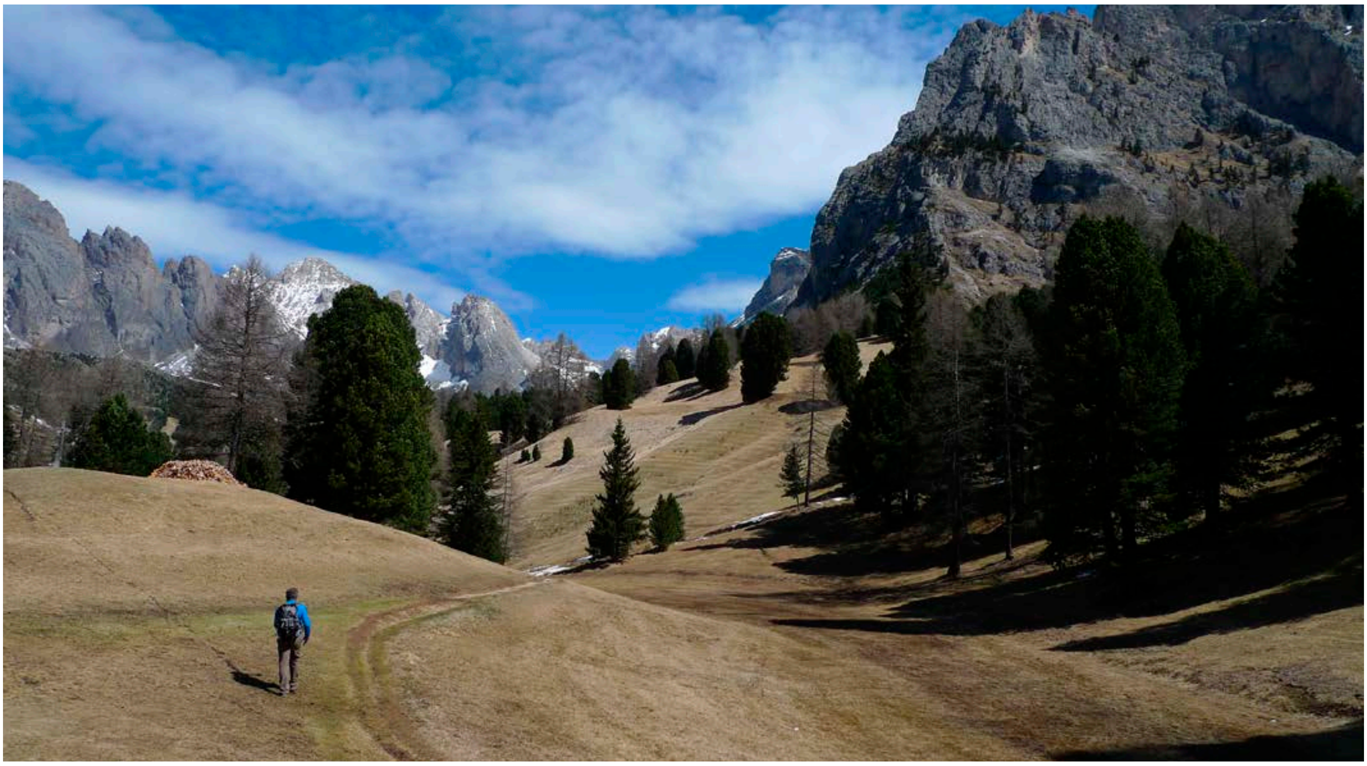
We consider the percentage of ground installed PV in loco (EPIA, Global market outlook 2013), if no data for ground mounted PV were available. French data for solar and hydropower regards the installed power; we compute the production by assuming a value of equivalent working hours from PVGIS © European Union, 2001-2012 for PV and a capacity factor equal to 33.7% for hydropower (Digest of United Kingdom energy statistics (DUKES) 2007-2012).
Data refers to wood biomass, except for Germany where we consider the solid biomass. In Switzerland, several data sources were considered due to the absence of a national database. In Italy and France, data of biomass are available at NUTS2 and NUTS3 levels only for thermal biomass energy; the electrical one is estimated starting from national data. Slovenia only has national data about RES production.
Due the inhomogeneity of data sources in time and space, data are considered as an indication about the current Alpine production to compare with the estimated potential. In Figure 9 we report data about the RES production at different units, in Table 6 data refers to NUT3 units.
Noticed that biomass and hydropower are the most exploited RES in Alpine countries by considering thermal and electrical energy productions. Biomass and hydropower are predominant at both NUTS1 and NUTS3 level.

WEB

http://www.epia.org

Figure 9:
RES production in the Alpine countries (NUTS1) and in the total NUTS2 and NUTS3 unit.





Trade-off and perceived impacts

03

Where land use is the issue, conflicts result from diverging demands on landscape and nature. Moderated governance processes are very important to deal with these conflicts. Stakeholders should be able to expect transparent processes and access to all relevant information, right from the start and throughout a project.

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An important issue in decision-making is public participation of the local communities while making the decisions, so that each form of development will gain much consensus as possible. The participatory approach, also called bottom-up approach, is opposed to the traditional top-down approach (Fraser, Dougill, Mabee, Reed, McAlpine, 2006) through which the power of choosing is concentrated in the hands of few decision-makers. A participatory approach reduces conflicts that may occur when adopting a top-down approach, because the local communities are involved in the decisions and they can voice their need and preferences for the development of their territory. The recharge.green project aims at involving a large number of stakeholders in the whole process, so that each interested stakeholder (or group of stakeholders) may express his opinion regarding RE development.

The activities were organized as follows: (1) EURAC Research and CRA (EURAC's sub-contractor for the project) created the questionnaire; (2) Representatives of the Pilot Areas identified the local experts. The experts were identified considering their proven experience in various sectors of RE and/or ESS. In order to obtain responses unbiased by personal considerations, pilot areas verified the lack of political bindings and the lack of a personal interest in the RE strategy; (3) Questionnaire was administrated to the identified experts by the Pilot Areas; (4) EURAC Research elaborated the questionnaires in order to highlight the relevant indicators for the RE development and for identifying the important group of stakeholders in each Pilot Area; (5) Pilot Areas received the results and derive recommendations for the development of RE in their territory.

The questionnaire survey allowed the collection of important data on the current situation of RE production, on the possible RE to be developed in the Pilot Areas and the most plausible sites for harvesting RE. Furthermore, experts were asked to identify local stakeholders, to be involved in the decision making process. Once the scenarios of RE are produces by the DSS, the stakeholders identified by the experts will be invited to a public session in which the scenarios of RE will be presented and critically analyzed. The public discussion should lead to the identification of a scenario shared by the majority of the stakeholders, so that the decision makers have the information about the desired direction of development of the stakeholders.

The present chapter introduces the main findings of the questionnaire survey, highlighting the responses of the experts of each Pilot Area in order to provide recommendations for the future development of RE. The chapter shows the responses of the experts concerning the sources of RE that should be developed in the territory, the expected impact of each form of RE on the environment and in the society and, finally, the list of stakeholders that should be involved in the final public session.

STAKEHOLDER ANALYSIS: INDICATORS DEEMED RELEVANT

The experts' perception of the negative and positive impacts of renewable energies development in Alpine Region was analyzed through a questionnaire survey. The questionnaire was created and elaborated by EURAC Research, together with its sub-contractor CRA (Agricultural Research Council of Italy). A semi-structured questionnaire - subdivided in 6 thematic sections and composed of 20 questions – was administered to a sample of experts of Alpine Region. The latter was identified in the Pilot Areas involved in the recharge.green project (Alpine Space): Triglav National Park (Slovenia), Mis valley, Maè valley, Maritime Alps Nature Park (Italy), and Leiblachtal (Austria). The experts were selected in each Pilot Area taking into account the following criteria: balancing of expertise between two main fields (renewable energies and ecosystem services), local knowledge and expertise, indirect stake in the recharge.green project. The semi-structured questionnaire was administered through face-to-face interviews to the experts previously identified.

TABLE 7: EXPERTS SUBDIVIDED PER PILOT AREAS

Country	Pilot Region	Number of experts
Austria	Leiblachtal (Vorarlberg Region)	10
Italy	Mis valley (Veneto Region) Maè valley (Veneto Region) Maritime Alps Nature Park (Piedmont Region)	5 6 8
Slovenia	Triglav National Park (...)	13
Total		**42**

Here are shown and discussed the main findings on five main relevant indicators useful for the RE development:

- The sources of RE that can be still harvested in the Pilot Areas;
- The expected impacts of RE use on ESS;
- The expected impacts of RE use on the social sphere and the local economy;
- Perceived risk on the environment and on the society;
- The stakeholder analysis.

The ecological and socio-economic impacts of renewable energies development were evaluated using a 5-point Likert scale (0=very positive impact, 1= positive impact, 2 = no impact, 3 = negative impact, 4 = very negative impact). The perceived risk was evaluated with a 5-point-Likert scale as well, but from 0 (no risk) to 4 (very high risk). Finally, the stakeholder analysis was elaborated through open questions, in which experts had to list the relevant group of stakeholders to be involved into the decision-making and the intensity of the involvement. The stakeholders network was then derived with UCINET 6.504 (Borgatti et al. 2002), a software for the Social Network Analysis.

The results of the aforementioned indicators will be shown separately for each Pilot Area. With regard of the first indicator, experts were asked to express their opinion on the sources of energy that can be developed in the territory, considering the current harvesting typology and the characteristics of the area. Furthermore, the experts also had to indicate the most likely location within the Regions. Based on the interviewer preferences, information on the best location was collected either spatially-explicit (pointing the most suitable sites on a map) or simply indicating the toponyms.

Concerning the impact on ESS, CRA and EURAC developed a list of nine ecosystem services (Table 1) derived from the literature on environmental impacts of renewable energies (IPCC, 2011, Boyle, 2012, Kaltschmitt et al., 2007, Hastik et al., 2014). The ESS were based on the proposal for a common international classification of ecosystem goods and services (CICES) for integrated environmental and economic accounting (Busch et al., 2012). The impacts on ESS were collected separately for each form of RE: forest biomass, wind, solar and hydropower.

A similar approach was implemented in order to capture the impacts of RE production on the local development. These positive and negative impacts were analyzed through three groups of indicators: social, economic and cultural indicators. Nowadays, social indicators are employed to assess both the technological impacts, and the effects of political strategies, interventions or plans. There are various models for the measurement of social impact, which can be employed for the research of social indicators (Wildavsky et al.,1990; Bourdieu, 1987; Hradil, 2005) and the discipline of social indicator research provides a vast list of works on which to base the choice and selection of appropriate indicators (Gallego Carrera and Mack, 2010). Economic indicators track the costs and business aspects of a process; when considering sectors such as renewable energies production, these indicators must go beyond conventional financial reporting to describe the creation of wealth and its distribution and reinvestment for future growth (Marteel et al. 2003). The term cultural indicator is a term developed by Gerbner (1969) and refers to the elements that reflect our culture.

The local culture can influence the rational choices of the people (i.e. political decision makers, managers, members of community) but, conversely, the economic investments and the land use changes can influence in a long-term period the local culture. Consequently, the cultural indicators have the purpose to quantify the potential impacts of an investment on cultural aspects in a specific territory. The authors selected 11 indicators (4 economic indicators, 6 social indicators and 1 cultural indicator) in order to evaluate the impacts of renewable energies production on local development in selected Pilot Areas. The 11 indicators have been described evidencing their impact dimension and the specific ambit of the impact. The ambit of impact of the renewable energies production concerns: i) the impact and the efficiency for the local economy, ii) the impact on the quality of life and on the social stability, involvement and legitimacy, iii) the impact tied to the social risk, iv) the impact on local traditions and values. Table 8 includes a description of each indicator, which differs from the general definition to the specific issues related to renewable energies.

TABLE 8: SOCIO-ECONOMIC IMPACTS ON LOCAL DEVELOPMENT

INDICATOR	AMBIT	DESCRIPTION AND RELATED ISSUES
Economic indicators		
Local market diversification	Local economy	Allocation of resources over a large number of markets in an attempt to reduce risks of concentrating resources and to exploit the economies of flexibility. Willingness to invest in renewable energies to diversify the market. System flexibility to react to market changes and to renewable energies price fluctuations.
Local entrepreneurship	Local economy	Propensity of the local population to initiate business enterprises'. Effects on business opportunities and productive diversification of the area.
Resource efficiency	Local economy	Use of natural resources, with the main purpose of minimising their input when producing a product or delivering a service. Amount of energy production with a less amount of non-renewable resource input.

Social indicators		
Employment of local workforce	Quality of life	Improving the economic development of local community. The installation, operation and maintenance of renewable energy technologies are generally of modest scales, so they create more employment, for the local workforce. Building the technical capacity of the local workforce.
Increasing income per capita	Quality of life	Income per capita is a positive variable of social welfare, and is often an effect of technical progress. Payments to local farmers for hiring their land and ‘‘compensations’’ to the local community made by the owner of the renewable energy plant.
Tourism	Quality of life	Renewable energies development creates changes in the area and effects on tourism development. Attractiveness of the area for visitors is an indicator of social development.
Social and community aggregation	Social stability, involvement and legitimacy	Effects on the capacity to improve local people participation (i.e social and political empowerment, participative decision-making, participatory integrated assessment) Effect on social capital and on community capacity-building
Political stability	Social stability, involvement and legitimacy	Citizens' acceptance of the system or, in other words, the potential of conflicts induced by energy systems, and the citizens participation in the decision making process.
Human health	Health and safety	Health hazards for the local population linked to the renewable energies production (potential health impact due to severe accidents; health consequences of normal operations).
Cultural indicators		
Property rights and rights of use	Local traditions and values	Land and resource tenure, dependencies on foreign sources (e.g. financial investments, knowledge), customary rights.

Source: Adams et al. (2011), Björklund (2000), Brukmajster et al. (2007), Buchholz et al. (2009), Coffey and Polese (1984), Del Río and Burguillo (2008), Eppink et al. (2004), Hampel et al. (2005), Jiang Jiang et al. (2009), Gallego Carrera and Mack (2010), Nguyen (2007), Olusoga (1993), Richards (2008), Sala and Castellani (2011), Wilkens and Schmuck (2012)

The data of impacts renewable energies production on the local development were collected in three of four Pilot Areas. The experts of Leiblachtal area in Austria have not answered to this section of the questionnaire.

Collecting information on the perceived risk in the Pilot Areas is important in order to understand how interested people perceive the implementation of development strategies. Typically, low risk levels are connected with a higher social acceptance.

Finally, information on the stakeholders to be involved in the participatory process and the structure of the social network were collected in the last part of the questionnaire through open-ended questions. There were 2 questions for this purpose. The former asked the respondents to list the stakeholders or group of stakeholders to be involved in the process of RE development, together with their perceived importance of each stakeholder. The latter aimed at identifying the intensity of the stakeholders' involvement (active involvement in the decision process or passive, i.e. stakeholder to be just informed of the project).

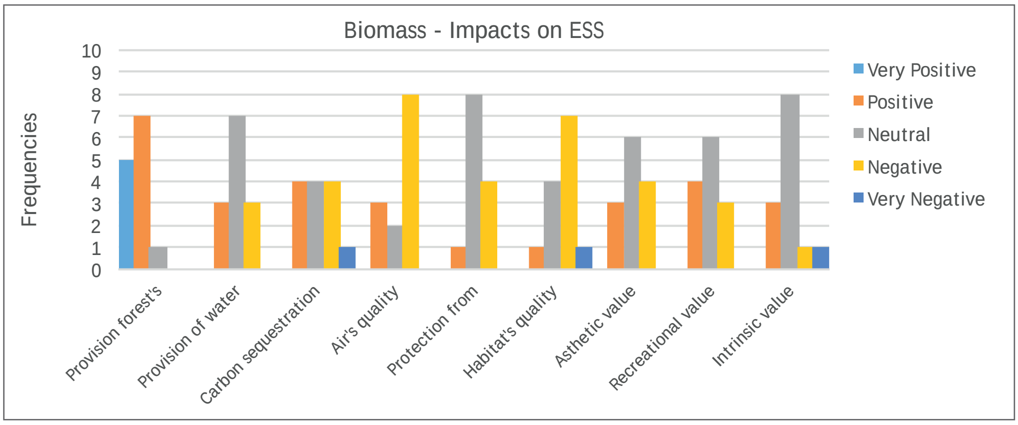
3.1 Analysis of the questionnaires and recommendations for possible future policy pathway

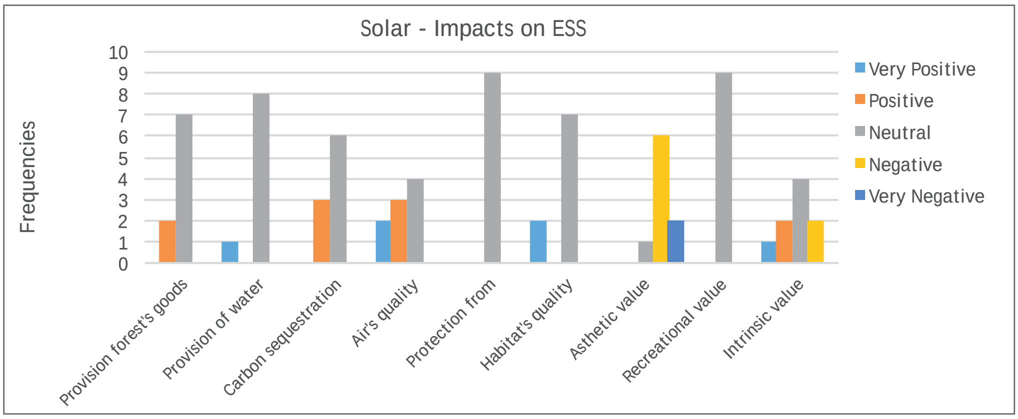
This part shows the results of the questionnaire in each Pilot Area that are an analysis of the experts' opinions (in particular preferences and perceptions) on the development of renewable energies technologies (solar, wind, hydropower and forest biomass). The structure of the questionnaire is reported at the end of the Chapter. The data about the impacts of renewable energies on the ESS were collected on a 5-point Likert scale (from very negative impact to very positive impact).

