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Employment effects of renewable electricity deployment. A novel methodology☆

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There has been an intense debate on the quantification of the employment effects of renewable electricity deployment in the European Union. However, most studies carried out in the past have focused on specific countries and those with a European-wide scope have not provided disaggregated results per country. Furthermore, differences between importing and exporting countries have not been considered. This paper aims to cover those gaps. It presents a novel methodology which integrates the aforementioned considerations in order to calculate the employment effects of renewable energy deployment. The methodology is useful to calculate dynamic employment factors (considering technology learning effects) and the specific capacity (based on trade effects) to which these factors should be applied. It is applied to three renewable energy technologies – photovoltaics, wind on-shore and wind off-shore- in the European Union Member States in the 2008–2012 period. The results using this novel methodology broadly confirm the figures provided in other contributions in the literature. The proposed methodology can be instrumental in assessing the socio-economic effects of policies and investment programmes targeting the deployment of renewable energy technologies.

1. Introduction

The deployment of RES (renewable energy sources) has since long featured prominently in the European policy agenda [1,2]. Because of its important role to improve energy security, sustainability, and to create growth and jobs, investment in RES is one of the priorities in the "Investment Plan for Europe", which aims to foster economic recovery, job creation, long-term growth and competitiveness in the EU (European Union) [3]. Mostly as a result of public support, installations producing electricity from RES have spread all over Europe [4,5]. This has mostly been the case of wind energy and solar PV (photovoltaics). The accumulated wind energy capacity in the European Union (EU28) was 117,936 MW (including wind off-shore) in 2013, experiencing a four-fold increase since 2003 [6]. The growth of PV has been very strong in the last decade in the EU28, with a thirteen-fold increase between 2003 and 2013 (from 599 MWp to 79,623 MWp) [6], although a slow-down has occurred in the last years as a result of cost-containment measures.

Arguably, the development of those markets has led to an increase in the number of related jobs. As a result, there has been an intense debate on the employment effects of renewable electricity deployment in the EU, with most studies (including the European Commission itself), claiming that RES promotion has led to higher employment levels [7] and other authors being more cautious in this regard [8,9].

Indeed, there is already an abundant literature on the employment associated to renewable energy technologies (see the next section for further details) using CGE (computable general equilibrium) models, I–O (input–output) techniques [10–17] or

Abbreviations: CGE, Computable General Equilibrium; EF, Employment Factor; EPIA, European Photovoltaic Industry Association; EU, European Union; EU28, European Union (28 Member States); EWEA, European Wind Energy Association; IEA, International Energy Agency; I–O, Input-Output; LR, Learning Rate; MS, Member State; O&M, Operation and Maintenance; PV, Solar photovoltaic system; RES, Renewable Energy Sources.

☆ The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission or the other organizations.

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analytical methods [18–22]. However, most studies focus on a specific country or region, whereas those carried out at the world or European level do not provide disaggregated results per country. To the best of our knowledge, calculations on the jobs related to the deployment of RES using analytical methods which take into account the differences between importing and exporting countries are not available. This is in spite of the advice of some authors that argue in favour of including these differences in the analysis [23,24]. The learning curve is another concept worth considering. Learning curves imply that technological improvements and economies of scale lead to cost reductions [25] and, thus, can result in a reduction of jobs per unit produced or installed, as shown by Ref. [26]. Previous studies have not considered the impact of learning curves on the employment factors.

The aim of this paper is to provide a methodology to calculate the effects on employment due to the deployment of renewable energy technologies. In contrast to other contributions in the literature, the methodology proposed in this article considers the existing industry structure of each MS (Member State), and distinguishes between importing and exporting countries by using trade data. Furthermore, the effects of the technology learning curves on the employment factors are also included. The methodology is later validated by comparing the results thus obtained for three renewable electricity technologies (PV, wind on-shore and wind off-shore energy) in the EU MS for the period 2008–2012 with the results from the existing literature on the topic.

This methodology can provide a useful input to the conception, implementation and monitoring of policies targeting renewable energies. It can also be instrumental in analysing possible impacts of investment plans and can support prioritization of investment proposals, especially when these involve public funds.

