Employment effects of electricity generation from renewable energy technologies in the UK

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Abstract

In response to the need of reducing CO_2 emissions, the European Union (EU) has set ambitious targets to increase the share of electricity generated from renewable energy sources (RES-E). Therefore, the promotion of the deployment of renewable energy technologies (RET) has come to form a crucial part of governments' strategies to prevent climate change.

Although it is difficult to refute the claim that increasing the use of RES-E will help to prevent global warming, along with adding to Europe's energy security, policy-makers and 'green growth' advocates further argue that it will lead to the creation of a large number of jobs. However, the exact number of jobs quoted by current studies varies enormously with a tendency for member states to base policy decisions on employment estimates that are arguably too optimistic.

Taking the United Kingdom (UK) as a case study, this paper provides an assessment of the impact that renewable energy targets for electricity generation will have on employment. The job creating potential of each RES-E will be made available through the use of Input-Output (IO) employment multipliers with projections for the year 2020.

The analysis indicates that the number of jobs associated with RES-E is expected to be less than anticipated by the UK government. Thus, with employment benefits smaller than anticipated, and as a consequence, less able to offset any negative employment effects that are likely to transpire from the move to a low carbon economy, it is argued that current policy measures do not adequately protect or prepare the workers for this transition.

Keywords: Green jobs, RES-E, climate change, Europe 2020

1. Introduction

Increasing the share of RES-E is expected to play a fundamental role in the fight against climate change by shifting Europe's energy dependence away from high carbon emitting energy sources. Consequently, it is important that the implications of this change on the labour market are assessed, especially in light of the economic crisis, whereby unemployment in Europe has been left at an all-time high.

As contemplated by much of the recent literature on employment vis-à-vis the environment, switching to a 'low carbon' and 'resource efficient' economy will have significant repercussions for Europe's labour market and jobs. Climate change policies ultimately force adjustments to occur in both production and consumer habits, which industries and thus the labour market must respond to in order to meet the rising employment pressures coming from the expansion of some sectors (e.g. renewable energy) whilst at the expense of a decrease in others (e.g. fossil-fuel based industries).

A distinction is typically made between four employment outcomes that are anticipated as a consequence of switching to a low carbon economy. It is expected that: additional jobs will be created; jobs will be substituted; jobs will be eliminated; and existing jobs will be transformed (UNEP, 2008). Arguably, however, a further outcome of 'job displacement' could transpire as a consequence of 'carbon leakage' - the relocation of industries to abroad due to less stringent CO_2 standards.

However, the concept of 'green jobs' is a notoriously vague. International organisations such as UNEP (2008) have tried to solve this problem by defining 'green jobs as work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality.' EUROSTAT (2011); on the other hand, does not attempt to define green jobs per se, but instead defines the 'Environmental Goods and Service Sector' as 'a heterogeneous set of producers of technologies, goods and services ... that seek to protect the environment or minimise the use of natural resources'.

Although such definitions are now firmly entrenched in much of the discourse, the European Commission, when referring to job estimates, has steered away from using them in practise. The Employment Committee argues that '[a] too narrow definition of the 'green economy' or 'green jobs' risks missing out on the wider economic and labour market effects of the environmental challenge' (EMCO, 2010).

With varying definitions of what a 'green job' is, present figures estimating the potential employment impact of a transition to a low carbon economy vary considerably. According to ECORYS (2008), gross employment forecasts for Europe in the year 2020 range between 2.3 million to 21 million.

Along with differing definitions, the discrepancy between employment estimates is also caused by a diverse range of methodologies being used, making it difficult to accurately draw comparisons between results (Breitschopf, 2011). This problem is further exacerbated by the fact that the approach taken and assumptions underlying estimates are not always explicitly stated (Hughes, 2011). As a consequence of such diversity, the reliability of estimates has increasingly been called into question.

Finally, the EU set a distinct goal in relation to renewable energy in the Climate Change and Energy Package to see an increase in the share of renewable energy in final consumption of 20% by 2020 compared to the year 1990 (European Commission, 2013). Considering that member states are legally bound to meet such targets, renewable energy sources (RES) – particularly through its role in electricity generation (RES-E) - is anticipated to be a key driver in the changing dynamics of employment resulting from green growth.

The purpose of this paper is to have a clearer understanding of what are the implications of government support for renewable energy on jobs, and to see if current claims over employment benefits are too optimistic or even pessimistic in light of these findings. From this, conclusions will be made regarding the extent to which current renewable energy measures account for their employment effects, and whether or not the workers are adequately prepared for the transition. Conclusions will be reached based on the analysis but also with reference to the literature and specific context of the UK.

The remainder of this paper is structured as follows: Section 2 provides a brief review in terms of the techniques used to quantify the employment effects, in particular, how studies have attempted to make employment projections. Section 3 introduces the case of the UK by first giving background information on how the government has thus far responded to the threat of climate change, before going on to describe the developments of the renewable energy policy in the country. Section 4 outlines the methodology applied to arrive at employment estimates. The results are then interpreted before final conclusions and suggestions for further research are provided in Section 6.

2. Methodologies to estimate employment effects

There are a number of identifiable methods that have been used to quantify the employment impacts of RES. However, in general, it is possible to categorise them into bottom-up and top-down approaches, or more specifically as using the analytical or IO method (World Bank, 2011; Silva et al., 2012).