3.1.1 Leiblachtal

In the results of the questionnaire survey, forest biomass is supposed to increase the provision of forest and agricultural products, but decrease the air and habitat quality. Forest biomass has perceived neutral impacts in the majority of the considered ESS. The solar power would have a positive impact on carbon sequestration and air quality, but would have negative impacts on aesthetic value. A better representation of the impacts is available in Figures 10 a and b.

Figures 10 a and b: Expected impacts on ESS according to experts' perceptions in Leiblachtal (wind and hydropower were not considered by the interviewed experts).





The state of Vorarlberg (Austria), partner of the project, has developed a personal guideline for the development of its territory (see the INFOBOX below), including Leiblachtal.

THE PARTICIPATORY APPROACH OF VORARLBERG

Together with the spatial-economic approach, the state of Vorarlberg pursuits an innovative, participatory approach to reconcile strategies on renewable energies (Vorarlberger Landesregierung 2010). This strategy includes the definition of specific goals on how to reach energy autonomy by 2050. Within various stakeholder meetings, the partners UIBK and region-V are currently developing a method called "sample hectares" to reveal most urgent conflicts and priorities for expanding renewable energies. As this method is strongly linked to WP6 a detailed documentation will be given at the end of that work package but a summary of the results is reported in Figure 11. An already conducted workshop and various interviews hold in the Pilot Area of Leiblachtal revealed that stakeholders are aware of the negative impacts on Ecosystem Services caused by expanding renewable energies. Nevertheless, most of the stakeholders interviewed are willing to accept these impacts particularly because of: a) a secure and autonomous provision of energy, b) support of the local economy, c) possibilities for new governance approaches and d) the possibility to present themselves as best-practice Region. This is true for wind and biomass, but not ground-mounted photovoltaic where most stakeholders prefer to use photovoltaic only on buildings only.

Scenario Wind Energy	++	+	=	-	--	
Recreational value	0	1	4	12	2	
Aesthetical value	0	3	5	7	4	
Prov. Forest/Agriculture	1	1	16	0	0	
Natural hazards prot.	1	0	17	1	0	
Fresh water provision	1	0	16	1	0	
Carbon sequ./climate reg.	1	2	15	1	0	
Habitat quality, Biodiversity	0	1	11	7	0	
Desirable?	yes					no
	8	5	4	1	1	0

Scenario Biomass	++	+	=	-	--	
Recreational value	0	2	5	5	7	
Aesthetical value	0	4	5	4	6	
Prov. Forest/Agriculture	9	9	0	1	0	
Natural hazards prot.	0	4	4	7	4	
Fresh water provision	0	0	8	7	4	
Carbon sequ./climate reg.	0	2	5	8	4	
Habitat quality, Biodiversity	0	1	4	7	7	
Desirable?	yes					no
	8	4	3	2	1	1

Scenario Photovoltaik	++	+	=	-		
Recreational value	0	0	0	8	11	
Aesthetical value	0	0	0	6	13	
Prov. Forest/Agriculture	0	0	0	5	14	
Natural hazards prot.	0	0	7	6	5	
Fresh water provision	1	1	8	4	5	
Carbon sequ./climate reg.	0	1	5	6	6	
Habitat quality, Biodiversity	1	4	1	6	7	
Desirable?	yes					no
	1	2	3	2	4	7

Figure 11: Results of Ecosystem Service ranking from ++ ("very positive change") to – – ("very negative change") by stakeholders (n=19) in the Leiblachtal based on the sample hectares approach and three scenarios (wind, forest biomass and ground mounted photovoltaic).

3.1.2 *Triglav National Park*

Triglav National Park (TNP) interviewed 13 experts belonging to different branches as environmental protection, agriculture, forestry, tourism and energy. They provided us different views about the important themes of renewable energy potential and impacts. The interviews are not enough to claim a good representativeness of the population, but they give us an insight on possible influences of RE use on ESS according experts' perception.

The qualitative analyses of the impacts on ecosystem services, society and economy were carried out both in case of "high"/"very high" and "low"/"very low" potential renewable energies, so to collect more feedback on the perception of people (experts in this specific case). In TNP building facilities for use of energy from wind, solar and hydro have legal constrains (Triglav National Park Act). It is prohibited to build new facilities or put up the device for the production of energy outside the villages, except from renewable sources for the subsistence needs, where there is no possibility to connect to the public power grid. The use of renewable energy that are environmentally and nature acceptable and accessible locally (wood biomass, solar, geothermal and wind energy) is in TNP limited and intended only for the supply of individual objects. There are 39 small hydro power plants with a concession in TNP area that produce energy for commercial use (NUTNP, 2014). Nevertheless, experts identified also the potential development of hydro, solar and wind renewable energy sources in TNP.

The most important RE source in TNP is forest biomass (Figure 12). Almost 60% of the park is covered by forest and most of the forests are highly productive. It was used in the past as technical wood and source for the ironworks. Today wood cutting is mostly for technical wood and source of energy (forest biomass) for private households (Figure 13). The demands for forest biomass as energy source is growing. The potential is high (high productive forests, increasing forest stock) and it represents opportunities for income for the forest owners. On the other hand, oversized exploitation might represent a threat for biodiversity and sustainable use of forests (Poljanec & Pisek, 2013).

Figure 12: Current forest biomass cut in TNP (SFS data 2012).

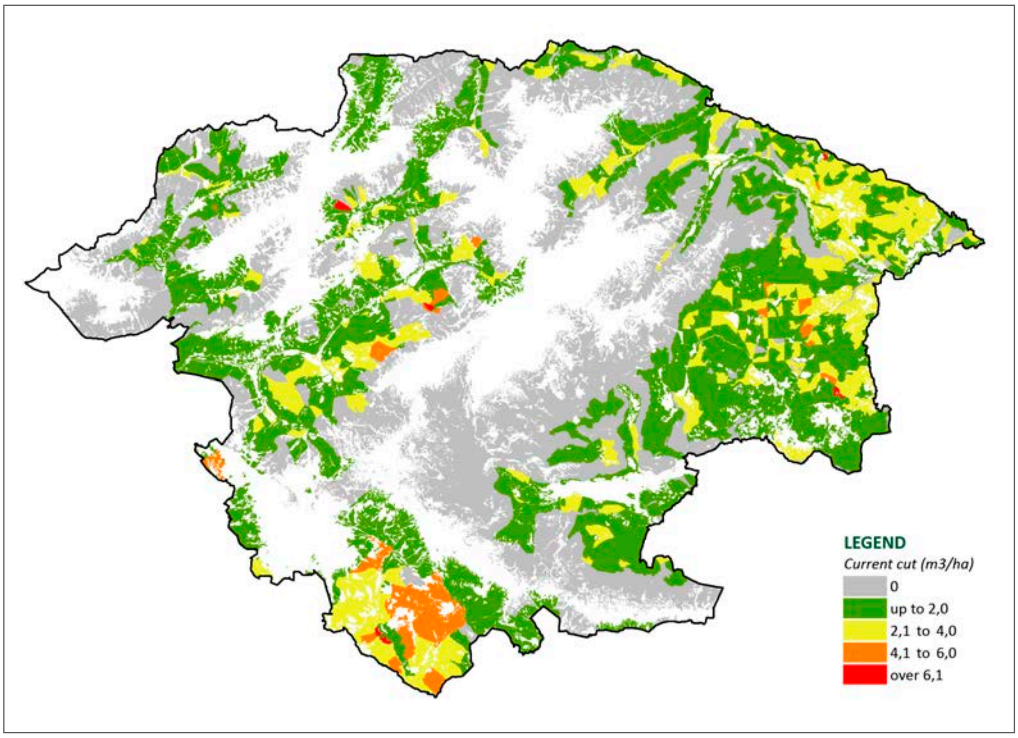
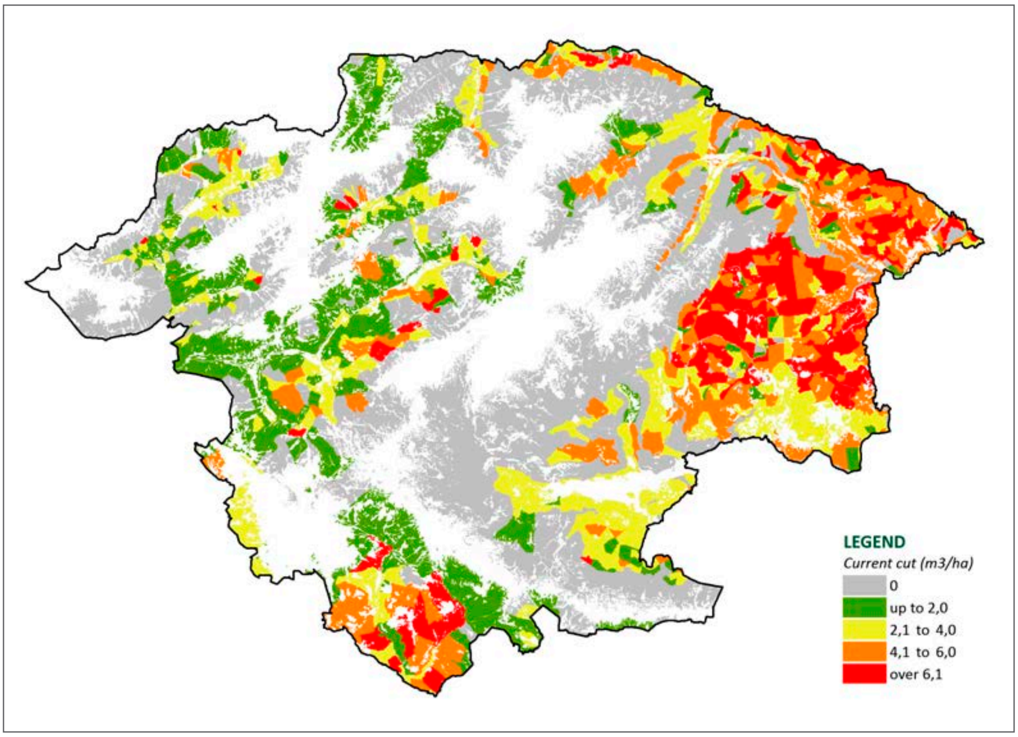
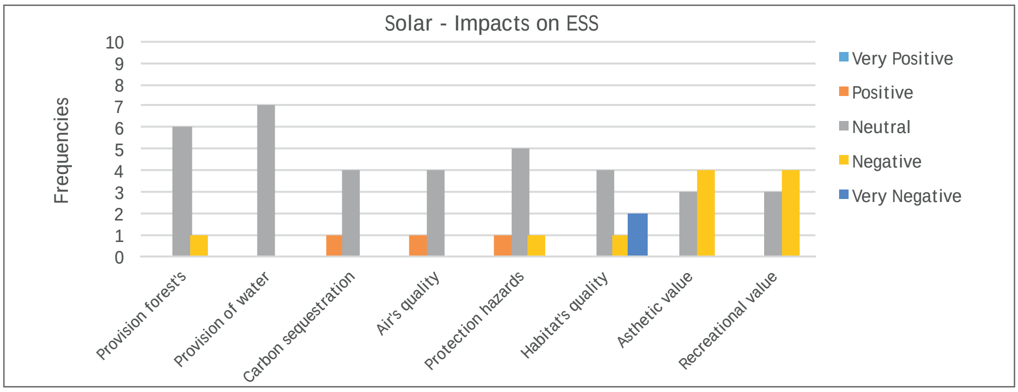


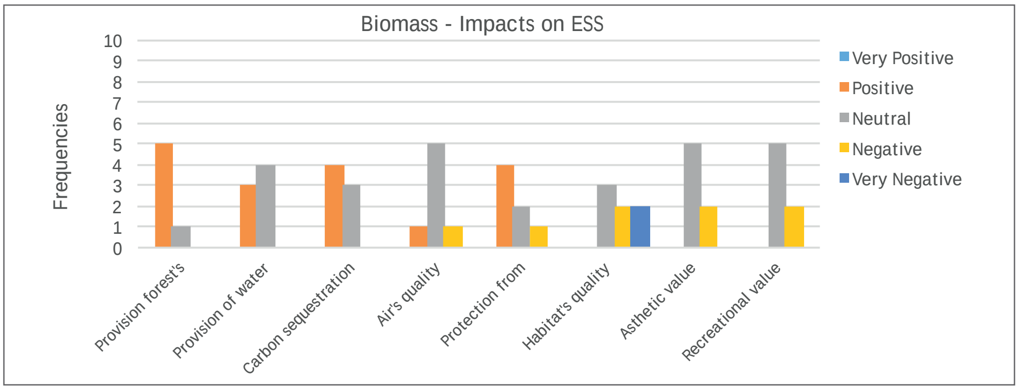
Figure 13: Current cut of wood in TNP for technical wood and biomass together (SFS data 2012).

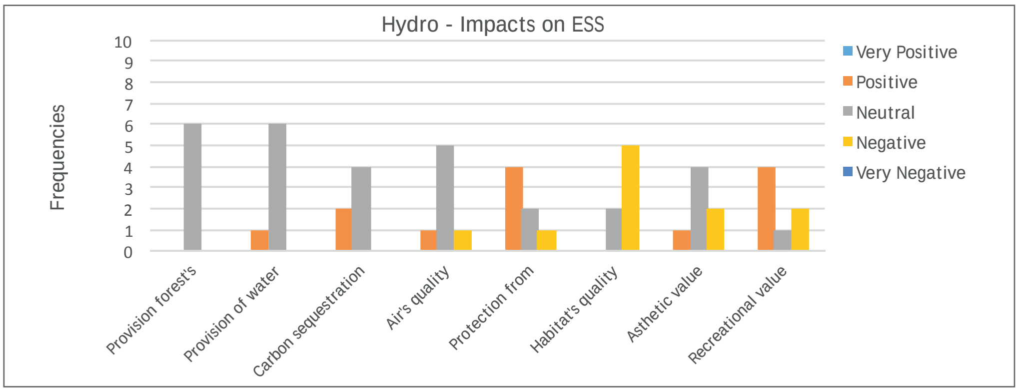


For qualitative analyses of the impacts on chosen categories of ESS, experts gave a scale of evaluation ranges from "very positive" impact to "very negative" impact (Figures 14 a, b, and c). Concerning ESS, solar energy is mostly perceived as a source with negative impacts on habitat quality, recreational and aesthetic value. Hydropower has negative impact on habitat quality; instead has a positive impact on protection from hazards and recreational value. The impacts of forest biomass use are positive for provisioning of goods, carbon sequestration and protection from hazards, since agricultural areas have been overgrowing with forest and forest biomass use is a tool for preserving cultural landscape. On the other hand, the use of forest biomass is perceived as negative above all for habitat quality. The experts stressed out that removing the wood residues from TNP forests has the negative effects on saproxylic insects and other deadwood-dependent organisms. Forest biomass harvesting can have positive effects on biodiversity, but harvesting effects and deadwood removal can also produce negative effects on habitat (Grilli et al, 2014).

TNP focuses mostly on biomass, because of several difficulties of implementing the other sources of RE (most of them related to the legal constrains that make their development a very hard task). For that reason expected impacts of wind power on ESS was not evaluated according by experts.