This paper is structured as follows. The next section provides a brief review of the literature on the employment effects of renewable electricity deployment. Section 3 describes the methodology proposed in this paper. The results of its application and its validation are provided in Section 4. Section 5 concludes.

2. An overview of the literature on the employment effects of RES deployment.

The employment associated to RES can be classified in three categories: direct, indirect and induced [27]:

- *Direct employment* refers to the jobs being created in the renewable energy sector, without considering the employment created in the value chain of other manufacturing industries (e.g. manufacturing of wind turbines).
- *Indirect employment.* These jobs are generated in secondary sectors of activity, which are not directly related to the renewable energy sector while they provide inputs to its main activities (e.g., steel industry).
- *Induced employment* refers to the employment created in other sectors of activity, which are different to the main and secondary sectors associated to renewable energies and not linked with their value chain. The increase in the income of workers in sectors directly or indirectly related to renewable energies falls in this category (e.g., jobs created in unrelated service sectors such as leisure).

The employment being created can be measured as *gross jobs* (the number of total jobs being generated) or as *net jobs* (jobs created in one sector minus those destroyed in other sectors which use competing generation technologies).

The methods for the calculation of the jobs related to RES can be classified in two groups:

- *Use of I–O (Input-output) tables and CGE (computable general equilibrium) models.* These methods allow the modelling of the impact of renewable energy on employment by including the interrelationships of the renewable energy sectors with other sectors of the economy. Direct, indirect and induced jobs, as well as net employment, can be calculated with these methods. They are data intensive and require a detailed characterization of the relationships between industrial sectors. However, their applicability at the regional level is limited, since the information in the different countries is not homogenous, being disaggregated in different manners. Consequently, there is often a significant time lag between data collection and its availability in a consolidated form. Furthermore, this method assumes that there are not any limits to the industrial production in one specific sector. The main features of these models have been critically described by Ref. [28]. Many authors have used this methodology in order to calculate the employment associated to RES deployment. For instance, [10] analyses the employment created in Germany using I–O techniques and estimates the jobs in 2030 considering two scenarios. [11] quantifies the future employment related to renewable energies in Europe. [12] and [13] focus on the jobs created in Greece, whereas [14] and [15] analyse the Chinese and Portuguese cases, respectively. [16] uses I–O tables to calculate the indirect employment associated to wind energy in Brazil, [17] analyses the jobs in the solar thermoelectric sector in Spain and [18] estimates the employment related to ocean energy in Wales.
- *Analytical methods.* These methods are usually considered more transparent than the aforementioned ones. They usually rely on interviews and questionnaires to relevant actors in the renewable energy business or on the observation of the value chain of already implemented projects. As a result, the so-called employment factors (jobs/MW or job-years/MW) are obtained, which are (partially) transferred to other regions. However, this method only allows the calculation of gross employment and it is necessary to apply additional multipliers in order to calculate the indirect jobs. Some studies have used this method. [19] analyses the employment factors for biomass plants. [20] assesses the employment associated to wind energy in Europe and [21] uses the employment factors to calculate the jobs generated by solar and wind energy in the Middle East. [22] provides an exhaustive review of the employment factors for different renewable energy technologies.

Fig. 1 illustrates the existing methods for the calculation of the employment effects of RES deployment and their scope.

The empirical analysis of the employment effects of renewable energy deployment has been the focus of several studies in the past. At world-wide level, UNEP (United Nations environment programme) [29] estimated 2,300,000 “green jobs” in 2006 (300,000 jobs associated to wind energy and 170,000 jobs related to PV energy). According to IRENA (International Renewable Energy Agency) [27], 5,730,000 people were employed in the renewable energy sector in 2012 (both direct and indirect jobs, wind: 753,000 jobs; PV: 1,360,000 jobs). REN21 [30] calculated that in 2013 the number of jobs related to renewable energy was around 6,500,000 (wind: 834,000 jobs; PV: 2,273,000 jobs).

There is already a recent and growing literature on the employment in the renewable energy sector in Europe using several methodologies and leading to different results. Worth mentioning are the analyses carried out by the wind energy and PV European Associations ([31] or [32], respectively), as well as those undertaken by Eurobserv'er [33] for all the technologies in each MS. Mainly, National Energy Agencies and Statistical Offices provide data for these annual reports [33] and the methods used by these