COMPARING SECOND-BEST STRATEGIES TO MANAGE A SPATIALLY HETEROGENEOUS AND INTERACTING EXTERNALITY OF RES DEVELOPMENT

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Overview

Fostering renewable energy sources (RES) for power production has been one of the main answers of governments all over the world to challenge the problem of climate change. By reducing environmental externalities in the power sector, RES are known as sustainable alternative for electricity generation as compared to fossil fuels. However, apart from their positive impact on climate, RES themselves exhibit negative effects on the environment, primarily on a local or regional scale. For example, wind turbines may pose a threat to raptors and bats or impair landscape quality. Likewise, biomass cultivation and large open space photovoltaic plants can decrease local biodiversity (Borenstein 2012, Hastik 2015). Occurrence and extent of these externalities are highly site-specific and thus differ between plant locations. Placing a wind turbine in a high quality landscape, like a mountainous region, will impact scenery more negatively than siting it in a region with scenery of lower aesthetic value, e.g. in flat-land areas. In addition to these spatially-heterogeneous effects on the environment, the total environmental impact of RES electricity production may add up to more or less than the sum of regional impacts on people, wildlife and scenery. These cumulative effects can be positive, i.e. power production levels in each region jointly increase total environmental impacts, or vice versa. For example, the visual impairments people experience from RES plants may decrease if they are exposed to them in several locations. This habituation effect is jointly created by siting RES plants in different regions and decreases the overall welfare loss from RES plants. Managing the negative environmental effects of RES entails two regulatory challenges that emerge from the externality characteristics of spatial heterogeneity and cumulative effects. So far, economic literature is centred mainly upon the analysis of policies to promote RES development as a means to mitigate climate change (Lehmann 2013, Fischer and Preonas 2010). With respect to the negative environmental impacts of RES, past contributions primarily capture and measure these impacts with a focus on onshore wind energy (Zerrahn 2017, Mattmann et al. 2016). For some externalities of onshore wind power, studies on the respective optimal siting of turbines exist but do not stretch the topic to regulatory choices (Drechsler 2011). A comprehensive theoretical concept to depict the characteristics of negative environmental externalities of RES power production, that is spatial heterogeneity and cumulative effects, and the comparison of policy options for their regulation is yet missing. Standard insights from spatial environmental economics suggest that a first-best instrument that leads to the welfare optimal allocation of RES plants across locations is always preferable to a second-best spatially-uniform regulation if environmental externalities are site-specific (Tietenberg 1978, Kolstad 1987). However, due to legal restrictions, informational deficits or administrative costs, implementing the first-best solution may not be feasible. In this case, a comparative analysis of different second-best spatially differentiated instruments with a second-best uniform instrument can alter optimal policy choice. However, second-best analysis so far largely neglects spatial regulatory challenges and is rather concentrated on models with spatially homogeneous externalities (see i.a. Bennear and Stavins 2007, Quirion 2004). Furthermore, cumulative environmental effects are mainly analysed for multiple (non site-specific) externalities (see i.a. Ambec and Coria 2015, Kuosmanen and Laukkanen 2011). This paper aims at providing a first approach to bridging this gap by analysing the question of second-best instrument design for managing environmental impacts of RES power production on a conceptual level. In particular it is examined whether, within a second-best policy setting, spatially-uniform instrument design may outperform spatially heterogeneous options in terms of efficiency to address a site-specific externality of RES power production with cumulative effecs on the environment. The selected second-best design options are based on informational deficits of the regulating entity with respect to the spatial variation of environmental effects and/or their cumulative impacts.

Methods

The question of optimal second-best instrument choice for a spatially-heterogeneous externality of RES power production with cumulative environmental effects is analysed within a simple static partial-equilibrium model of the renewable power sector. Power production takes place in two regions that are both suitable for RES electricity generation. Private production costs as well as environmental externalities from electricity generation are heterogeneous between regions. Apart from power units produced, environmental damages in each region also depend on abatement efforts made to reduce environmental impacts. To introduce the cumulative nature of power production externalities, aggregate environmental damages are represented not only by the sum of regional damages, but also by a multiplicative term that considers power production in both regions. In this set-up, a private investor maximises profits from electricity generation across both regions. A regulator who aims at reaching an external quantitative target for RES production renumerates each electricity unit produced with a subsidy. The regulator seeks to achieve the target at minimal social cost. Regional power production quantities may be substitutes or complements in reaching the production target. Within this framework, different second-best subsidy design options are compared with respect to their welfare effects. More precisely, a spatially-uniform subsidy is compared to a set of second-best spatially-differentiated subsidies that are implemented if the regulator is partly or completely uniformed about the heterogeneity of regional environmental damages, about cumulative environmental effects of regional power production or both.

Results

We expect that if first-best policy design is ruled out, the welfare losses from uniform instrument design to address a site-specific externality with cumulative effects are reduced or even negated under certain circumstances as compared to spatially differentiated instruments. Consider a scenario where the regulator can differentiate a subsidy based on local costs and damages but is only partially informed on cumulative effects on the environment. Preliminary results suggest that, if the information deficit is sufficiently high, uniform instrument design is less costly in terms of welfare than second-best spatially-differentiated regulation. This is true for both, positive and negative, cumulative effects. However, these results are highly dependent on the specification of and relation between cost and damage functions and on the extent of cumulative effects. In a next step, the analysis is extended to the case of the regulator having only partial knowledge of the variation in regional environmental effects and cumulative effects.

Conclusions

The model results suggest that there exist further reasons for uniform instrument design within a second-best setting that adds to established arguments like the existence of transaction costs associated with designing and implementing spatially-differentiated policy options. If the level of the regulator’s knowledge on the cumulative effects of RES development on the environment remains below a certain threshold, social costs from RES electricity generation are lower when a spatially-uniform subsidy is implemented to govern the spatially-heterogeneous RES externalities. These findings might shed new light on instrument design choice for RES support schemes that also address negative environmental impacts from RES power generation. As renumeration levels for electricity produced by RES are usually decided on a higher governmental level, as opposed to locally, it can be assumed that decision-makers are not perfectly informed about the characteristics and the extend of environmental damages caused by RES plants. Most likely, policy makers will have some information on the difference of local environmental damages, while the cumulative effect of total RES power production on the environment might still be unclear. In this context, it could thus be less costly to neglect the knowledge on heterogeneous local environmental effects when governing RES expansion, i.e. choosing a uniform subsidy for the entire area suitable for RES expansion.

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