

## **Identifying the regional potential for renewable energy systems using ecosystem services and landscape visualizations**

Ulrike WISSEN, Adrienne GRÊT-REGAMEY

### **Abstract**

The pressure to use more renewable energies to mitigate climate change brings new challenges for landscape planning. A massive expansion of these new infrastructures has a strong impact on landscape functions and their goods and services. Yet, missing concepts and methods to evaluate the impacts of these infrastructures makes it difficult to understand how the new energy systems should be integrated into the environment in order to sustain the identification of the people with their cultural landscape, to preserve the ecosystem processes, and at the same time to address the economical requirements related to energy production. We present a concept to evaluate regional potentials for a sustainable mix of renewable energy systems based on the analysis of ecosystem services. The spatially explicit quantification of ecosystem goods and services at technical optimal locations for the new energy systems is accompanied by a participatory process to ensure proper identification of the ecosystem services at stake and their value. The results are meant to present stakeholders with an approach to identify potential locations and conflict areas for renewable energy systems. This provides decision-makers with a tool for balancing interests and designing optimal landscape development options. The outlined pro-active approach can significantly reduce the environmental impact of renewable energy systems and enhance their public acceptability.

### **1 Renewable energy systems – a new pressure on landscape development**

Worldwide we are facing rapid changes in land cover and land use changes coming along with, irreversible loss of many heritage values and natural resources, and dramatic consequences for livelihoods and biodiversity (Antrop 2004, Kristensen et al. 2004). A formulation of effective goals for future landscape development is required in order to ensure sustainable management of a multi-functional landscape that supports the well-being of people (Kienast et al. 2008, Rodewald 2008).

Alpine countries could cover their energy needs by the use of renewable energy and even exceed the Kyoto-goals (Hahn and Rauzi 2008). According to the 'Road Map Renewable Energies Switzerland' (Berg and Real 2006) - a study that sketches the possible development of renewable energy power capacity assuming that the technically and economically usable resources are utilised - the renewably energy supply could be doubled in Switzerland till 2050. However, the authors point out that the limitation is the implementation and thus the societal accepted potential that has to be determined.

The pressure to use more renewable energies to mitigate climate change brings new challenges for landscape planning. A massive expansion of these new infrastructures will

## Identifying the regional potential for renewable energy systems using ecosystem services and landscape visualizations

modify landscape functions and the goods and services they provide to people. On one side, these landscape changes can be supportive of the production of ecosystem goods and services and biodiversity. The management of agricultural areas for biomass production, for example, can lead to an increase in biodiversity and a more diverse rural economy. These land-use changes can however on the other side also cause negative impacts on habitats and particular native species (Thornley 2006). Solar energy technologies can affect the visual landscape aesthetic (Tsoutsos 2005). The use of water power changes the water quantity with impacts on the aquatic ecosystems and can also cause visual intrusion (Tsoutsos 2007). Wind power plants have high impact on the view of a landscape (Wolsink 2007), triggering the fear of residents with regard to effects of noise, leading to falling house prices (Szarka 2006).

Due to the absence of concepts and methods to evaluate the impacts of these infrastructures on landscape functions and the goods and services they provide, it is not known yet how the new energy systems can be integrated into the landscape in order to sustain the identification of the people with their cultural landscape, to preserve the ecosystem processes, and at the same time to address to economical requirements related to energy production. There is a lack of approaches that allow for spatially explicit identification of areas for careful integration of the new elements in the landscape recognizing the value of ecosystem goods and services (Peters and Graumann 2006).

Moreover, a tendency to top-down, technocratic planning approaches in the implementation of renewable energy technology can be noticed. This has been determined as one major obstacle to successful implementation, causing very slow development of renewable production capacity in many countries. Rather open, democratic decision-making is necessary, that takes into account multiple views and thus allows for learning and creating perceived fairness (Higgs et al. 2008, Szarka 2006, Wolsink 2007).

## **2 Concept to optimise the evaluation of regional potentials for renewable energy systems**

Concluding from the requirements mentioned above, landscape development with renewable energy systems needs collaborative approaches to planning that are well informed about the impacts of these facilities on landscape goods and services (Kienast et al. 2008) and offer possibilities to integrate stakeholder valuations into the decision-making process. In the following, a concept is presented to optimise the evaluation of regional potentials for a sustainable mix of renewable energy systems in order to provide a sound basis for decision-making.