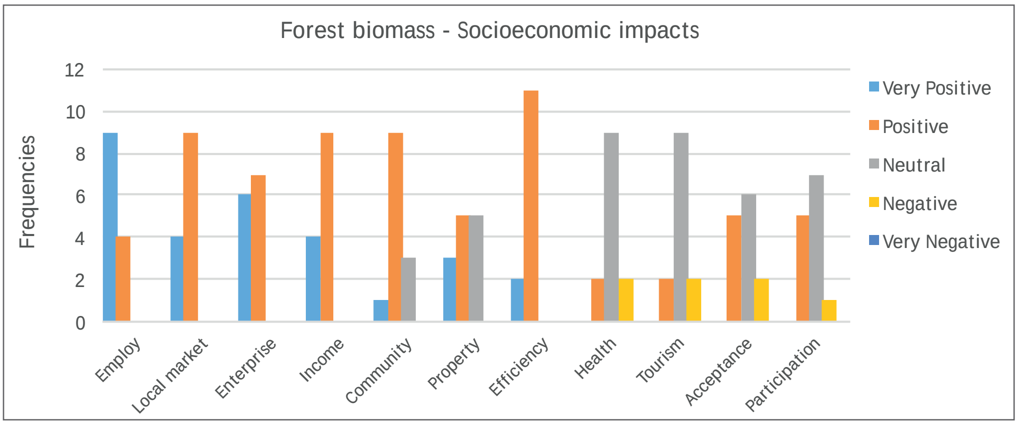




Figures 14 a, b and c: Expected impacts on ESS according to experts' perceptions in TNP. Wind power was not considered due to legal constrains.

The experts were also asked to evaluate the impact of RE on different socio-economic factors. The ranked impact from very positive to very negative. In Figure 15 we present only impact of forest biomass on socio-economic factors as percept by experts. In average, forest biomass use has positive or neutral impacts on socio-economic factors. Two experts gave a negative value for human health since injuries at work in forest are possible and on waste management due to ash residue. Some negative comments were also registered for tourism, system's acceptance and citizen's participation, but almost all the answers were positive.

Figure 15: Expected impacts of biomass use on the society according to experts' perceptions in TNP.



Experts were required to identify organizations and associations to be involved during the definition of the renewable energies systems development (scenario definition) of the Pilot Areas. The experts identified 31 stakeholders belonging to governments, associations, municipalities, scientific/environmental organisations, NGO's, forest companies, etc. (Table 9).

TABLE 9: STAKEHOLDERS IDENTIFIED BY THE EXPERTS IN TNP

Name of stakeholder	Category
Public institution of Triglav National Park (TNP)	Public body
Slovenia Forest Service	Public body
University of Ljubljana	Public body
Association of forest owners	Private organization
Municipality of Bohinj	Public body
Institute of the Republic of Slovenia for Nature Conservation	Public body
Agrarian community Dovje Mojstrana	Private organization
Company EL-TEC Mulej (Society for Energy and Environmental Solutions)	Private organization
Agricultural/Forest Cooperative	Association-NGO
Ministry of agriculture and the environment	Public body
Forest company GG Bled	Private organization
DOPPS - Birdlife Slovenia	Association-NGO
Slovenian Environment Agency	Public body
CIPRA Slovenia	Association-NGO

Name of stakeholder	Category
Slovenian Forestry Institute	Public body
Bled-Tourist Association	Private organization
Alpine Association of Slovenia	Association-NGO
Institute for the protection of Cultural Heritage of Slovenia	Public body
LEAG - Local Energy Agency of Gorenjska	Public body
Fisheries Research Institute of Slovenia	Public body
Municipality of Gorje	Public body
Municipality of Kranjska Gora	Public body
Municipality of Bled	Public body
GOLEA - Goriška Local Energy Agency	Public body
Chamber of Commerce and Industry of Slovenia	Association
RAGOR - Upper Gorenjska development Agency	Private organization
Regional Development Agency of Gorenjska	Public body
Association of hoteliers	Private organization
Archdiocese of Ljubljana	Church association
Company Lip Bohinj d.o.o.	Private organization
Machine club Bled	Private organization

Experts also identify the level of involvement of the stakeholders (department, association, institution, etc.). Most often identified stakeholders were: the public institution of the TNP (9 experts), the Slovenia Forest Service (8 experts) and Biotechnical Faculty at University of Ljubljana (7 experts) (Figure 16). Most of the experts identified only few stakeholders.

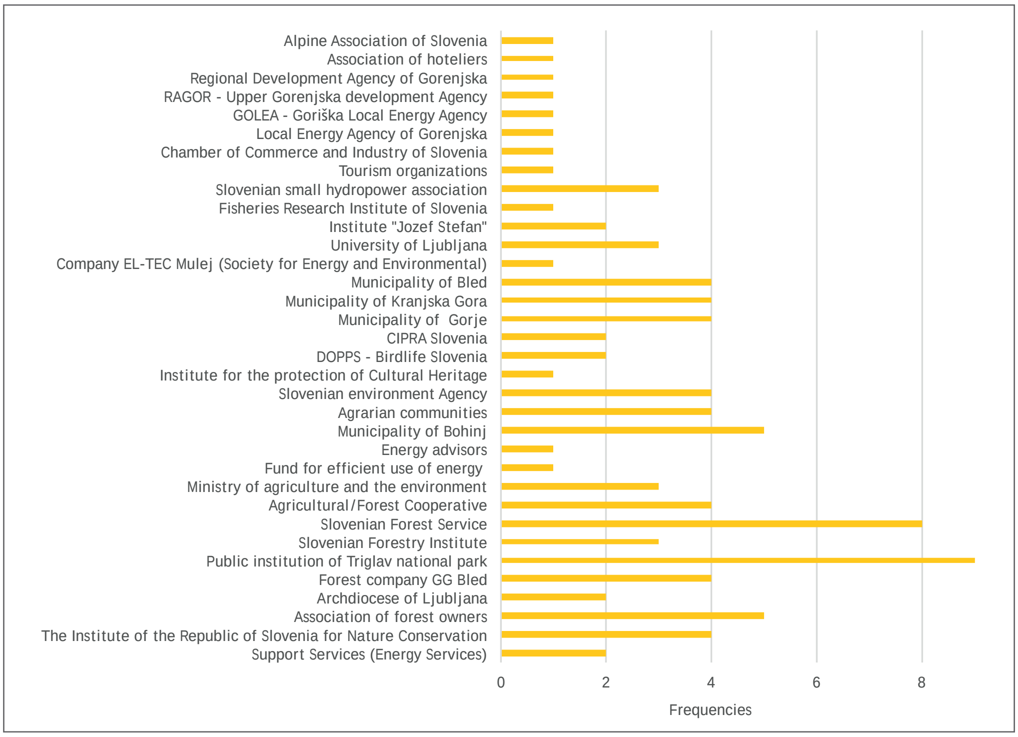
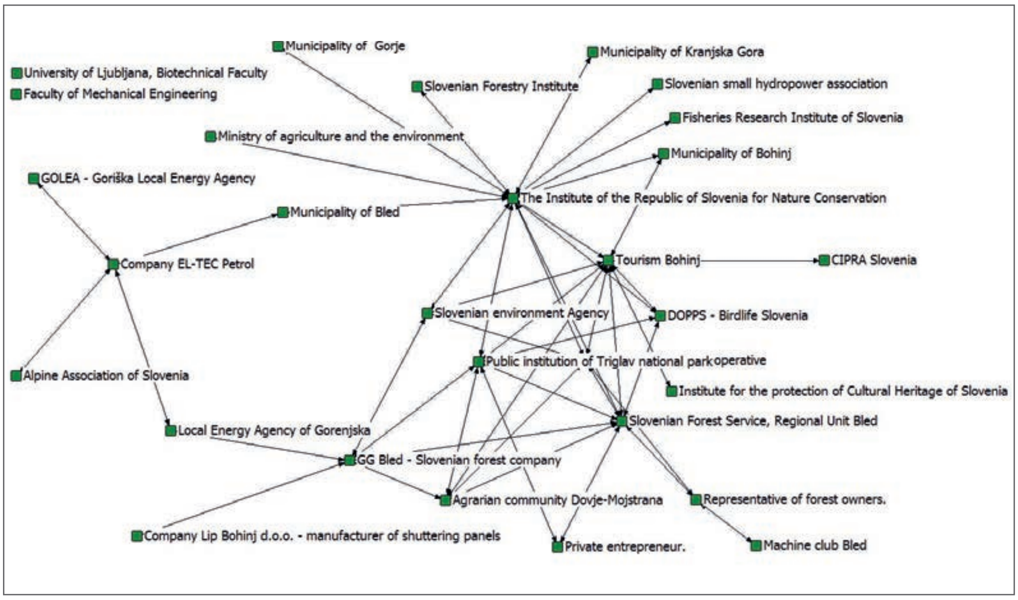


Figure 16: Frequency for stakeholders by experts in TNP.

The Social Network Analysis (SNA) shows which are the key stakeholders from those indicated by experts. Two ego-network features were used; i.e. ego degree centrality and ego network betweenness to classify the stakeholders in the TNP into three categories: key stakeholders, primary stakeholders and secondary stakeholders (Grilli et al in press). The stakeholder with the highest value is the Institute of the Republic of Slovenia for Nature Conservation. Observing the sociogram of stakeholders (Figure 17) we can see that this stakeholder is a “bridge” between the rest of the network. The classification of stakeholders on the basis of the index of importance gives 8 key stakeholders: Institute of the Republic of Slovenia for Nature Conservation, Bled-Tourist Association, Forest company GG Bled, Slovenia Forest Service, Company EL-TEC Mulej, Agricultural/Forest Cooperative, Public institution of Triglav National Park (TNP) and Slovenian Environment Agency (Grilli et al. in press).

Figure 17: Social network of TNP’s stakeholders.



3.1.3 Gesso and Vermenagna Valleys

Concerning the Pilot Area Gesso and Vermenagna basins, EURAC interviewed 8 experts. Experts belonging to different branches as hydraulics, forest management, environmental protection and have assured different point of views about the important theme of renewable energy potential and impacts. The qualitative analyses of the impacts on ecosystem services, society and economy were carried out both in case of "high"/"very high" and "low"/"very low" potential renewable energies, so to collect more feedback on the perception of people (experts in this specific case). Starting from the evaluation of the current use of renewable energy in the basin, experts identified the potential development of each source. The questionnaire survey highlights that only hydropower (> 1 MW) has been widely developed in the study area. The reason of this result is represented by the presence of ENEL power plants in Entracque and Andonno, as showed in Figure 18.

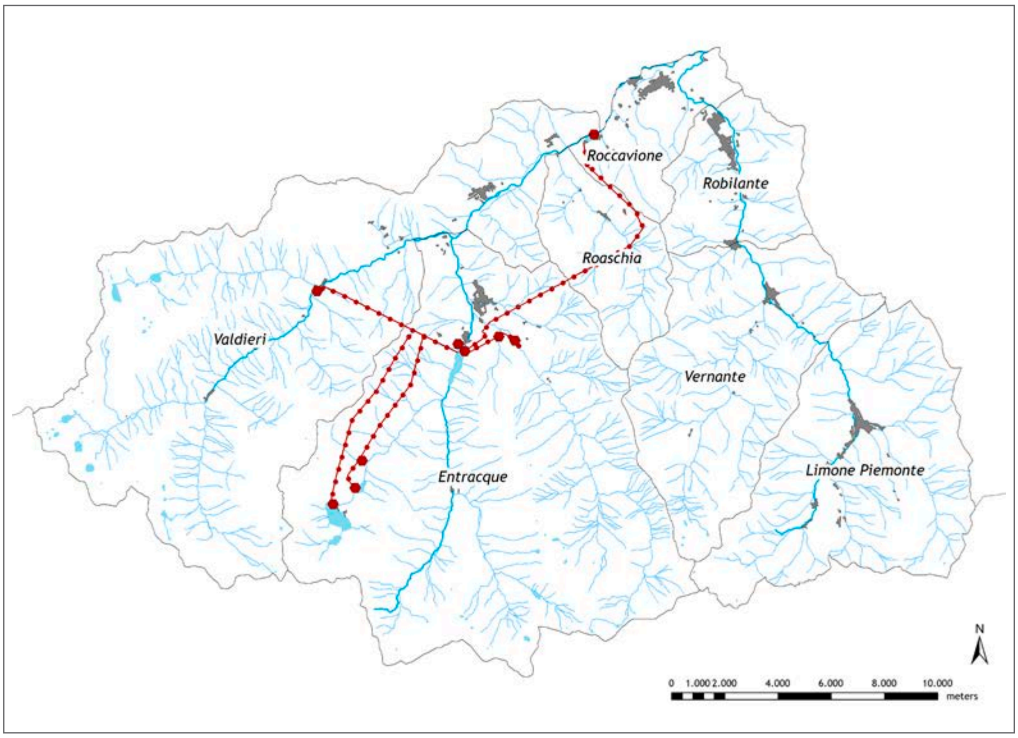


Figure 18: Scheme of NEL Power Plants (in red).

Several hydropower plants of medium size (up to 1 MW) are already installed in the study area. Other exploitable sites fall into the Alpi Marittime Natural Park (PNAM), so according to the experts additional hydro plants are not likely to be installed. The realization of these systems would lead to an impact on natural ecosystems that is not acceptable within a protected area.

Experts underlined that a possible solution to have further use of water to produce energy could be represented by hydropower in aqueducts or existing check dams, to minimize impacts and take advantage of existing structures.

Solar and wind energy were excluded as suitable sources in the area, mainly for the following reasons. Related to wind energy, it was remarked the complexity of this kind of installation in the area, due to the morphology and the visual impact. As regard solar energy, the main reasons that were stressed as an obstacle to these typologies of power plants are the soil consumption joined to the visual impacts they would have on landscape.

The final analysis showed that the renewable energy source that could have a potential development in the area is forest biomass only, a source that is abundant and available, as underlined by the most of the experts. In Gesso and Vermenagna Valleys, the utilization of forest biomass was abandoned during the years '70-'80 and '90. The use of fossil fuels and the depopulation of the valleys has led to a considerable increase in the forested surface. Many agricultural lands are now invaded by the forest. However, the situation has changed during the last 10 years. The energetic use of forest biomass was again re-evaluated and forest management is resumed. Currently, the cuts affect mainly public forests and the main assortment is fuel wood. The beech forests are the most used for the production of fuel wood. Public-owned forest has recently been subjected to forest planning (Forest Assessment Plan of Natural Park of Maritime Alps and Forest Assessment Plan of Maritime Alps Mountain Community). Today forest biomass for energy purposes is mainly used by residents as a source of energy to power small household systems (working mainly with fuel wood). Currently there are no power plants of medium size (100-200 kW) for the heat production and electricity using wood chips. In the next future some public-private initiatives are planned for the construction of some facilities of this type.

A key point that was stressed during interviews was that is important to manage forests, and the use of wood for biomass could represent an opportunity to combine the recovery of open areas – that is important also in a landscape point of view – with the management of growing forest. This should be done giving attention to save some typologies, as maple-ashes (priority habitat for Nature 2000 Network, code 9180), to preserve biodiversity. The qualitative analysis of impacts on ecosystem services and social and economic aspects can be summarised as follows. Concerning ecosystem services, the overall evaluation reveals how experts do not agree about the impacts of the forest biomass use on ESS. The scale of evaluation ranges always from "very positive" to "very negative" impacts.

As it is possible to note from Figure 19, biomass is considered to have neutral effects for the provision of water and water quality; but it can have a negative impact on touristic and recreational services. The photovoltaic appears to be the renewable energy source with the most negative impacts on ecosystem services. This type of power plant seems to impact on almost all ecosystem services, with the exception of air quality and availability of water. The wind energy is considered having neutral impacts on ecosystem services, unless producing negative effects on habitat quality, aesthetic and intrinsic values.

