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Employment factors for wind and solar energy technologies: A literature review

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ABSTRACT

In this paper we present an up-to-date literature review on employment opportunities associated with the deployment of renewable energy technology. We identified approximately 70 studies and data sources published over the past decade that report analysed or observed employment impacts of renewable energy growth. These publications cover many different countries and several technology options, and present widely varying results derived from distinct methodological approaches. Our first overall conclusion is that there is clear lack of authenticity of findings in this literature, since recursive referencing abounds and relatively few studies yield truly original research. When we omit non-authentic analyses, as well as those that aggregate results in a way that does not allow us to calculate 'employment factors' (defined as the number of jobs or amount of work generated per unit of electricity production capacity), the total list of references is brought to 31 independent items. Of these, only 14 references provide separate estimates of the employment factors for the stages of manufacturing and installation, respectively, as opposed to employment factors for these two activities combined. A total of 23 items provide values for operation and maintenance (O&M) employment factors. We observe significant uncertainties in quoted figures for job creation, both across and within publications.

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1. Introduction

Renewable energy technologies for electricity generation have been widely deployed in a number of developed and developing

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economies. The use of these technologies is increasing in an ever growing number of countries, driven by concerns about energy insecurity, climate change and air pollution. Energy independence, greenhouse gas abatement and air quality are strong arguments for the introduction of renewable technologies, but policymakers must consider the economic impacts of new technologies even more broadly. As a result, the job creation potential of renewable energy generation has received attention from a wide range of sources in recent years, including academia, government agencies, civil society and the private sector [1–3]. The International Renewable Energy Agency (IRENA) has even launched a series of annual reviews of global employment related to renewable energy [4]. It is often argued that the deployment of renewables can be beneficial in terms of the stimulation of employment in a broad range of sectors, directly or indirectly related to their use [1]. The purpose of this paper is to review the literature published to date that inspects the job creation potential of renewable energy technologies, in particular for wind and solar energy. In Section 2, we present an exhaustive overview of the current literature on employment factors associated with the deployment of these renewables. Section 3 summarises our findings and presents employment factors drawn from the available literature, while Section 4 gives some concluding remarks.

2. Literature review

A substantial body of the literature is dedicated to the effects of the use of renewable energy on employment. As a starting point for our study we reviewed this literature, which today covers at least 70 publications. The literature we identified can be categorised in three major ways. First, with regards to the approach of analysis employed, three more or less exclusive types of publications can be distinguished:

(i) studies that calculate ex ante linkages between renewable energy technologies and employment opportunities through an explicit methodology (which can involve more or less intricate models, industry surveys, simple exogenous estimates, or adaptations of values from other studies),
(ii) studies that conduct a literature review and directly adopt employment values reported elsewhere without further analysis, interpretation and/or modification (like we do in the first part of the present paper), and
(iii) publications that present ex post historical employment data, on the basis of which linkages between renewable energy technology capacities and national employment levels can be inferred.

All three publication types are relevant to us and represent potential data sources, but ultimately classes i) and iii) are of most interest for this review since they yield the authentic data required for our analysis. When non-authentic (class ii) data sources are omitted from our original set of references, 40 authentic publications remain. This is another way of saying that many studies rely on the same sources of original research results [1].

Second, publications can be categorised with regards to the applicability of the reported results. Some studies provide findings that cannot be readily adapted to other contexts or compared across studies. For example, a number of studies for Germany [5–7], Greece [8], Portugal [9] and the EU [10, 11] calculate employment impacts of renewables deployment, but provide results aggregated at a level that renders them hard to compare with those from more detailed studies. Although interesting from a methodological standpoint, these types of studies have limited value for our present analysis, in which we attempt to collate findings on employment and renewables into a single common format. Omitting those items from our literature database that do not allow employment factors to be readily calculated, leaves us with 31 from the 40 authentic data sources.

Third, the available literature can be distinguished on the basis of whether or not it is peer-reviewed. We confirm the observations of Perry [12], who conducted a detailed analysis of literature related to renewables deployment and employment opportunities in Canada and found that the majority (~75%) of published documents was non-peer-reviewed, in the sense that they did not appear in academic journals. In our sub-set of peer-reviewed sources, 15 articles present novel data for employment opportunities associated with the use of renewables [6–9, 13–23] and 2 proffer some form of literature review and/or synthesis analysis [24, 25].

2.1. Approaches to estimating jobs

Authentic studies that focus on calculating employment impacts, as meant under class i), can be broadly grouped into two main types [26, 27]: a) those that use input–output (IO) or computable general equilibrium (CGE) models of the economy; and b) those that use simpler largely spreadsheet-based analytical models. The economic interdependencies of different sectors and sub-sectors are used as the starting point for IO models. These models can be used to estimate the results of a change in any particular industry based on the impacts of this change on other industries. For example, the manufacture of a renewable energy technology may require inputs from a range of industries such as mining, equipment supply, fabrication, energy supply, plastics, transport services and others. IO models can therefore provide estimates of employment effects across multiple sectors of an economy, and are often capable of calculating total employment impacts of a technology deployment [1]. The ability of IO models to investigate shifts between sectors means that they can be used to quantify net job impacts, by simultaneously accounting for gains in one sector (e.g. associated with the deployment of renewables) and losses in another (such as related to the phasing out of conventional fossil-based electricity generation). These models can imply a large burden on the user in terms of data collection, as they require detailed knowledge of how industries link to one another. Their outcomes may sometimes be difficult to query, as commonly neither the underlying primary data nor the final input–output matrices are provided. In addition, reports published on the basis of IO modelling efforts generally present findings in an aggregated format, so that the specific impacts of a certain technology cannot always be easily extracted from a given study [26]. For this paper we reviewed 16 studies that utilised either a *static* or *dynamic* IO model – which, respectively, ignore or account for the impacts of employment changes on income and revenues – or a macroeconomic model to determine the potential employment impacts of the diffusion of renewables [5–11, 16, 17, 23, 27–34].

In contrast to IO techniques, a high level of transparency and simplicity are key advantages of simpler analytical approaches to estimating job impacts. Unlike IO models, analytical models generally ignore those jobs that are less directly associated with an industry. They are thus more likely to under-report overall employment impacts [28]. In these more concise models the factors linking renewable energy technology diffusion to employment are often based on interviews or questionnaires with industry. Such interviews yield job intensities or employment factors, defined as the number of jobs derived from a certain renewable technology investment or capacity. Only a small number of the analytical studies we reviewed collect their own data on job intensities by using some kind of survey [18, 21, 22, 35–37]. A much larger number of publications rely on job intensity numbers found in the broader literature – or on occasion in unpublished sources – to develop estimates of employment impacts [19, 25, 38–47].