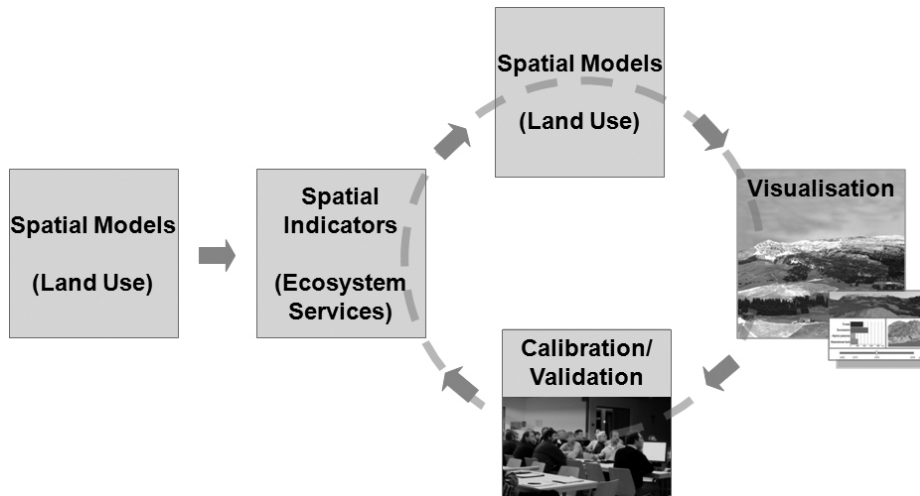
For a case study site a mix of thermal solar and photovoltaic systems, hydro power, wood and biomass, and wind power plants is mapped by an overlay of results from the analysis of the general spatial potential for the individual renewable energy systems. In the following the economic, social and environmental costs of utilising the renewable energy potentials are determined.

Not all services supplied by the ecosystems have to be assessed but a wide range of values (Meyer et al. 2008) with a focus on particularly important criteria. Therefore, a reasonable

overall number has to be figured out that should be included into the assessment (Park et al. 2004). We thus suggest (1) to calculate the regional added value of the exploitation of the maximum number of renewable energy systems in a region, e.g., energy production, return on investment, and effect on employment, and (2) to ask stakeholders to identify further regional potentials for alternative land uses that are provided by the natural resources, such as for example, the habitat for certain species, agriculture and forestry production, or the recreation attractiveness.

Based on this selection of landscape uses by the stakeholders, we identify corresponding ecosystem goods and services, and quantify and value the impacts of the infrastructure on their provisioning using different methods (Grêt-Regamey et al. 2008). Expected ecosystem goods and services, which might be impacted by the new infrastructures, include timber, food, erosion prevention, habitat, enjoyment of scenery, non-recreational appreciation of landscape features, travel to natural ecosystems for eco-tourism, heritage value, as well as of course raw materials for energy.

The valuation of the ecosystem goods and services – the “weighting” of the criteria, which influence the evaluation of the potentials - is hard to define. It is often arbitrary and does not necessarily reflect wider public opinion or preferences (Higgs et al. 2008). To overcome this problem, stakeholder feedback has again to be integrated. The resulting quantitative spatially explicit information is combined with demonstrative visualisations of the view of the landscape change based on GIS data. These visualisations with linked indicators are presented again to the stakeholders in order to facilitate the definition of optimisation goals for the development of the environment (Fig. 1).