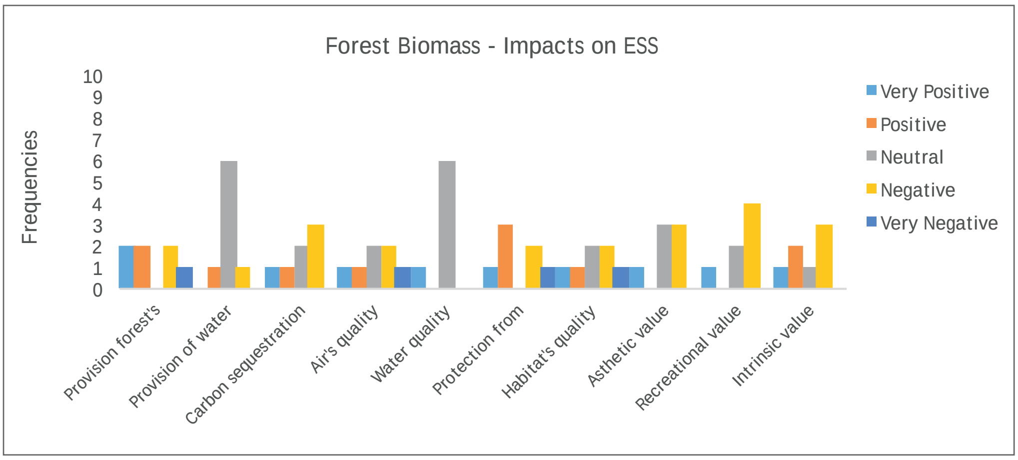
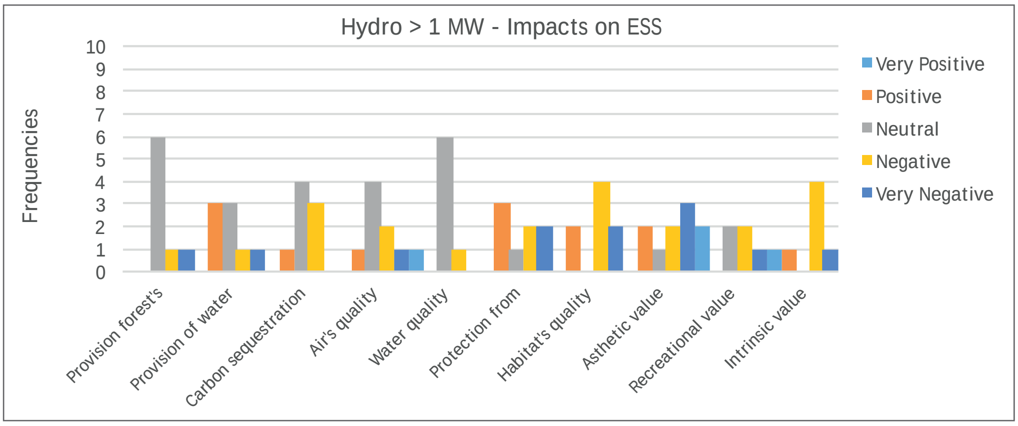
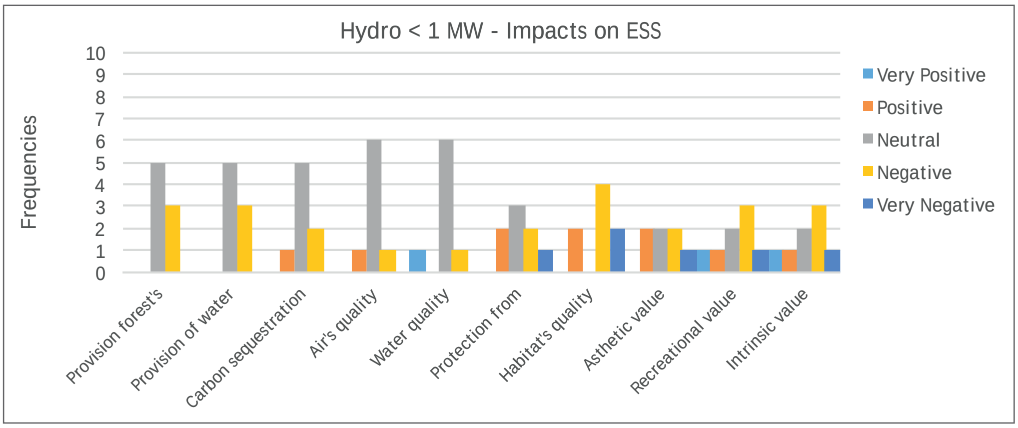
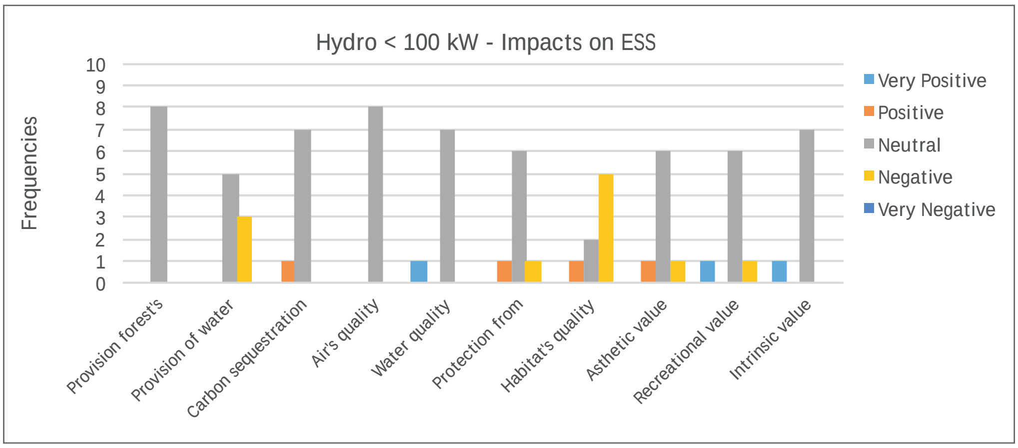


Figure 19: Expected impacts of forest biomass use on ESS according to experts' perceptions in Gesso and Vermenagna Valleys.

Hydropower appears to have an overall negative impact on the ESS, decreasing depending on the plants power (from > 1 MW to < 100 kW), as showed in the Figures below.







Figures 20 a, b and c: Expected impacts of different kind of hydropower on ESS in Gesso and Vermenagna Valleys.

The hydropower plants with low power (< 100 kW) have neutral and positive impacts on the social development, especially on local enterprise, local income and efficiency in the use of resources. These plants have always a positive impact on society and appear to be the most viable source to be developed within the study area (Figure 21).

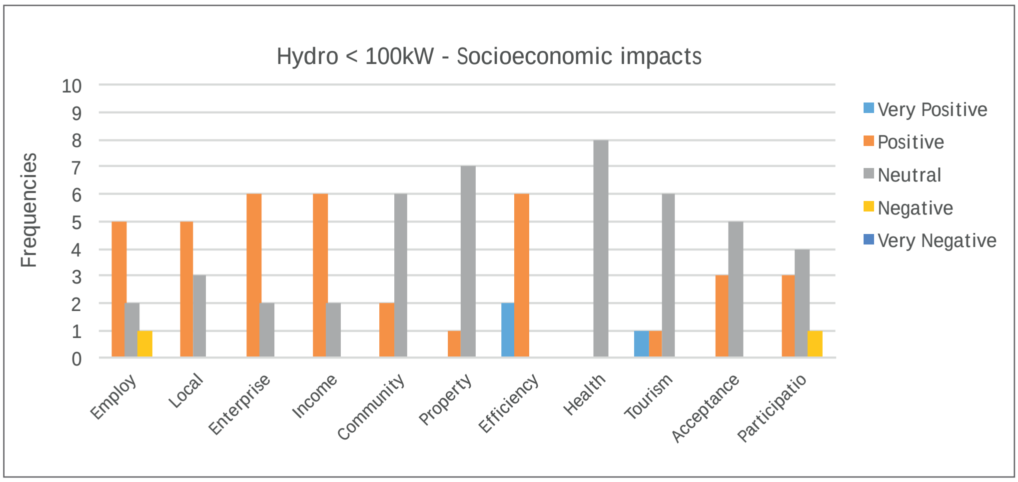


Figure 21: Expected impacts on local socio-economic aspects of hydroelectric plants (< 100 kW) according to experts' perceptions.

At the end, experts were required to identify organizations and associations to be involved during the definition of the renewable energies systems development (scenario definition) of the Pilot Areas. They proposed a list of people, local governments, associations etc.; EURAC updated it in a detailed way, specifying the single unit to be involved in future steps. The aim was to better characterize who can have real interest in the project's discussion and results. As an example, experts indicated the Piedmont Region as general institution; EURAC focused the attention on three main departments – Department of protected areas, Department of protection and management of wildlife and aquatic, Department of forest etc. – as more involved and interested in hydropower and forest biomass.

In Table 10 it is possible to compare the complete list of stakeholders identified by experts (first column) with the details by EURAC (second column). Experts had also to identify the level of involvement, i.e. if stakeholders should actively take part of scenario definition or they should only be informed of the results, without consultation. The Figure 22 shows the frequency of identification of the department, association, institution as a stakeholder.

TABLE 10: STAKEHOLDERS IDENTIFIED BY THE EXPERTS IN GESSO AND VERMENAGNA VALLEYS

Stakeholders	Further details
Piedmont Region	Protected Areas Department
	Protection and management of wildlife and aquatic Department
	Forests Department
	Mountain Department
	Sustainable energy development Department
Cuneo Province	Management of territory resources department
	Terrotory protection department
	Agriculture, Parks and Forests department
Mountain Community of Maritime Alps	Technical office
	Technical-agrarian office

Stakeholders	Further details
Municipalities	Limone Piemonte
	Vernante
	Robilante
	Roccavione
	Roaschia
	Entracque
	Valdieri
Maritime Alps Natural Park (PNAM)	
Regional Environmental Agency (ARPA)	
Institute for timber plants and environment (IPLA)	
Fishing associations	
Local Government Association associations	
Military Forest Service (CFS)	
Scientific associations	
Collective interests associations	ASBUC ("Usi Civici" Association)
Environmental associations	WWF Piemonte
	Legambiente Cuneo
Unions and Associations	Coldiretti
	CIA
	Unione Agricoltori
	Federpern
	AREB Piemonte

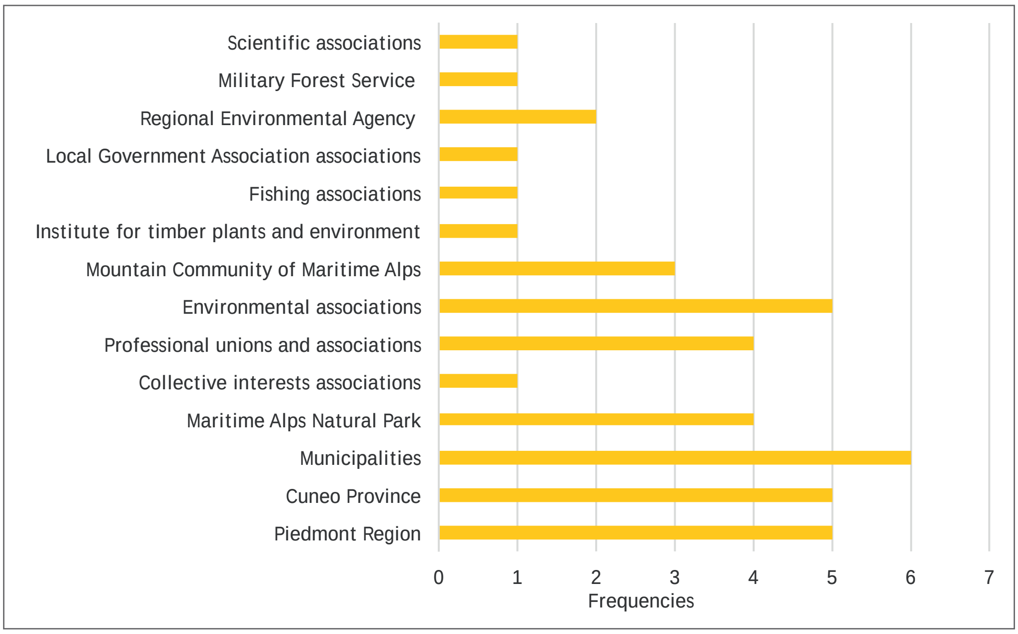
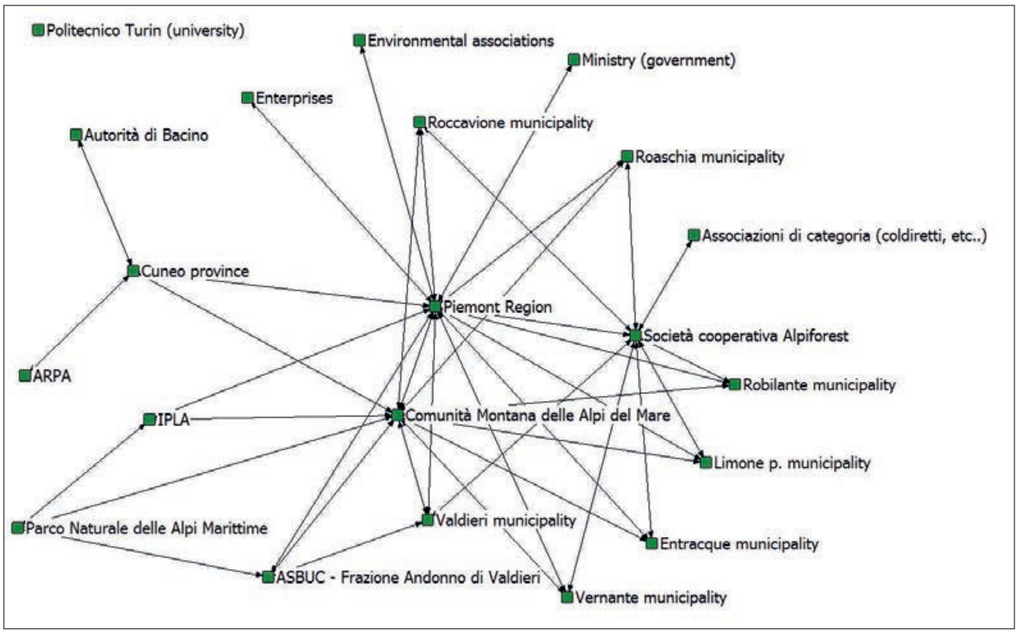


Figure 22: Frequency for stakeholders, by experts in Gesso and Vermenagna Valleys.

The social network analysis shows which are the key stakeholders from those indicated by experts. As can be seen in Figure 23, the key stakeholders are the Mountain Community and the Piedmont Region. Also important is the role of the Cooperative Alpiforest (Association of woodcutters).

Figure 23: Social Network Analysis.



3.1.4 Mis and Maè Valleys

The Veneto Region interviewed 11 experts: 5 for Mis Valley and 6 for Maè Valley. Experts belonging to different branches as hydraulics, law, forest management, botany, urban planning and have assured different point of views about the important theme of renewable energy potential and impacts. The qualitative analyses of the impacts on ecosystem services, society and economy were carried out both in case of “high”/“very high” and “low”/“very low” potential renewable energies, so to collect more feedback on the perception of people (experts in this specific case). Starting from the evaluation of the actual use of renewable energy in the two basins, experts identified the potential development of each source.

Besides, during the questionnaire, the potential and suitable areas for the development of any renewable energy plant have been mapped. In particular, for both Pilot Areas, distinct localized zones have been identified respectively for the implementation of forest biomass energy plants and for that of mini/micro hydropower plants. In the willingness to represent the more realistic scenarios and aiming at a simplification of the analysis, the economic evaluation of the ESS relevant for the Mis and Maè Pilot Areas will be carried on mainly relating to the zones which could most-likely accommodate any plants for the production of renewable energy.

Most of the benefits provided by ecosystems are indirect and result from complex ecological processes that often involve long time frames and nonlinear changes. The economic evaluation starts from the understanding which are the biophysical variables entailed and which the preferences of the individuals with regard to the benefits arising from ecosystem processes (EC, 2008). It is possible to develop an assessment for only those ESS whose functions are quantitatively describable with an adequate number of data. Evaluation through monetary values, always conditioned by the quality of the data and the uncertainty of the estimate, has to be necessarily combined to qualitative analysis. There are several methodologies for evaluating the ESS and their common characteristic is that they are based on the principles of welfare economics (Marino and Piotto, 2010). We, therefore, referred to the basic concept of Total Economic Value (Total Economic Value - TEV) that represents the overall objective for the assessment of environmental economics (MATTM, 2011). It is based on the distinction between two major categories of values associated with natural resources: the value of the use and non-use.

The first one comprehends: the direct use values - when the benefits derive from the direct use of the ESS (among the methods for the evaluation we have the Travel cost method and the Contingent evaluation method); the indirect use values – when benefits are obtained thanks to the accomplishment of the ecosystem functions (for their evaluation we can refer to the existent market prices of the hedonic prices, consisting in the observation of existing markets considered as surrogates of the environmental goods). Finally, the option values - reveals the possibility of maintaining constant the availability of the good, highlighting the values attributed to the conservation of resources for a possible future use. The option value can also be considered a form of insurance and it is further defined by the contingent valuation method. The value of non-use derives from the awareness that the natural environment is maintained over time. This value is relatively difficult to estimate because it is often difficult to put a price on goods which are not usually defined through market instruments. The method most commonly used is the contingent valuation. The non-use value is distinguishable in the bequest value (depending on the transferability to future generations), the altruistic value (depending on the availability of the resource for other individuals belonging to the present generation) and the existence value (even if you do not practice any use or intended use of it).

