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Employment creation potential of renewable power generation technologies: A life cycle approach

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ABSTRACT

The present study analyses the employment characteristics of nine different renewable power generation technologies: two types of solar photovoltaic, wind, small-scale hydro, geothermal, wood biomass and three types of biogas. The analysis uses a Renewable Energy-Focused Input-Output model that the authors developed to analyse life cycle environmental and socio-economic impacts of renewable power generation technologies and policies. The analysis reveals that there are distinctive differences among the nine technologies' impacts on employment. The total employment creation potential over the life cycle is estimated to be in the range of 1.04–5.04 person-years per GWh. Furthermore, the nine technologies have unique features regarding how many and what kinds of jobs are created across the whole life cycle; the introduction of these technologies into an economy directly and indirectly induces jobs in different industrial sectors reflecting their technological characteristics. On the other hand, the nine different technologies have a common employment effect in that they create relatively high employment opportunities in the service sectors such as wholesale trade, non-life insurance, and judicial, financial and accounting services. The present study reveals quantitative employment characteristics of the different types of renewable power generation technology to provide valuable information for renewable energy policy making.

1. Introduction

Renewable energy has the potential to provide a wide range of benefits such as the reduction of greenhouse gas emissions, the improvement of energy self-sufficiency, the creation of employment opportunities, and the development of local economies. Therefore, polices to promote the use of renewable energy technologies have been formulated and performed worldwide. For example, the Japanese government started a feed-in-tariff (FIT) scheme for renewable power generation technologies such as photovoltaic (PV), wind, small hydro, geothermal, and biomass in July 2012 [1]. Ministry of Economy, Trade and Industry, Japan [2] estimates that the percentage of renewable power generation (except for non-small hydro) rose from 1.4% of the national electricity supply in 2011 to 3.2% in 2014 as a result of the FIT scheme.

To develop more effective policies and measures for promoting renewable energy deployment in the future, it is important to assess potential environmental and socio-economic impacts of a wide range of renewable energy technologies from life cycle perspective. The environmental impacts of renewable energy technologies have been extensively examined [3–12], with a consensus on the environmental benefit of renewable power generation, in particular from the climate change perspective [3–6]. As for a socio-economic aspect, while there are many studies that focus on life cycle costing and payback time [12–15], relatively few studies attempt to assess the public benefits on a regional or national scale associated with the use of renewable energy technologies. Recently, there is a growing interest in employment effects of renewable energy technologies in Japan as well as other countries. Since there are still many arguments about the employment impacts of renewable promotion policies, more evidence is required to support better policy-making in the future.

The objective of the present study is to analyse the employment effects of a wide range of renewable power generation technologies by using a Renewable Energy-Focused Input-Output (REFIO) model developed by the authors [16]. The REFIO model was built on the latest Japanese IO table (for the year 2011) with about 400 sectors. Specifically, employment creation potential is quantified across the life cycle of nine different power generation technologies, and the employment characteristics of these technologies are analysed and compared.

The present paper is structured as follows. First, we present background and a literature review on the employment effects of renewable power generation technologies. Next, we describe the

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REFIO model and a method to quantify employment potential using the model. We present and discuss the results regarding the employment creation potentials of renewable power generation technologies. Finally we conclude with a discussion of the main findings and future analysis.

2. Literature review

An increasing body of literature examines the impacts of renewable power generation technologies on employment. As a starting point for the present study, this section reviews the existing employment studies mainly focusing on the input-output model.

2.1. Analytic process and input-output models

There are two main approaches [17–21] used in quantifying employment creation potential of renewable energy policies and analysing employment characteristics of renewable power generation technologies, namely, the analytic process model (bottom-up model) [22–29] and the input-output (IO) model (top-down model) [30–38].

In general, analytic process models have an advantage in micro-level studies where IO models cannot easily be applied, for instance, assessments of local or provincial employment effects of renewable technology investments [24,29], estimation of employment by company type (e.g. manufacturers, developers, consultancy) [28], analyses of employment structure focusing on job categories (e.g. managers, installers, administrative staff) [22,29], and quantification of employment from a particular plant rather than generic scenarios [25]. Additionally, analytic process models are relatively straightforward from a methodological perspective, being commonly more transparent and easily understood than IO models. The simple analytic approach is easy and quick when the employment intensities (e.g. person-years per MW) for processes such the plant construction is available from literature without original surveys [23,26]. For a more reliable estimation of the employment effects, however, a collection of large scale data is necessary through extensive surveys with industry associations and companies [28,29], making this approach laborious and time-consuming. Analytic process models usually focus on the direct employment effects, and are difficult to use for the calculation of indirect employment in more upstream industries. Thus, they generally do not include indirect employment that is less directly associated with renewable energy-related industries.