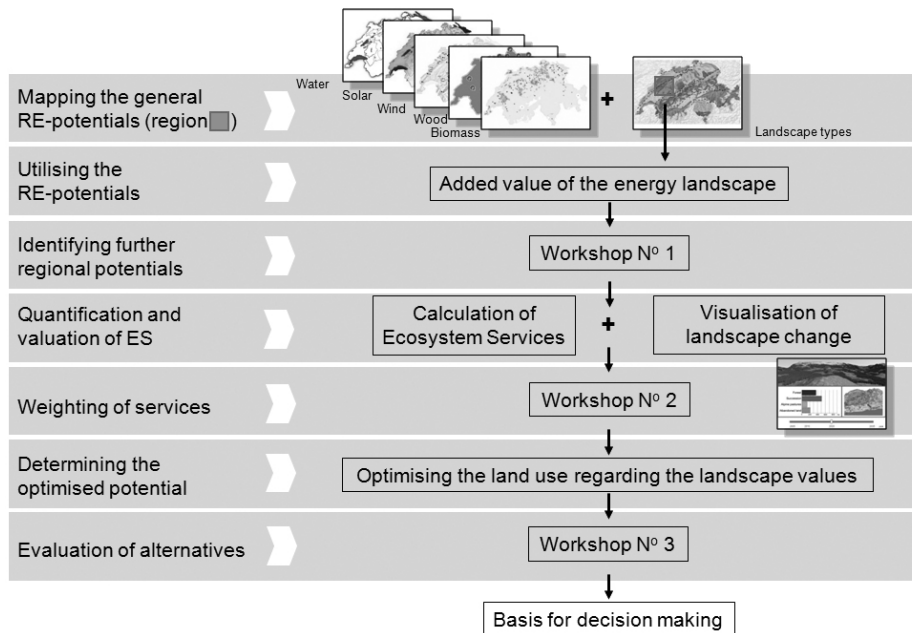


**Fig. 1:** Optimising the spatial land use model by social values in an iterative process.

Finally, different alternatives can be derived that demonstrate an optimisation of the distribution of renewable energy systems with regard to defined criteria. The results are areas of interest for renewable energy systems as well as regional concerns about certain

Identifying the regional potential for renewable energy systems  
using ecosystem services and landscape visualizations

locations building a sound basis for preliminary optimisation and balancing of interests. An overview on the whole workflow is given in Fig. 2.



**Fig. 2:** Workflow for an optimised evaluation of regional potentials for a sustainable mix of renewable energy systems (RE = Renewable Energies; ES = Ecosystem Services).

### 3 Conclusion

Core contention of critics against a massive implementation of renewable energy systems into the landscape is that it entails economic, social, and environmental costs (Szarka 2006). The analysis of ecosystem services for determining regional potentials ensures that these costs are partially taken into account. The proposed concept ensures a systematic approach that strongly incorporates the societal dimension. Social values are used to facilitate an inverse modelling process, determining the socially accepted landscape development goals and integrating them into the quantitative simulation.

Which compromise should be selected is the purpose of a participative negotiation process. The outlined pro-active approach can significantly reduce the environmental impact of renewable energy systems and enhance their public acceptability. Thus, an optimised, more sustainable planning of landscape development is possible.

## Literature

- Antrop M (2004) Landscape change and urbanization process in Europe. *Landscape and Urban Planning* 67: 9-26
- Berg M, Real M (2006) Road Map Erneuerbare Energien Schweiz – Eine Analyse zur Erschliessung der Potenziale bis 2050. Schweizerische Akademie der Technischen Wissenschaften SATW (ed), SATW-Schrift Nr. 39, 23 pp
- Hahn F, Rauzi S (2008) Die Alpen – eine Modellregion für den Klimaschutz! *natur und mensch* 3: 14-17
- Higgs G, Berry R, Kidner D, Langford M (2008) Using IT approaches to promote public participation in renewable energy planning: Prospects and challenges. *Land Use Policy* 25: 596-607
- Kienast F, Bolliger J, DeGroot RS, Potschin M, Haines-Young R, Verburg P, Heller I (2008) Assessing landscape functions at the continental scale: a methodological framework, *Environmental Management*, submitted
- Kristensen LS, Thenail C, Kristensen SP (2004) Landscape changes in agrarian landscapes in the 1990s: the interaction between farmers and the farmed landscape. A case study from Jutland, Denmark. *Journal of Environmental Management* 71: 231–244
- Meyer BC, Phillips A, Annett S (2008) Optimising Rural Land Health: From Landscape Policy to Community Land Use Decision-making. *Landscape Research* 33/2: 181-196
- Park JR, Stabler MJ, Mortimer SR, Jones PJ, Ansell DJ, Parker GPD (2004) The Use of a Multiple Criteria Decision Analysis to Evaluate the Effectiveness of Landscape and Habitat Enhancement Mechanisms: An Example from the South Downs. *Journal of Environmental Planning and Management* 47/5: 773-793
- Peters J, Graumann U (2006) Regenerative Energien und Kulturlandschaft. Chancen für Schutz und Entwicklung von Kulturlandschaften durch den Ausbau erneuerbarer Energien. *Stadt+Grün* 12: 48-53
- Rodewald R (2008) Welche Landschaft soll es sein? Von der Suche nach konsensfähigen Zielen der Landschaftsentwicklung. *GAIA* 17/2: 189-195
- Szarka J (2006) Wind power, policy learning and paradigm change. *Energy Policy* 24: 3041-3048
- Thornley P (2006) Increasing biomass based power generation in the UK. *Energy Policy* 34: 2087–2099
- Tsoutsos T, Frantzeskaki N, Gekas V (2005) Environmental impacts from the solar energy technologies. *Energy Policy* 33: 289–29
- Tsoutsos T, Maria E, Vassilis Mathioudakis V (2007) Sustainable siting procedure of small hydroelectric plants: The Greek experience. *Energy Policy* 35: 2946–2959
- Wolsink M (2007) Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy Policy* 35: 2692-2704