In the following text, Mis and Maè Valleys are considered as two different case studies, unlike Gesso and Vermenagna Valleys.

MIS VALLEY

In the Mis Valley, there is the common opinion about hydropower, stated by all the experts, as a source that has already been overexploited and that could not have further development, except for some cases in the northern part of the basin, near Gosaldo. The area was touched by a severe judgement (19389/2012), concerning the authorization – already released – of a power plant inside the Park area, in the central part of the Valley. Coherently to the National Law on Protected Areas (L. 394/1991) and the Plan of the Park, the judgement establishes that within the “reserved oriented areas” it is forbidden to modify the hydrological regime and to build any new construction. Experts underlined that a possible solution to have further use of water to produce energy could be represented by hydropower in aqueducts or existing check dams, to minimize impacts and take advantage of existing structures. Solar and wind energy were excluded as suitable sources in the area, mainly for the following reasons. In general, it was remarked the complexity of this kind of installation in the area, due to the morphology and, in the specific case, to the scarcity of wind blows to be exploited. However, the main reason that was stressed as an obstacle to these typologies of power plants is the visual impacts they would have on landscape. The final analysis showed that the renewable energy source that could have a potential development in the area is forest biomass only, a source that is abundant and available, as underlined by the most of the experts. All following data and considerations are related to this topic. Experts identified in a map the areas suitable for biomass production and utilization, as it is possible to see in Figure 24. Different colours identify different experts’ marks. This information were geographically stored in a shapefile.

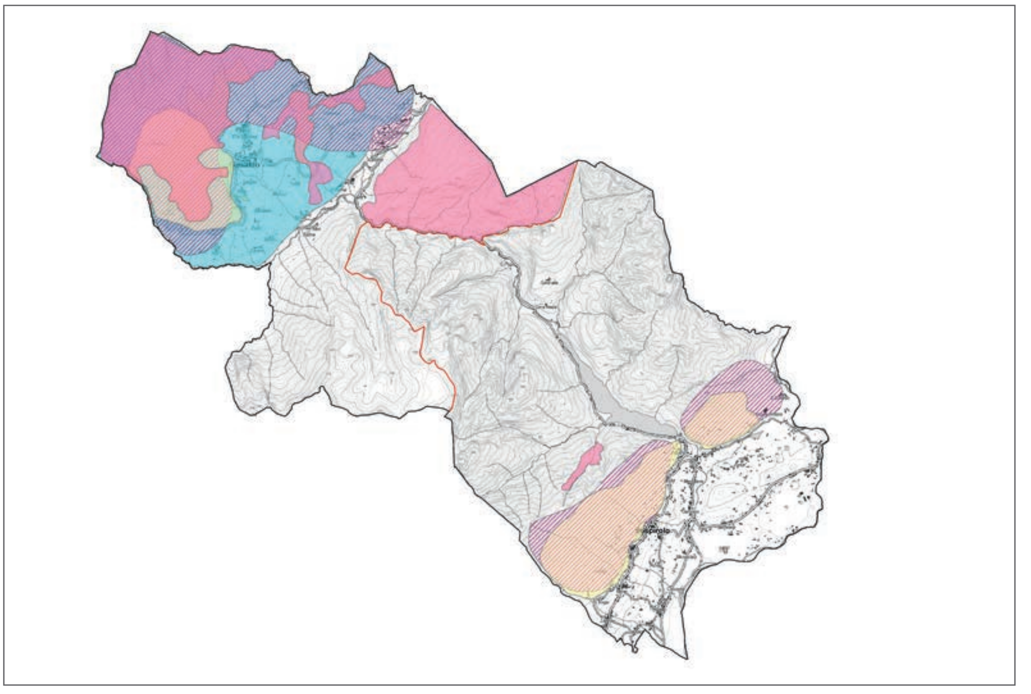


Figure 24: Suitable areas for forest biomass supply in Mis Valley, as marked by experts (different colors identify different experts' marks).

It should be noted that the central part of the Valley, covered by the Dolomiti National Park, was excluded, as subjected to restrictions and particular rules. The use of forest biomass is analysed in relation to the existing rules of forest management plans. A key point that was stressed during interviews was that forest is growing and covering grassland and pastures, with a consequent loss in biodiversity and problems related to the presence of trees closer and closer to villages. It is important to manage it, and the use of wood for biomass could represent an opportunity to combine the recovery of open areas – that is important also in a landscape point of view – with the management of growing forest. This should be done giving attention to save some typologies, as maple-ashes (priority habitat for Nature 2000 Network, code 9180) and to preserve biodiversity. Finally, near Sospirolo a wood chip platform has recently been built, and it was considered as helpful for a potential future development of biomass plants in the area. The qualitative analysis of impacts on ecosystem services and social and economic aspects can be summarised as follows. Concerning ecosystem services, the overall evaluation reveals how forest biomass is perceived as a source with positive impacts, in contrast with the other energies. As it is possible to note from Figure 25, biomass is considered to have positive effects in the majority of services (lightly negative for carbon sequestration and neutral for provision and quality of water).

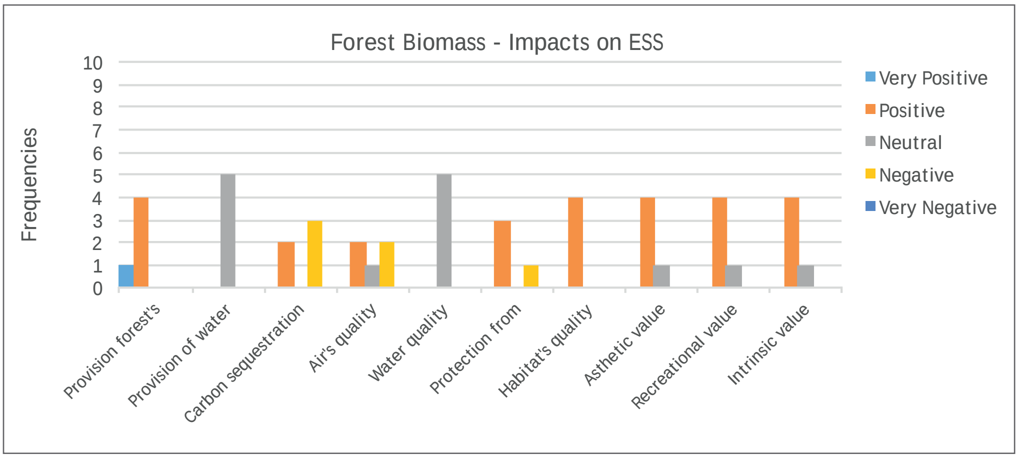
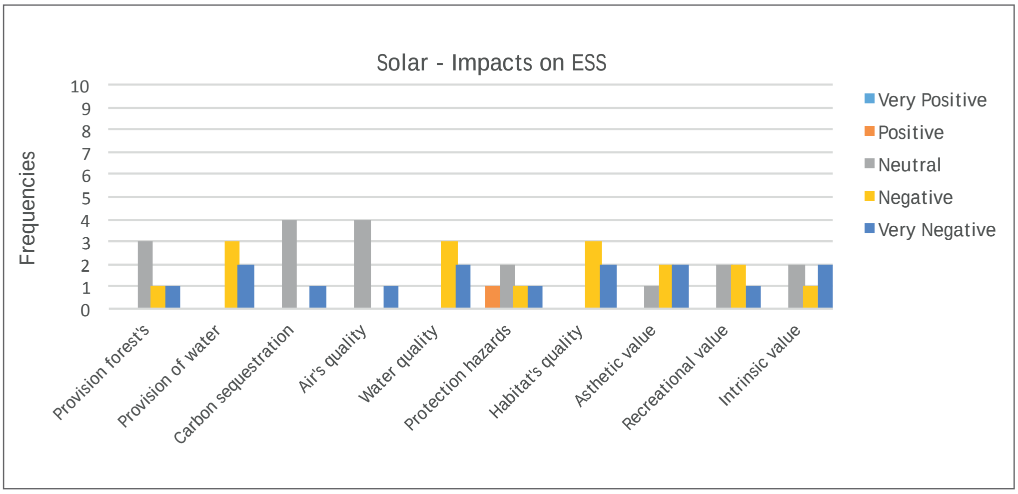
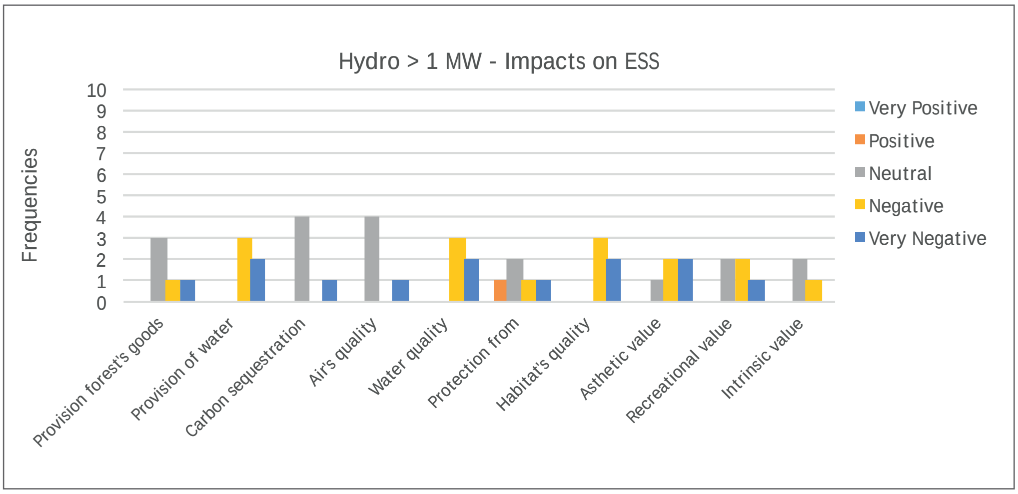
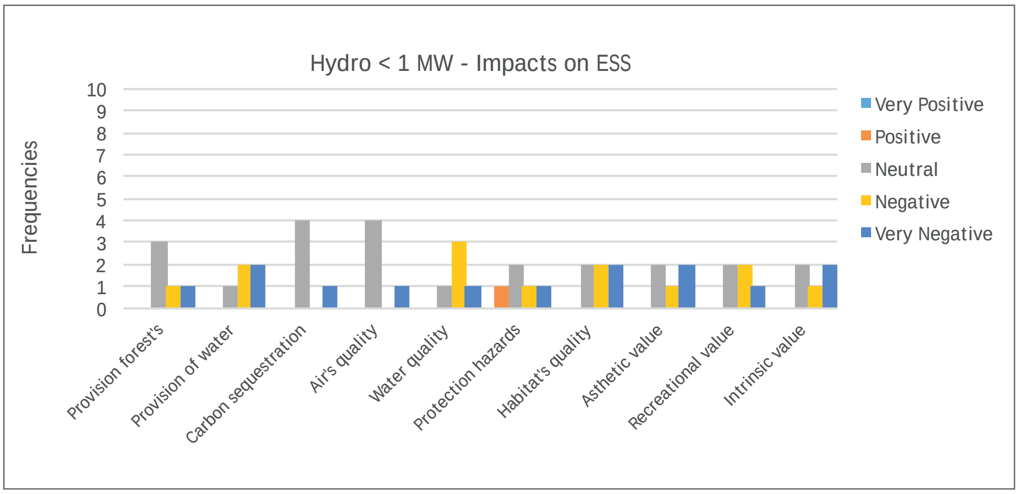


Figure 25: Expected impacts on ESS according to experts' perceptions in Mis Valley.

In Figures 26 a, b and c qualitative impacts on others ecosystem services for Mis Valley are reported; the scale of evaluation ranges always from “very positive” to “very negative” impacts.







Figures 26 a, b and c: Expected impacts on ESS according to experts’ perceptions in Mis Valley.

As it was stressed by experts, a correctly-managed forest is important to provide forest and agriculture products, protect from hazards, maintain habitat quality, aesthetic, recreational and intrinsic values. Concerning socio-economic features, again forest biomass is revealed as a potential source that can have good influence on them, especially for job opportunities and local economy, related to the traditional woodcutting. In general, renewable energies can represent a field of employment.

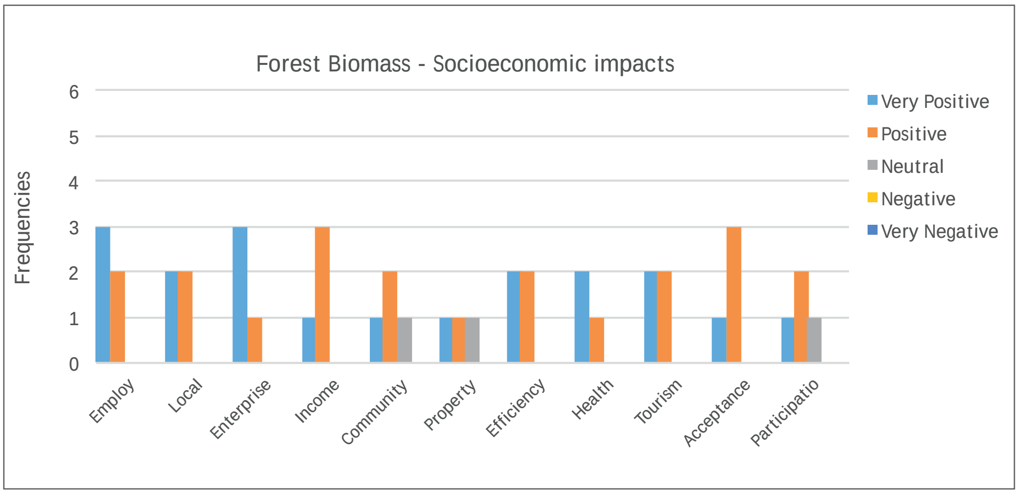
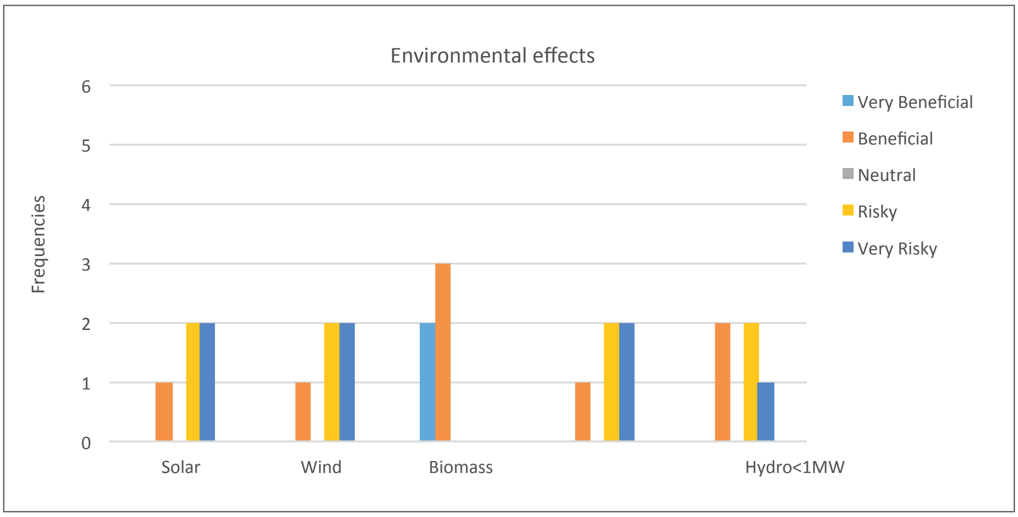
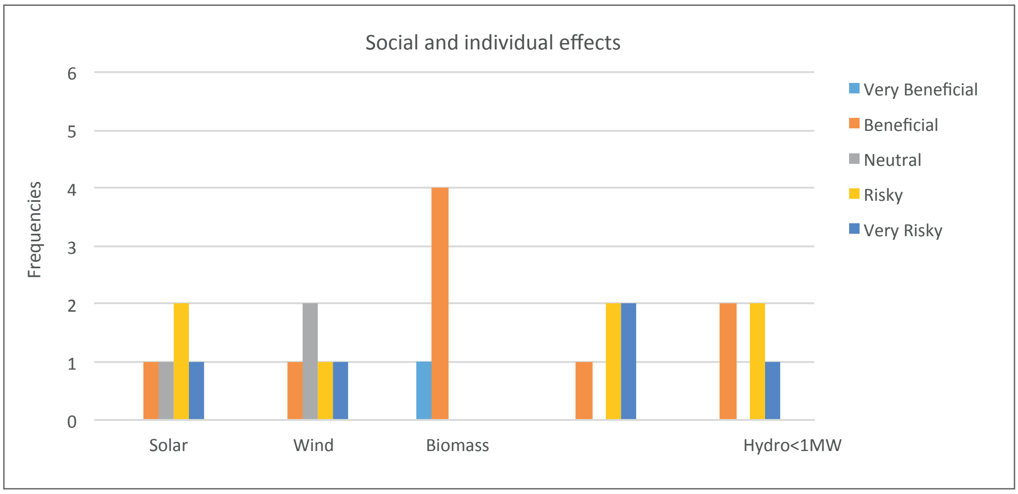


Figure 27: Expected impacts on the society in Mis Valley.

