Renewable and Sustainable Energy Reviews 93 (2018) 35–51

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Assessing the regional economic impacts of renewable energy sources – A literature review

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ARTICLE INFO

Keywords:
Regional impacts of renewable energy
Economic impact assessment
Economy and renewable energy
Literature review renewable energy and economics
Guideline impact assessment
Renewable energy sources

ABSTRACT

The transition of the global energy system is one of the main trends that offers opportunities as well as challenges for the economy. Most literature evaluates the impact of that transition at a national level. That view is broadened towards a regional scale. Due to the lower energy density of many renewable energy sources, renewable energy generation will be more decentralised, leading to potentially significant changes in the regional economy when transitioning to a renewable energy system. In this paper the current literature and methods of assessing regional economic impacts of a transition to renewable energy generation is reviewed. The findings suggest an overall need to clearly define the topics, such as technologies, that are assessed and the evaluated time period. A guideline for a regional impact assessment is provided, focusing on the suitability of applied impact assessment methods (employment ratios, supply chain analyses, input-output models, and computable general equilibrium models).

1. Introduction

Among researchers in the field of climate, it is widely accepted that the emission of greenhouse gases is changing the world's climate. This negatively impacts the ecosystem [1]. As the highest proportion (25%) of greenhouse gases is emitted by heat and electricity generation [2], increasing the development of renewable energy sources (RES) is an important strategy for reducing greenhouse gas emissions and thus combatting climate change.

Therefore, facilitating and accelerating the development of renewable energy technologies for the generation of heat and electricity is a key point in the global debate about the energy transition as it requires a structural change to the energy system [3]. This structural change creates new economic impulses (e.g. growth of the wind power industry) but also decreases investment in traditional energy industries (e.g. the lignite industry) [4].

On a spatial scale, the conventional energy generation system which is based on large centralised energy generation units is shifting to a smaller scale, decentralised, spatially dispersed system of energy generation [5].

The various renewable energy technologies (e.g. wind power, solar photovoltaic (PV) or geothermal energy) require different location factors and not every location may be equally appropriate. Therefore, a change in the spatial arrangement of energy generation systems is taking place. Traditional locations for energy generation (e.g. lignite or hard coal mining areas) may lose their substantial significance in favour of renewable energy generation locations, if the former do not possess suitable local conditions for the generation of renewable energy (RE),[1] which leads to economic losses. In contrast, locations where energy generation by non-renewable energy carriers does not take place may be integrated in the system and benefit economically due to the possibility of providing energy generation potentials for renewable energy systems, which is especially important for economically less-favoured regions such as rimlands. An example of a region making use of that potential may be the economically less favoured North German state Schleswig-Holstein which has aimed to achieve a share of 300% of its

List of Abbreviations: BEA, Bureau for Economic Analysis; CGE, computable general equilibrium; CHP, combined heat and power; CSP, concentrated solar power; EPRI, Electric Power Research Institute; ESCO, energy service company; FTE, full-time equivalent; GDP, gross domestic product; GVA, gross value added; GW, gigawatt; h, hour; IMPLAN, IMpact analysis for PLANning; IO, input-output; JEDI, Job and Economic Development; kW, kilowatt; LAU, Local Administrative Units; MW, megawatt; NDP, net domestic product; NREL, National Renewable Energy Laboratory; NUTS, Nomenclature des Unités Territoriales Statistiques; English, Classification of Territorial Units for Statistics; O&M, operation and maintenance; PV, photovoltaic; RE, renewable energy; REPP, Renewable Energy Policy Project; RES, renewable energy sources; RIMS, Regional Input-Output Modelling System; RIOT, Regional IO Table; SAM, social accounting matrix; SEED, Sustainable Energy and Economic Development; WEBEE, Modell zur Ermittlung von Wertschöpfungs- und Beschäftigungseffekten durch Erneuerbare Energien (Assessment model for value added and employment effects of renewable energies)

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[1] Regarding the discussion of changing spatial arrangements concerning energy systems from a historical perspective cf. Brücher [6].

https://doi.org/10.1016/j.rser.2018.05.008
Received 26 July 2017; Received in revised form 4 May 2018; Accepted 4 May 2018

gross electricity consumption from renewable sources by 2025 [7], thus making the region a future electricity exporter. It can be concluded that changes which take place in the spatial arrangements of the energy system are characterised by a transregional crowding out of conventional energy generation plants and a development of renewable energy generation facilities in regions with sufficient potentials for this kind of energy generation.

Although there is a broad body of literature assessing the economic impact of shifting to a renewable energy system on a national scale (e.g. Hillebrand et al. [8]and Lehr et al. [9] for Germany, Wei et al. [10], for the US, or de Arce et al. [11] for Morocco), there is relatively little attention paid to the economic impact of RES on regions, whereas at this geographic level the changes may be more significant. Focusing on a lower geographic level concerning the effects of RES, developments may be beneficial for various reasons. Firstly, decision-making on the deployment of RES sometimes takes place at a local or regional level instead of the national level, because regions may have decision-making power to hinder, or promote the deployment of RES, as Jacobsson or Bergek [12] show this in an example of the Dutch wind power industry. Assessing the economic benefits of RES, will help decision-makers to understand the impacts of the development of RES in their regions. Besides the benefits for RE industry related businesses that are located in the region, information on the economic potentials may support other regional businesses in order to identify market opportunities or encourage businesses from outside to settle in a region. Therefore, the economic potentials of RES may offer a substantial opportunity for many regions.

