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Conflicts between decentralized renewable electricity production and landscape services – A spatially-explicit quantitative assessment for Switzerland

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ABSTRACT

The production of decentralized renewable electricity often collides with provisioning, regulating and cultural services of the landscape. In this paper we operationalize the landscape service approach and generate conflict maps between three renewable energies (wind; PV; forest biomass) and six competing landscape services (nutrition and materials; aesthetics; physical and experiential interactions; heritage and symbolic content; water and liquid flows; lifecycle maintenance, habitat and gene pool protection). Media content analysis and expert interviews were used to ground-truth the national conflict maps in several Swiss regions and to understand to what degree the national conflict assessments match the regional and local perceptions of these conflicts. In Switzerland (approximately 40,000 km^2) biomass from forests is by far the least conflicting renewable energy, followed by PV on roofs. For the latter 68% of the technically feasible energy potential can be generated with low conflicts, and more is expected with new materials. Wind has a high conflict potential: only 12% of the technically feasible energy potential is low conflict. PV on open land, marginal land and shrubland, is – at the moment – not currently feasible in Switzerland. The accuracy of our conflict assessment is sufficiently high to estimate the proportion that socially sustainable energy could cover of the overall energy gap of 22–25 TWh/yr caused by the phase-out of Swiss nuclear plants by 2050. Low-conflict solar energy from rooftops could contribute approximately 30% of the required 22–25 TWh/yr. Intensified wood production and wind energy could add another 40%. The gap of approximately 30% must come from undisputed energy sources such as biogas from recycled organic material, from centralized renewable energies such as geothermal or large hydropower, or from new or technologically improved renewable energies. The presented decision support tools are a timely contribution to the designation of legally binding zones for renewable energy production.

Contents

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1. Introduction

In the aftermath of the nuclear disaster in Fukushima (spring 2011), the production of decentralized renewable electric energy (wind, small hydropower, photovoltaic, and biofuel energy) ranks high in the agenda of many countries. However, pioneers in the field (e.g. summarized in [77]) emphasized the use of renewable energies long before the Fukushima accident in order to fight climate change. PV has increased considerably in the European Union energy market, i.e. from installed 2.2 GWp in 2005 to 86.7 GWp in 2014 [20]. Germany, Italy, and Greece are the major producers. Installed wind electricity potential in the EU & candidate countries and EFTA has increased from approximately 65,700 MW to approximately 134,000 MW between 2008 and 2014, which would – in a normal wind year – provide 284 TWh, approximately 10% of Europe's electricity demand [21]. The main producers are currently Spain, the UK, Germany, France and Italy.

There is broad consensus that electricity production from decentralized renewable resources is sustainable [77]. However, devices with high land consumption often generate major landscape[1] changes, and trigger conflicts with current land use. In principle, land managers have three options when siting renewable energy devices:

- avoid conflicts with existing land use by placing power generators in the least conflicting zones;
- generate multifunctional landscapes by fostering synergies or co-existence [35], e.g., between wind and agricultural production;
- 'promote' energy regions where renewable energy production represent a democratically authorized commitment of the inhabitants for a sustainable energy future [7].

All three approaches can be observed concurrently, depending on the planning culture of the country concerned. Whatever management option is adopted, however, research-based strategies for minimizing conflicts with other land uses are decisive. Since unsolved land-use conflicts and legal uncertainty might easily paralyze needed investment, spatially explicit conflict-mitigating strategies need to be implemented in the spatial planning of new energy devices. Switzerland is in the midst of such a planning effort: cantons (internal state jurisdiction level) must revise their master plans in order to accommodate zones for renewable energy production. Our presented approach is therefore timely and enables planners to base their decisions on sound scientific and transparent decision support tools. Before describing the present study, we define important terms, explain why certain energy types are excluded in the assessment, and review literature relevant to the present topic.

1.1. Definition of "landscape services" and other terms used in the present paper

A land-use conflict is defined as "a situation in which involved parties or individuals have incompatible interests concerning the use of a certain piece of land" [72,73]. The "incompatible interests" concerning land-use go beyond land-use in a strict sense, involving other benefits of the land, such as aesthetics. Wind turbines, for example, have an impact on scenic beauty and perceptions regarding the value of landscapes. Since the best wind conditions usually occur on ridges or off-shore, wind turbines can also lead to conflicts with wildlife such as birds, bats, or fish [23,42]. Because of these diverse land benefits of the land, we claim that the "incompatible interests" are best framed by using the concept of "landscape services" [29,38,64]. The term "landscape services" is used instead of ecosystem services[2] [58] to express that (1) services are context-sensitive and do not only depend on the characteristics of a patch of land but also on its surrounding landscape; (2) services also refer to the cultural and perceived environment, which is best expressed with the term "landscape"; and (3) "landscape" is a widely accepted concept in spatial planning ([41,62], European Landscape Convention ELC (Council of Europe, Web Resource [12])).

As shown by Dijkman and Benders [17], the conflict potential between decentralized renewable energies and landscape services increases with decreasing energy density of the energy resources. Energy density is defined as the amounts of land consumed per unit energy [17].

1.2. Selected energy resources and landscape services

This paper examines landscape-sensitive energy resources only, i.e. resources with generally low energy density/m^2 such as wind, PV and biomass [16,17]. Consequently we exclude large hydropower plants (> 10 MW). In Switzerland, new and

[1] The term "landscape" is used to describe "a medium-scale excerpt of the globe's surface, shaped by nature and humans and perceived by people" [41,54].

[2] "Ecosystem services are defined as the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, scientific, spiritual, and other nonmaterial benefits." [11].