Forest biomass could be better accepted by local people, as it can have positive effects on environment as mentioned above. It is a real and good alternative to the main source of renewable energy in the Belluno Province: water as a resource has been over-exploited in recent years, and many problems have raised between the local communities and policy makers. Tourism is mainly linked to the beauty of the place, so to landscape and how it can be changed by the presence of a power plant and the related activities and structures. A wind turbine can change view; a solar plant occupies a certain amount of land, optically considerable, especially in uncontaminated nature. A hydropower plant, in the specific case a run-of-the-river system, subtracts water and change shapes. Qualitative impacts are summarized in Figure 27. Perceived benefits and risks are plotted in a graph, in a scale from “very beneficial” to “very risky”; impressions given by experts can be summarised as in Figures 28 a and b. This is the confirmation that forest biomass is the only source perceived in a positive way, both environmentally and socially and economically.





Figures 28 a and b: Perceived environmental, social and individual risks of RE in Mis Valley.

At the end, experts were required to identify organizations and associations to be involved during the definition of the renewable energies systems development (scenario definition) of the Pilot Areas. They proposed a list of people, local governments, associations etc.; Veneto Region updated it in a detailed way, specifying the single unit to be involved in future steps; the aim was to better characterize who can have real interest in the project's discussion and results. As an example, experts indicated the Belluno Province as general institution; Veneto Region focused the attention on three main departments – Department of energy planning and management, Department of hunting and fishing, Department of soil protection – as more involved and interested in hydropower and forest biomass. Some stakeholders are the same for both the Pilot Areas, some are more specific – for example the municipalities involved and the collective ownerships. In Table 11 it is possible to compare the complete list of stakeholders identified by experts (first column) with the details by Veneto Region (second column). Experts had also to identify the level of involvement, i.e. if stakeholders should actively take part of scenario definition or they should only be informed of the results, without consultation. In Figure 29, the blue colour identify the passive involvement – just one of them. This picture shows also the frequency of identification of the department/association/institution as a stakeholder.

TABLE 11: STAKEHOLDERS IDENTIFIED BY THE EXPERTS IN MIS VALLEY

Stakeholders	Further details
Dolomiti Unesco Foundation	
Belluno Province	Department of energy planning and management
	Department of hunting and fishing
	Department of soil protecion
	project Moreco - Alpine Space
Agricoltural and trade associations	
Professional Association for agronomist and forestry	to be added: Engineers, Architects, Lawyers, Agricultural and Mining Experts
Mountain Communities	Agordina
	Val Belluna
High School for agronomists	
Forest enterprises/Confederation of Italian Industries	Consorzio Legno Veneto
	CoGeFor (Forest management consortium)
	small industry associations Belluno
	chamber of commerce Belluno
Social Cooperatives	
Municipalities	Gosaldo
	Sospirolo
Environmental associations	Mountain Wilderness
	Acqua Bene Comune
	Confini Comuni
	WWF Belluno
	Legambiente Belluno
Private forest owners	
Veneto Region (i.e. Forest Service, Hunting and Fishing Service)	Forest Service Department
	Civil Engineering Department
	Hunting and Fishing Department
	Environmental Impact Assessment Department
	Energy Department
Superintendance for Cultural Heritage and Landscape	
Committee of Tiser community	
Dolomiti National Park	
Regional Environmental Agency	
Archaeological site association	
Italian Association for agricultural and forest energies	
BIM Consortium	
ENEL	
Civil Engineering Department	(see. Veneto Region)
Fishing basin institutions	Fishing basin n. 5 - Agordino
	Fishing basin n. 5 - Sospirolo
Shooting ground (hunting) institutions	

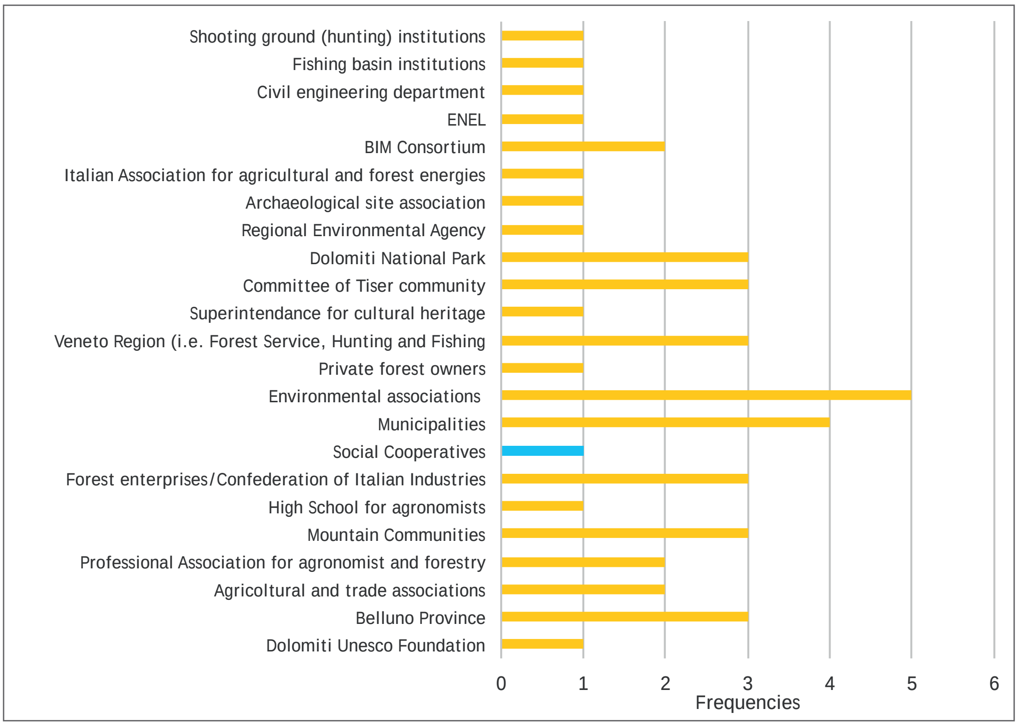


Figure 29: Frequency for stakeholders, by experts in Mis Valley (the blue colour identifies the passive involvement).

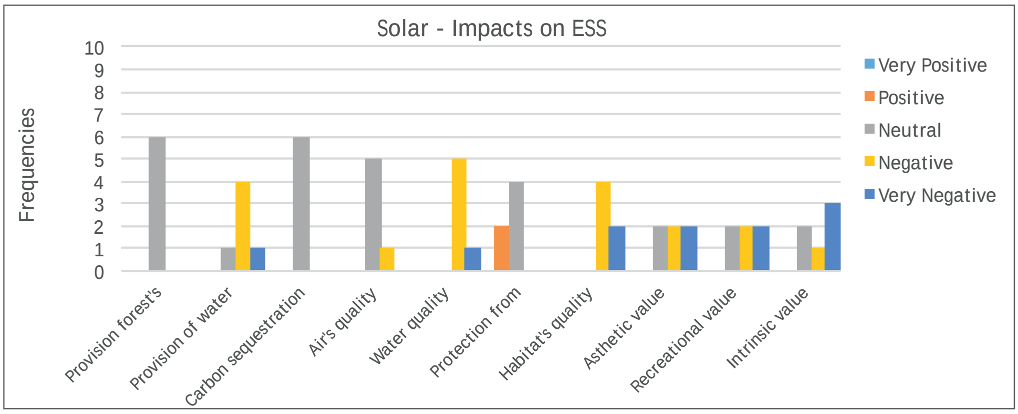
Other possible interlocutors for scenario definition have been identified:

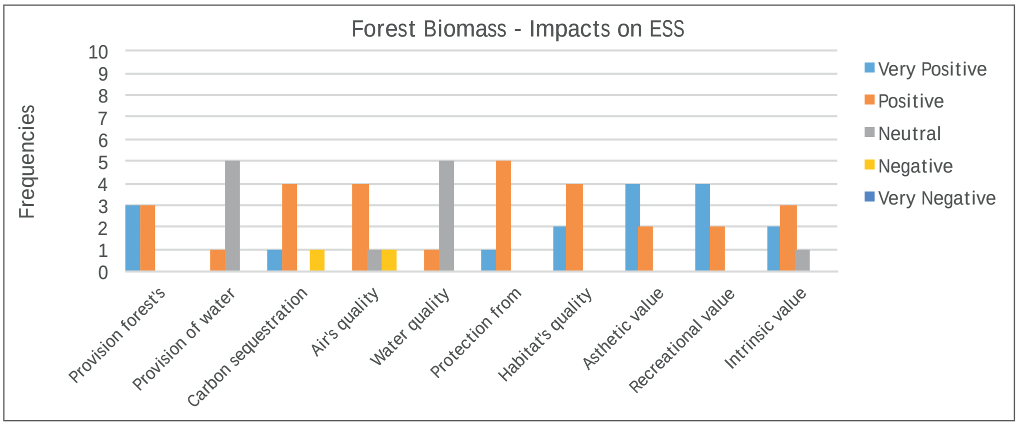
- Italian Alpine Club (CAI);
- Military Forest Service (CFS);
- Basin Institution;
- Angelini Foundation for studies on mountains;
- Veneto Agricoltura - the Veneto Region Agency that promote and carries out interventions for the modernisation of farms and agro-forestry soil conservation.

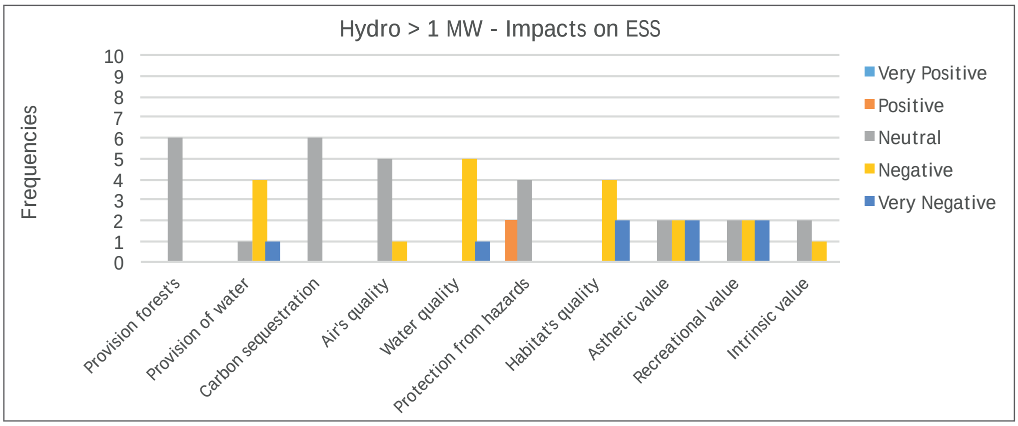
MAÈ VALLEY

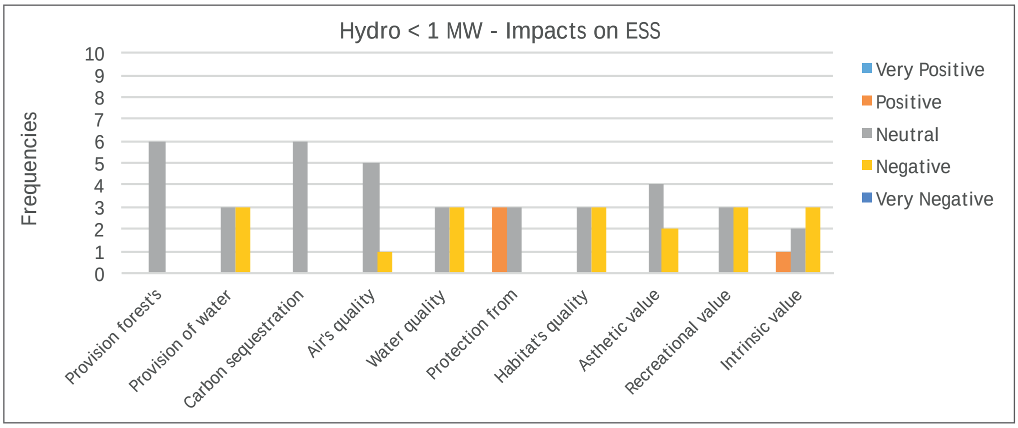
In the Maè valley case study, all the experts underlined the importance of forest biomass, and 4 of the 6 experts considered that hydropower < 1 MW could have a further development, in many cases giving some limitations and conditions. A curious note: wind (2/6 experts) and solar (only 1 interviewed person) energy were also put into attention. In particular, it is stressed that the industrial area of Longarone could be suitable for a plant, not only because considered as a windy area, but also from the aesthetic point of view – it could not be ruined by the presence of the plant. However, the general opinion is in line with what has already been reported for Mis Valley: morphology and visual impact prevent the potentiality of these two sources. For Maè Valley, experts identified hydropower (< 1 MW) and forest biomass as potential sources for energy. Hydropower is a controversial type of energy in the area. Experts underlined how small hydropower has less impact with respect to bigger one – less discharge involved, smaller structures and so on. Water is almost always present, a constant resource. However, some suggestions and limits were given. In particular, one of the interviewed people stated that the optimal distance between derivation and restitution in small hydropower is a maximum of 100 metres (length), to make the plant (including also all the connected structures) as punctual as possible and to limit the segment of the stream subjected to impacts. He also underlined the importance of the rethinking about the Minimum Environmental Flow concept, to better take into account all the environmental features of a stream. Hydropower in aqueducts or existing check dams could represent an alternative to be studied. Forest biomass, on the contrary, is perceived as a good alternative to increment renewable energy in the area. Forest has grown in a considerable way in recent years, and management is desirable, for maintenance of open areas and preservation of villages. It could be better to use mainly spruce, as pure stands or mixed with beech; also stands growing along riverbed should be taken into considerations. In Figures 30 a, b, c and d qualitative impacts on ecosystem services for Maè Valley are reported; the scale of evaluation ranges from “very positive” to “very negative” impacts.

Figures 30 a, b, c and d: Expected impacts on ESS according to experts' perceptions in Maè Valley.









In addition, areas for a possible plant and a possible storage area were identified (Figures 31, 32 and 33).

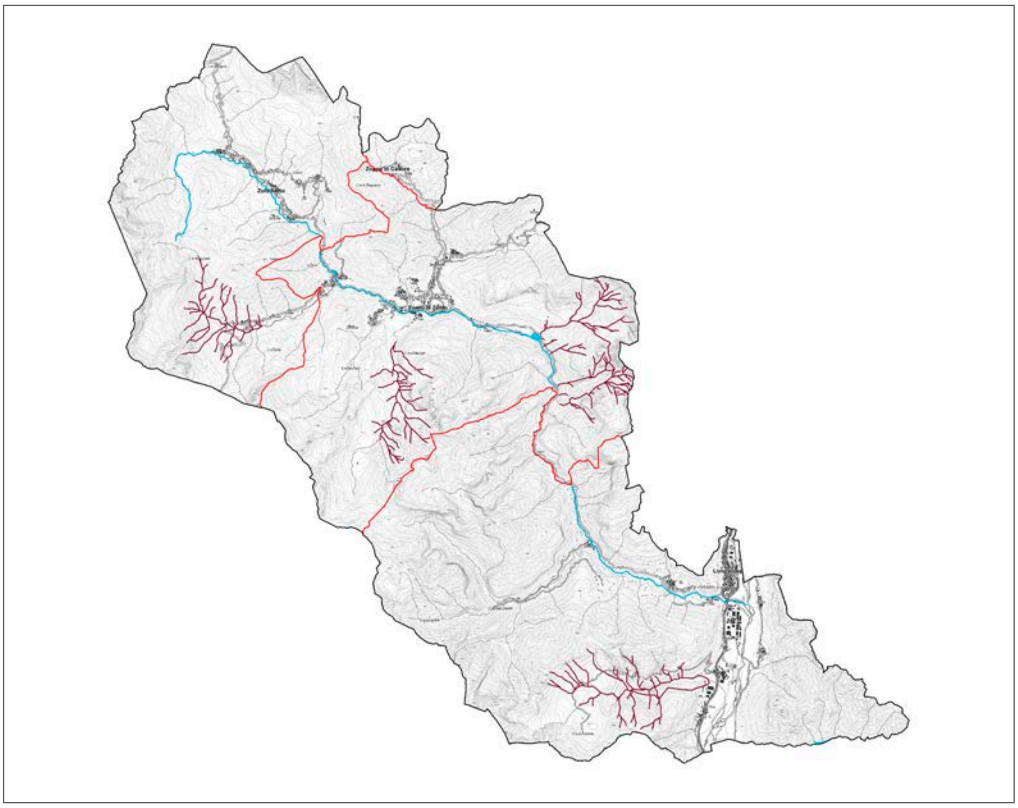


Figure 31: Example of suitable streams for small hydropower in Maè Valley, as marked by one expert (in purple).