Moreover, assessing the regional economic impacts of RES may be particularly important in regions where RES developments are observed critically, since illustrating the regional benefits leads to an increasing acceptance of RES by the population [13] which makes it easier for decision-makers and especially for elected ones to communicate positive aspects and decide in favour of RES developments.

Furthermore, because of spatially diverse natural conditions, potential economic impacts should be evaluated rather on a regional than on a national scale (unless the potentials in a country are evenly distributed). For example, the average yearly full-load operating hours of wind turbines are approximately 1/3 higher in Schleswig-Holstein (North Germany), than in Bavaria (South Germany) [14]. Additionally, in some countries RES industries are found spatially concentrated. For example, in Germany, approximately 23% of the employees of the wind power industry were employed in the North German federal state Lower Saxony in 2013 [15].

As conditions vary, it is important for regional decision-makers to evaluate which technologies include the best economic potentials in terms of natural conditions available and where regional economic potentials may efficiently be exploited in order to benefit from the opportunities of the energy transition. Relying on national impact assessments does not adequately take into account the specific local and regional natural conditions and economic potentials in a country and provides no solid decision support for regional decision-makers when defining a regional RES strategy.

In the case of the German wind power industry it has been found that regions take advantage of the potentials because there is a more progressive deployment of wind power in the North of Germany (which has a more favourable wind regime), than in the South (BDB [16] in Leipziger Institut für Energie [17]). Nevertheless, potentials may still not be fully exploited which calls for comprehensive economic impact assessments on a regional scale. These assessments should be attached to regional energy potential studies or regional energy strategies covering economic and ecological effects of renewable energy developments using an integrated approach.

Conclusively, national economic assessments are useful for defining an overall national RES strategy covering e.g. legal frameworks or financial support of economically promising RE technologies. However, when it comes to regional decisions of RES deployments or a definition of a regional strategy for RES developments which may be location and technology specific, regional assessments are more beneficial than national evaluations and complement them. The overall aim of the paper is to provide a review of existing literature in the field of regional economic impacts of RES and to set up a guideline for impact assessments. One cannot claim to refer to economic development as the most important aspect concerning a sustainable regional development which covers issues of “environmental quality, social equity, and economic welfare” [18]. Evaluating environmental quality or social equity concerning RES deployment are also important issues of the discussion [19]. However, the aim of the study is not to narrow down a sustainable regional development only to economic aspects, but to focus on economic development by RES as an important part of the debate.

The paper especially addresses researchers and analysts involved in the field of RES and regional economic impact analyses. Besides presenting existing literature, necessary steps to be taken in assessments are illustrated, as well as a critical review of the advantages and disadvantages of applied methods in the field so as to assist in choosing a suitable method for individual regional impact assessments. Furthermore, practitioners and regional decision-makers are informed about the possibilities and potential benefits of economic impact analyses which may encourage them to integrate such analyses in RES strategies, legitimating RES developments in their regions.

After referring to the procedure of literature selection and analysis (Section 2), evaluated regions, assessed technologies and time periods of publications are illustrated and discussed (Section 3). Four general methodological impact assessment approaches were identified i.e. employment ratios, supply chain analyses, input-output modelling, and computable general equilibrium models. A review of these approaches is provided in Section 4, including a detailed analysis of methodological strengths and weaknesses. The conclusions discuss the findings and provide guidelines for a comprehensive impact assessment for RES transitions (Section 5).

2. Process of literature selection

Although it cannot be claimed that every existing study in this field has been evaluated, a large body of literature has been analysed in order to capture the current debate and developments on evaluating and assessing the regional impacts of RES. Assessment methods which have been applied in the different papers are discussed concerning their strengths and weaknesses and applicability in specific contexts, which may help researchers to identify suitable methods regarding regional impact assessments.

To find relevant publications, a literature search was conducted, using the keywords ‘economic impacts’, ‘economy’, and ‘renewable energy’ in English and German. The most used sources were the internet platforms ‘Google’, ‘Google Scholar’, ‘ScienceDirect’, and ‘Web of Science’.

After scanning the literature references of appropriate publications to further identify literature, all relevant English and German speaking publications were filtered by including only literature concerning economic impact assessments on a regional scale. German publications were integrated as well, since they included various approaches which were not applied in English papers on a regional scale. In addition, German publications were used to evaluate the approaches to a non-German speaking audience.

The term region may be defined differently given the research context [20], and refers to an administrative unit on the sub-national scale in this paper. Because of the fact that the characteristics of administrative units in countries (e.g. size, population) may vary on an international scale, European regions have been categorised into the NUTS (Nomenclature des Unités Territoriales Statistiques; English: Classification of Territorial Units for Statistics) system on EU scale. In the non-European examination areas, which consist of regions in the United States the national classifications have been used (Section 3.1).