When employment effects of renewable power generation technologies are assessed, however, it is important to consider not only direct but also indirect effects over the life cycle. The IO model is useful to quantify the life cycle employment opportunities because it allows for comprehensive and consistent estimation of direct and indirect effects considering the interdependencies among all industrial sectors in the whole economy. It is also an advantage of IO models that other economic impacts (e.g. gross value added as a contribution to GDP) and environmental impacts (e.g. greenhouse gas and sulfur oxide emissions) can be calculated within the same framework [21].

In contrast, major points of criticism of the IO model approach concern the high aggregation of IO tables. The main database for IO models is official IO tables which are regularly published by the statistical offices in most countries. However, such official IO tables do not commonly have independent sectors related to renewable power generation technologies (e.g. wind power installation sector, photovoltaic module production sector). That is, although in the real world renewable power generation technologies (e.g. wind, geothermal, solar photovoltaic) are greatly different from conventional technologies (e.g. gas-fired, nuclear) with regard to cost structures and employment per unit of output, IO tables assume that all these technologies included in an IO sector have the same production structure. This homogeneity assumption prevents an adequate assessment of employment effects of specific renewable power generation technologies. To put it the other way around, the disadvantage of IO models can be greatly reduced by incorporating new sectors related to renewable energy technologies in existing official IO tables (i.e. by developing new renewable technology-focused IO tables).

The following two sub-sections thoroughly review the IO-based employment studies including attempts to overcome the disadvantages due to the homogeneity assumption.

2.2. Types of IO-based employment studies: technology-specific and renewable policy analyses

Although there are not so many peer-reviewed studies on IO-based employment effects [17], they range from technology-specific analysis [30–35,38] to a discussion of renewable promotion policies and green investments [20,36,37]. Most technology-specific studies deal with power generation using solar and wind energy. Ciorba et al. [30] quantify employment opportunities associated with the photovoltaic (PV) module production using the Morocco IO table. Caldés et al. [31] estimate the employment attributable to the construction of solar thermal power plants in Spain. Cetin and Egrican [32] analyse the employment impacts of PV and concentrated solar power generation in Turkey. Simas and Pacca [34] assesse employment opportunities created by wind power generation in Brazil. Matumoto and Hondo [33] deal with both PV and wind power generation technologies in Japan. The employment study by Hienuki et al. [35] is distinctive in that it focuses on geothermal power generation. Tourkolias and Mirasgedis [38] deal with five types of renewable power generation technology, namely wind, PV, hydro, geothermal and biomass to estimate the employment benefits associated with their facility construction and operation. These studies quantify employment opportunities created per kW or kWh of the technologies considered. Although the employment effects have been individually estimated for some renewable power generation technologies, there are few studies that consistently reveal employment characteristics of a wide range of technologies under an identical IO framework.

Some studies assess renewable energy polices and investments considering a wide range of renewable power generation technologies. Lehr et al. [37] analyse the employment effects of different policy scenarios for renewable energy including both electricity and heat in Germany. Ziegelmann et al. [36] also examine the employment effects of investments in renewable power generation on the German economy. Markaki et al. [20] quantify the employment opportunities created by green investments in the Greek economy, namely, the promotion of renewable energy technologies and the implementation of energy conservation measures. These studies aim at assessing the effects of renewable energy policies and investment packages on the economy of a country, but do not show the employment characteristics of each individual renewable power generation technology.

2.3. Classification from a methodological viewpoint: basic and modified IO methods

From a methodological viewpoint, IO-based employment studies are classified into two groups; one is the use of official IO tables published by governments [20,31,32,34,38], and the other is the use of modified IO tables [30,33,35,37]. When understanding the results of the former studies, it is important to note that IO models can only be undertaken under specific assumptions [39]. One such assumption is the homogeneity assumption that postulates that each IO sector produces a single commodity and has a single input structure. The use of official IO tables leads to an aggregation error because of this homogeneity assumption. For example, the electricity sector generally includes a mix of several power generation technologies; hence, the input structure for this sector reflects the average of these technologies. However, the input structure of a renewable power generation technology differs from that of the electricity sector. Thus, the electricity sector