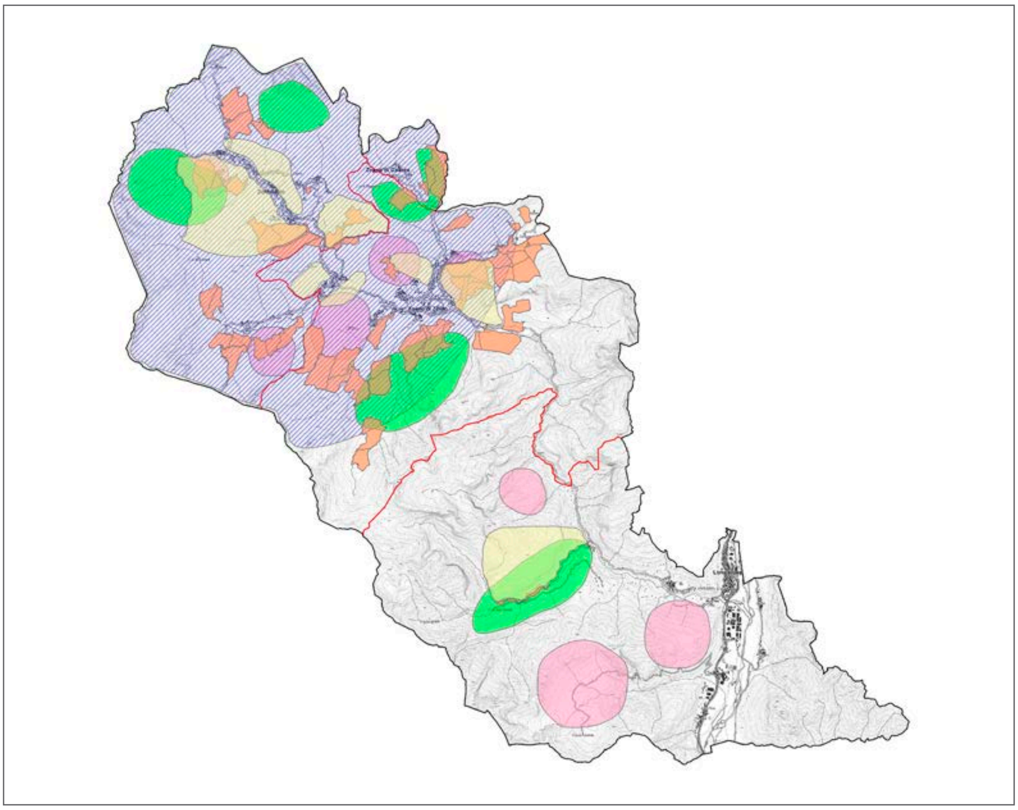


Figure 32: Suitable areas for forest biomass supply in Maè Valley, as marked by experts (different colors identify different experts' marks).

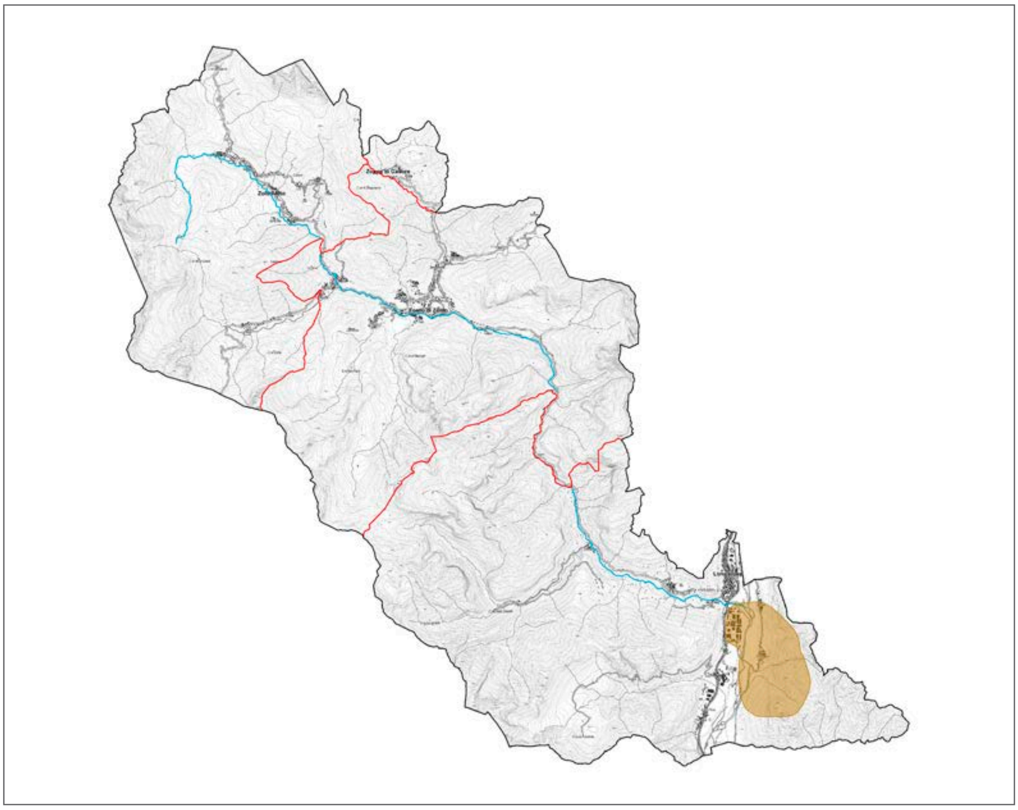
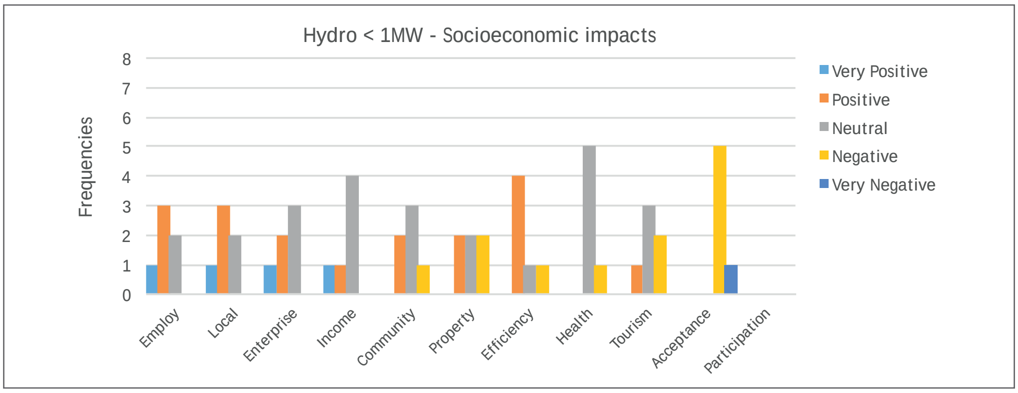
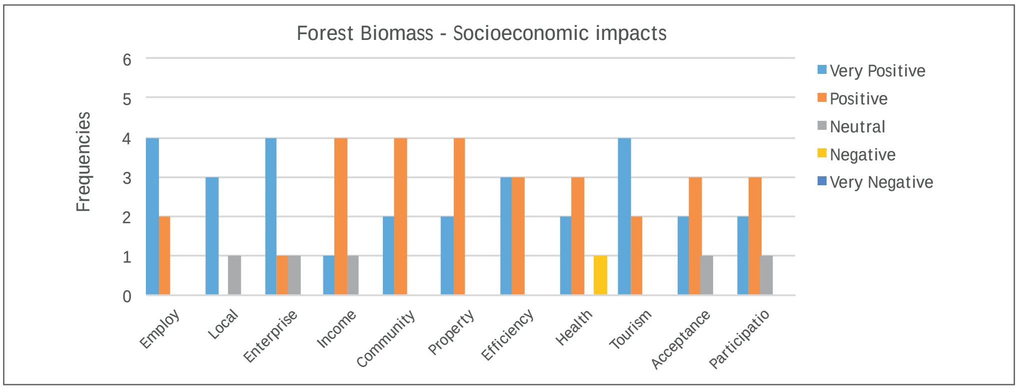


Figure 33: Example of a suitable area for storage of biomass and power plant in Maè Valley, as identified by an expert (in brown).

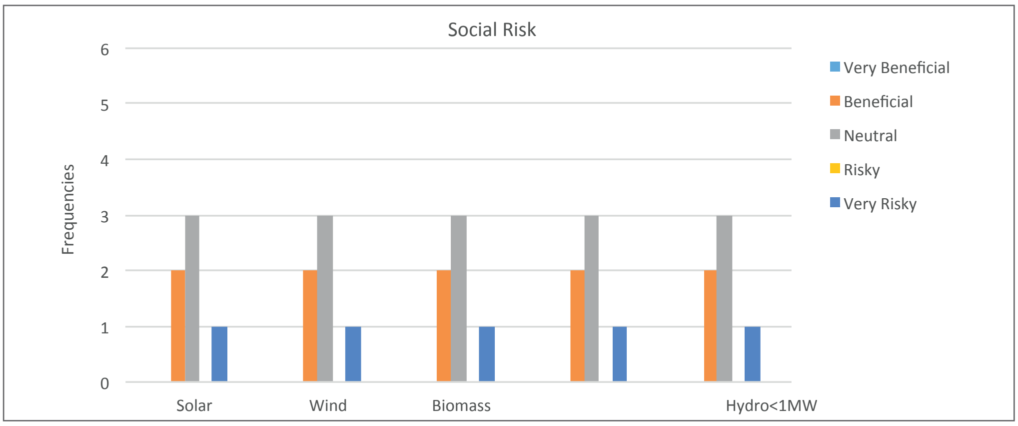
Forest biomass can have also positive effects for economy. Maè Valley had a traditional use of wood for rural building structures, now strongly declined, while nowadays the use of wood for heating remains high for households' traditional activity. An increment in the use of wood, under the condition of proper forest management, can be an opportunity for local economy and local chain to increase. On the other side, hydropower is not always well accepted by local people, as it is an energy that has already been exploited in the Valley for several decades. Small plants could be better accepted by people. They could also give some kind of income to the area, although it was stressed by experts the need to have a greater participations of local communities in the projects as a sort of "shareholding". Compensations should be greater for the territory where natural resources exists and are used. If perceived benefits and risks are considered, only forest biomass can be "beneficial" (Figures 34 a and b).

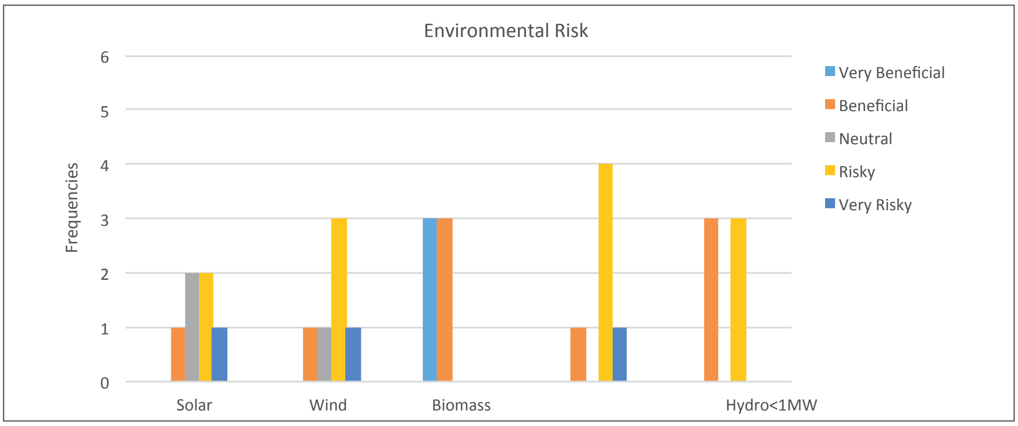




Figures 34 a and b: Expected impacts on the society in Maè Valley.

Despite indications given by interviewed people, hydropower is seen a bit more negatively in a whole contest (Figures below).





Figures 35 a and b: Social and environmental risks in Maè Valley.

As for the Mis Valley case study, the stakeholder analysis was carried out in Maè Valley, with the same procedure. The following Table and Figure show the results.

TABLE 12: STAKEHOLDERS IDENTIFIED BY THE EXPERTS IN MAÈ VALLEY

Stakeholders	Further information
Belluno Province	Department of energy planning and management
	Department of hunting and fishing
	Department of soil protecion
	project Moreco - Alpine Space
Municipalities	Longarone
	Forno di Zoldo
	Zoldo Alto
	Zoppè di Cadore
Dolomiti Unesco Foundation	
Acqua Bene Comune	Environmental associations
Mountain Wildness	
Confini Comuni	
Legambiente	
WWF	
Italian Alpine Club	
Angelini Foundation	
Collective ownerships	"regole"
	"usi civici"
Agricoltural and trade associations	
Dolomiti National Park	
BIM Consortium	
Chamber of Commerce	
Forest enterprises/Confederation of Italian Industries	Consorzio Legno Veneto
	CoGeFor (Forest management consortium)
	small industry associations Belluno
Civil Engineering Department	(see Veneto Region)
Veneto Region (Forest Service, Hunting and Fishering Service)	Forest Service Department
	Civile Engineering Department
	Hunting and Fishing Department
	Environmental Impact Assessment Department
	Energy Department
Fishing basin institutions	
Shooting ground (hunting) institutions	
Mountain Communities	Cadore-Longaronese-Zoldo
Veneto Agricoltura	
Military Forest Service (CFS)	
Guard of the local municipality	
Professional association for agronomist and forestry	to be added: Engineers, Architects, Lawyers, Agricultural and Mining Experts
ENEL	
University of Padua - Hydraulics	

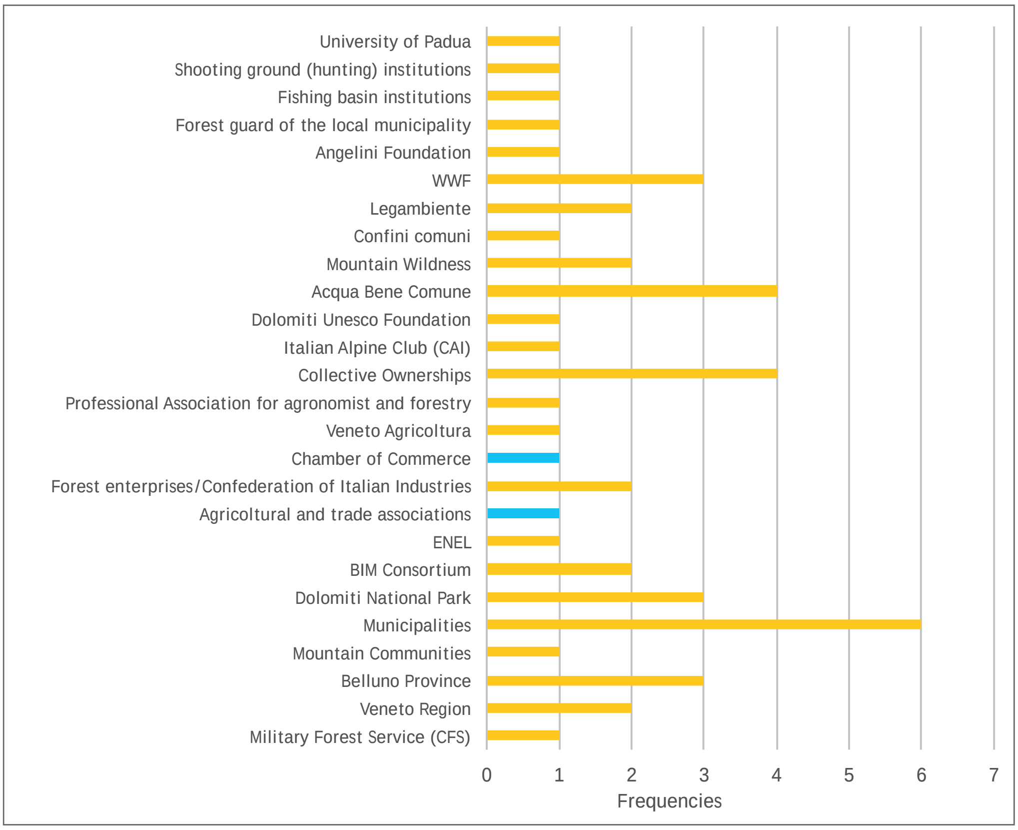


Figure 36: Frequency for stakeholders, by expert in Maè Valley (the blue colour identifies the passive involvement).

Other possible interlocutors for scenario definition have been identified:

- Regional Environmental Agency (ARPAV);
- Superintendance for cultural heritage and landscape;
- Basin Institution;
- Italian Association for agricultural and forest energies (AIEL).

For both the Pilot Areas, a more inclusive stakeholder analysis has been considered, so all the identified stakeholders will be involved in scenario definition, independently from the frequency they have been indicated more than once. All these stakeholders were invited to informative meetings in Pilot Areas, in June 2014.

3.2 Conclusion

The Renewable Energy production may create several benefits for the social and economic sphere of the sustainability, since it allows the growth of the local economy and stimulates entrepreneurship. Almost all the experts evidenced a positive impact on the social, economic and cultural indicators, except few negative responses concerning tourism development and participation.

On the other hand, the ecological effects of RE on the Ecosystem Services are not always positive, since there are many trade-off conditions that have to be considered. The indicator assessing the impact on ESS of RE use highly varies from source to source and from Pilot Area to Pilot Area. In such a situation, the multi-functionality of the ecosystems may be under threat if the RE development is not faced in a holistic and personalized manner. The differences in the experts' answers from Region to Region highlights the fact that a standardized approach is not effective in conciliating ecology, economy and social acceptance. Each Pilot Area has its own need and have to be treated separately. A participatory approach in the decision-making allows the inclusion of many contributions from the stakeholders that in a top-down management may be excluded or

taken for granted. Bottom-up policies that integrate public opinions and preferences in the decision making process are useful in bridging different sectors (Kraxner et al., 2009). Incorporating perceptions of experts and stakeholders is fundamental for ensuring successful formulation and implementation of energy policy in order to reduce conflicts and improving cooperation among the different groups of interest (Dwivedi and Alavalapati, 2009).
In addition, the review of the local experts is a good strategy to have a first glance of the importance and the potentiality of the target Pilot Areas, providing information very useful in the Decision Support System construction. The stakeholders' needs in the Alpine region are different given the socio-economic, cultural and political diversity. Their context is further dissimilar, because of different national and local legislation that in some cases facilitates participation and in other does not. The stakeholder analysis tool is very useful in such in this case, in order to capture the local differences in the people's interests and needs. Finally, the social network analysis highlights the real power in taking the decisions, so that it is easily visible how much a Region goes in the direction of participatory management and which Regions still pursue a top-down approach. The joint analysis of the mentioned indicators allows the identification of the trade-offs between RE and ESS and let decision-makers understand several aspects of the management problem that are usually excluded in a standard decision planning process. Such an analysis gives also the possibility to formulate several recommendations about the path in development of each Pilot Region. It is important to note that the analysis that similar tools provide is still preliminary and has to be tested and validated through the DSS. The experts' input may turn out to be not valid after the DSS implementation. This may occur because of other considerations that the experts did not consider, due to lack of knowledge of some issues not strictly related to their sphere of expertise. This part of the project is the first step before the DSS implementation and the sharing of the RE scenarios with the stakeholders. Notwithstanding the limit of this preliminary analysis, it is a fundamental step for identifying all the variables to be considered in the RE management in compliance with the stakeholders to be involved in the process.

3.3 Layout questionnaire

"Social Perception of Renewable Energies in Pilot Areas"

Context and purpose of the questionnaire:
The purpose of the questionnaire is to analyse the experts' opinions (in particular preferences and perceptions) on the development of renewable energies technologies (solar, wind, hydropower and forest biomass) in the Pilot Areas. The questionnaire will be administered to 5-6 experts in each Pilot Area, through a face to face interview. The results of the questionnaire will be treated and presented in an aggregate way and will be used to support the definition of development scenarios of renewable energies in the Pilot Areas. Information from questionnaire will be also used for the identification of local key-stakeholders.

1. PERSONAL INFORMATION

Name and surname: ____

Gender:	☐ Male	☐ Female	
Education:	☐ High school	☐ Associate degree	☐ Bachelor's degree
	☐ Master's degree	☐ Doctorate degree	
Age:	☐ less than 30 years old	☐ 31-40 years old	☐ 41-50 years old
	☐ 51-60 years old	☐ more than 60 years old	

Specific field of activity: ________________

Organization/association: ____

Role in the organization/association: ____

2. BASED ON YOUR KNOWLEDGE, DO YOU KNOW, OR CAN YOU ESTIMATE HOW MUCH RENEWABLE ENERGY IS ALREADY IN PLACE IN THE PILOT AREAS?

	Very high	High	Low	Very low	Legislative constraints absolutely inhibiting development	Share (%) (sum = 100%)
Solar	☐	☐	☐	☐	☐	____
Wind	☐	☐	☐	☐	☐	____
Forest biomass	☐	☐	☐	☐	☐	____
Hydropower	☐	☐	☐	☐	☐	____

3. OPINIONS CONCERNING RENEWABLE ENERGIES DEVELOPMENT IN THE PILOT AREA

3.1 In your opinion which renewable energy technology can be potentially developed in the Pilot Area?

	Very high	High	Low	Very low	Legislative constraints absolutely inhibiting development
Solar	☐	☐	☐	☐	☐
Wind	☐	☐	☐	☐	☐
Forest biomass	☐	☐	☐	☐	☐
Hydropower	☐	☐	☐	☐	☐

3.2 In the case of renewable energies with “very high” and “high” potential development (Question 2.1) please indicate which are - in your opinion - the most suitable areas for the development. Please state the main reasons why you consider these areas suitable.

Please insert the map of case study

Please mark with a different colour or symbol the different renewable energies (locations, numbers to better identify/refer to in the text).

____

____

____

____

____

3.3 In the case of renewable energies with a “very low” and “low” potential development (Question 2.1) please indicate which are - in your opinion - the main reasons (possible multiple-choice):

Solar energy systems

Technical-logistic reasons ☐ Remarks: ____________________________

Economic reasons ☐ Remarks: ____________________________

Social reasons ☐ Remarks: ____________________________

Geographical reasons ☐ Remarks: ____________________________

Environmental reasons ☐ Remarks: ____________________________

Other __________ ☐ Remarks: ____________________________

Wind energy systems

Technical-logistic reasons ☐ Remarks: ____________________________

Economic reasons ☐ Remarks: ____________________________

Social reasons ☐ Remarks: ____________________________

Geographical reasons ☐ Remarks: ____________________________

Environmental reasons ☐ Remarks: ____________________________

Other __________ ☐ Remarks: ____________________________

Hydropower energy systems

Technical-logistic reasons ☐ Remarks: ______________________________

Economic reasons ☐ Remarks: ______________________________

Social reasons ☐ Remarks: ______________________________

Geographical reasons ☐ Remarks: ______________________________

Environmental reasons ☐ Remarks: ______________________________

Other ______________ ☐ Remarks: ______________________________

Forest biomass energy systems

Technical-logistic reasons ☐ Remarks: ______________________________

Economic reasons ☐ Remarks: ______________________________

Social reasons ☐ Remarks: ______________________________

Geographical reasons ☐ Remarks: ______________________________

Environmental reasons ☐ Remarks: ______________________________

Other ______________ ☐ Remarks: ______________________________

3.4 To your knowledge, has there been a target increase of renewable energy production and energy savings for 2020/2050 been identified in the Pilot Area?

	Yes	Not	I don't know
Solar	☐	☐	☐
Wind	☐	☐	☐
Forest biomass	☐	☐	☐
Hydropower	☐	☐	☐

4. IMPACTS OF THE RENEWABLE ENERGY TECHNOLOGIES ON ECOSYSTEM SERVICES IN THE PILOT AREA (PLEASE CONSIDER ONLY THE RENEWABLE ENERGIES MARKED AS "VERY HIGH" OR "HIGH" IN QUESTION 2.1)

4.1 In your opinion which are the impacts of solar energy systems on the following ecosystem services? Please, indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Provision of forest- and agricultural production	☐	☐	☐	☐	☐	☐
Provision of fresh/potable water	☐	☐	☐	☐	☐	☐
Carbon sequestration in vegetation and soil	☐	☐	☐	☐	☐	☐
Air quality and microclimate	☐	☐	☐	☐	☐	☐
Protection against natural hazards	☐	☐	☐	☐	☐	☐
Ecological habitat quality	☐	☐	☐	☐	☐	☐
Aesthetical value	☐	☐	☐	☐	☐	☐
Recreational value	☐	☐	☐	☐	☐	☐
Intrinsic value	☐	☐	☐	☐	☐	☐
Other / further ____________________	☐	☐	☐	☐	☐	☐

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

4.2 In your opinion which are the impacts of wind energy systems on the following ecosystem services? Please, indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Provision of forest- and agricultural production	☐	☐	☐	☐	☐	☐
Provision of fresh/potable water	☐	☐	☐	☐	☐	☐
Carbon sequestration in vegetation and soil	☐	☐	☐	☐	☐	☐
Air quality and microclimate	☐	☐	☐	☐	☐	☐
Protection against natural hazards	☐	☐	☐	☐	☐	☐
Ecological habitat quality	☐	☐	☐	☐	☐	☐
Aesthetical value	☐	☐	☐	☐	☐	☐
Recreational value	☐	☐	☐	☐	☐	☐
Intrinsic value	☐	☐	☐	☐	☐	☐
Other / further ____________________	☐	☐	☐	☐	☐	☐

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

4.3 In your opinion which are the impacts of hydropower energy systems on the following ecosystem services? Please, indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Provision of forest- and agricultural production						
Provision of fresh/potable water						
Carbon sequestration in vegetation and soil						
Air quality and microclimate						
Protection against natural hazards						
Ecological habitat quality						
Aesthetical value						
Recreational value						
Intrinsic value						
Other / further ____________________						

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

4.4 In your opinion which are the impacts of forest biomass energy systems on the following ecosystem services? Please, indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Provision of forest- and agricultural production						
Provision of fresh/potable water						
Carbon sequestration in vegetation and soil						
Air quality and microclimate						
Protection against natural hazards						
Ecological habitat quality						
Aesthetical value						
Recreational value						
Intrinsic value						
Other / further ____________________						

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

5. IMPACTS OF THE RENEWABLE ENERGIES TECHNOLOGIES ON THE SOCIO-ECONOMIC FEATURES OF THE PILOT AREAS (PLEASE CONSIDER ONLY THE RENEWABLE ENERGIES MARKED AS "VERY HIGH" OR "HIGH" IN QUESTION 2.1)

a. In your opinion which are the impacts of solar energy systems on the following economic and social aspects? Please indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Employment of local workforce						
Local market diversification						
Local entrepreneurship						
Increasing income pro capita						
Social and community aggregation						
Property rights						
Resource efficiency						
Waste management system						
Human health						
Tourism						
Political stability (citizens acceptance of the system)						
Political stability (citizens participation)						
Other / further ____________________						

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

b. In your opinion which are the impacts of wind energy systems on the following economic and social aspects? Please indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Employment of local workforce						
Local market diversification						
Local entrepreneurship						
Increasing income pro capita						
Social and community aggregation						
Property rights						
Resource efficiency						
Waste management system						
Human health						
Tourism						

	+ +	+	0	-	- -	No answer
Political stability (citizens acceptance of the system)						
Political stability (citizens participation)						
Other / further ____________________						

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

c. In your opinion which are the impacts of hydropower energy systems on the following economic and social aspects? Please indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Employment of local workforce						
Local market diversification						
Local entrepreneurship						
Increasing income pro capita						
Social and community aggregation						
Property rights						
Resource efficiency						
Waste management system						
Human health						
Tourism						
Political stability (citizens acceptance of the system)						
Political stability (citizens participation)						
Other / further ____________________						

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

d. In your opinion which are the impacts of forest biomass energy systems on the following economic and social aspects? Please indicate the degree of the impact.

	+ +	+	0	-	- -	No answer
Employment of local workforce						
Local market diversification						
Local entrepreneurship						
Increasing income pro capita						
Social and community aggregation						
Property rights						
Resource efficiency						

	+ +	+	0	-	- -	No answer
Waste management system						
Human health						
Tourism						
Political stability (citizens acceptance of the system)						
Political stability (citizens participation)						
Other / further ___________________						

++ very positive impacts, + positive, 0 neutral, - negative, - - very negative

6. PERCEIVED RISK AND BENEFIT

a. In general, how do you consider the effects of the following energy systems to be for the environment of the Pilot Area?

	Very risky	Risky	Neutral	Beneficial	Very beneficial
Solar					
Wind					
Forest biomass					
Hydropower					

b. In general, how do you consider the effects of the following energy systems to be for the Pilot Area society as a whole?

	Very risky	Risky	Neutral	Beneficial	Very beneficial
Solar					
Wind					
Forest biomass					
Hydropower					

c. In general, how do you consider the effects of the following energy systems to be for a single individual in the Pilot Area?

	Very risky	Risky	Neutral	Beneficial	Very beneficial
Solar					
Wind					
Forest biomass					
Hydropower					

7. STAKEHOLDERS AND NETWORK ANALYSIS

7.1 Does your organization/association collaborate with other organizations and associations in the field of renewable energies in the Pilot Area? Can you list the name, the issue and the intensity of these collaborations?

Name of organization or association	Level	Intensity	Issue
	International National State/Province Trans-regional Region Municipality	Permanent (*/week) Regularly (*/month) Occasionally (*/year)	Coordination Technical/ scientific support Economic support

How much influence does this actor have on actual decision making regarding renewable energy?

Very high High Medium Low Very low

Name of organization or association	Level	Intensity	Issue
	International National State/Province Trans-regional Region Municipality	Permanent (*/week) Regularly (*/month) Occasionally (*/year)	Coordination Technical/ scientific support Economic support

How much influence does this actor have on actual decision making regarding renewable energy?

Very high High Medium Low Very low

Name of organization or association	Level	Intensity	Issue
	International National State/Province Trans-regional Region Municipality	Permanent (*/week) Regularly (*/month) Occasionally (*/year)	Coordination Technical/ scientific support Economic support

How much influence does this actor have on actual decision making regarding renewable energy?

Very high High Medium Low Very low

Name of organization or association	Level	Intensity	Issue
	International National State/Province Trans-regional Region Municipality	Permanent (*/week) Regularly (*/month) Occasionally (*/year)	Coordination Technical/ scientific support Economic support

How much influence does this actor have on actual decision making regarding renewable energy?

Very high   High   Medium   Low   Very low

7.2 In your opinion which organization and association must be involved during the definition of the renewable energies systems development (scenario definition) of the Pilot Area? For each organization, please indicate which is the more suitable level of involvement.

Name of organization or association	Specific field of activity	Level of involvement
		Active involvement in the scenarios' definition (consultation) Passive involvement in the scenarios' definition (information) Active involvement in the scenarios' definition (consultation) Passive involvement in the scenarios' definition (information)
		Active involvement in the scenarios' definition (consultation) Passive involvement in the scenarios' definition (information)
		Active involvement in the scenarios' definition (consultation) Passive involvement in the scenarios' definition (information)
		Active involvement in the scenarios' definition (consultation) Passive involvement in the scenarios' definition (information)
		Active involvement in the scenarios' definition (consultation) Passive involvement in the scenarios' definition (information)

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recharge.green – *balancing Alpine energy and nature*

The Alps have great potential for the use of renewable energy. Thereby they can make a valuable contribution to mitigating climate change. This, however, means increasing pressures on nature. What could be the impact of such changes on the habitats of animals and plants? How do they affect land use and soil quality? How much renewable energy can reasonably be used? The project recharge.green brought together 16 partners to develop strategies and tools for decision-making on such issues. The analysis and comparison of the costs and benefits of renewable energy, ecosystem services, and potential trade-offs was a key component in this process. The project ran from October 2012 to June 2015 and was co-financed by the European Regional Development Fund in the frame of the European Territorial Cooperation Programme Alpine Space.

This publication gives an overview on renewable energy potential and ESS in the Alps and on the possible conflicts that can arise in a complex territory as the Alpine Region.
Together with other project publications, it can be downloaded from **www.recharge-green.eu**

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