The first method uses survey or model plant data to establish the employment required to manufacture and operate a plant or certain piece of equipment and, therefore, it is a method that is most suitable to studies aimed at quantifying job effects of a precise energy project or industry (World Bank, 2011). Sterginzer (2006), for example, created a 'job calculator' which is based on a survey of current industry practices to measure the number and types of jobs resulting from the acceleration of renewable energy deployment. One of the main advantages of the analytical approach is that it can be made context specific and it is said to be more transparent than the IO framework (World Bank, 2011). However, the disadvantage is that it is less suited for forecasting economy-wide impacts as it cannot take into account the indirect employment effects, i.e. the effect on other sectors due to an increase in final demand for RES (Wei, 2010).

This is somewhat of a turn-off for policy-makers, such as the European Commission, who are keen to stress the positive supply chain employment effects also. The second approach, on the other hand, allows for the estimation of both the direct and indirect employment effects and it is typically used to quantify the number of employed persons at the national/regional level. In brief, an IO table gives an overview of the flows of goods and interdependencies of industries. Based on the target output or investment intended in renewables, the level of associated employment can be calculated from this link (World Bank, 2011). The major drawback, however, is that because the RES sector brings relatively new concerns, current IO tables are not sufficiently disaggregated to straightforwardly arrive at employment estimates (World Bank, 2011). It is therefore not only because different methodologies are being used that employment estimates may vary but also because different assumptions are being made even when the same methodology has been applied. Further variation, in some instances, is also due to the fabrication of original employment estimates. The European Commission (2012), for example, stated that if the renewable energy targets are met, then 3 million new jobs could be created by 2020 across Europe. However, the Commission based this number on the results of a study, which conducted an IO analysis and calculated that total gross employment to be between 2.3 million to 2.8 million (Ragwitz, 2009). Therefore, stakeholders, such as the European Commission, are presenting estimates in a way that 'leads to an overly optimistic impression of how many jobs are actually being created in the economy' (Lambert and Silva, 2012). Of special concern, when considering the accuracy of job estimates, is that many estimates are produced by, or on behalf of, RES itself and there is therefore a vested interest in conveying the message that the sector is a job creator in order to receive both financial and political support.

One of the main criticisms of current employment estimates relates to the so-called labour intensity of RES. The green transition is expected to be a job creator, partially because low carbon sectors are said to be more labour intensive than high carbon industries (Lambert and Silva, 2012). That is to say, more workers are needed for the same amount of output. However, the high labour intensity of renewables relates to the fact RES is more costly than supporting existing fossil fuel industries; the labour intensity of RES is not compensated for by lower capital intensity, thus the cost of the factors of production are higher (Bowen, 2012).

At present, renewable sources can only penetrate energy markets with the aid of large government subsidies. It is therefore argued that when calculating the net employment effects (i.e. jobs created in RES minus those destroyed, e.g. in traditional energy sectors), consideration should be given to jobs that could have been generated if the money used for subsidising RES was invested elsewhere (Marsh and Miers, 2011). Moreover, despite government support, the amount is typically too small to keep the costs low enough for it not to affect the consumers, who are eventually the ones having to bear the burden e.g. by paying higher electricity prices. This too can have a negative impact on jobs as consumers of energy will have less money to spend on other products, which can lead to the reduction in demand for labour in those sectors that will suffer as a consequence. It is therefore claimed that such induced effects should also be factored into net employment estimates (Hughes, 2011).

Additionally the argument that RES is a job creator because of higher labour intensity is further weakened when viewing the nature of these jobs. RES is said, in part, to be more labour intensive due to the jobs it initially creates in the construction, installation and manufacturing of new facilities, which are physically demanding activities (Lambert and Silva, 2012). Yet such jobs are likely to have relatively short life spans, as the work will diminish once the new facilities/plants have been developed. This will then leave the bulk of job creation in activities such operations and maintenance, which in comparison, are inclined to demand less manpower.

3. The Renewable Energy Sector in the UK

Historically, the UK's mechanisms for supporting RET have been more complex than the typical feed-in-tariffs (FIT) used by their European counterparts, due to the UK favouring minimum intervention within primary markets (Mitchell, 2007). There has been a delivery structure for renewable energy in the UK since 1990, when the Non Fossil Fuel Obligations (NFFO) was established (Wood and Dow, 2011). The function of NFFO was to subsidise non fossil fuels using funds from a Fossil Fuel Levy set up the year prior under the Subsidy 1989 Act. However, initially its main priority was to support Nuclear power with renewable energy only eligible for support when the Fossil Fuel Levy was raised later in the year, under the Electricity Act 1990 (Bouwen and Fankhauser, 2011). Deployment was nonetheless slow, largely as a consequence of the difficulties in receiving planning permission but more predominantly because the subsidy was too low for renewables to be seen as an attractive business option. The Renewables Obligation (RO) was therefore introduced in 2002 to largely deal with perceived defects resulting in the reversal of the rules of NFFO (Wood and Dow, 2011). Yet this in itself has acted as a barrier for new technologies to enter the market, as it has been cheaper for suppliers to opt for RET that are already relatively established and cheaper in price (Wood and Dow, 2011). In 2009 the Electricity Market Reform was introduced along with the so-called 'Contracts-for-difference', which introduce a FIT that will be used to guarantee a fixed price for generators producing energy, therefore allowing for greater incentives to supply energy from newer technologies, and thus for investments to be made.

In the meanwhile, as a member state of the EU, the UK has a legal obligation to contribute to fulfilling the goals of the European Energy and Climate Change Package set out in the European 2020 Strategy (European Commission, 2013). In line with European legislation, the UK declared its commitment to reduce GHG emissions by at least 34% compared to 1990 levels and to increase the share of renewable energy to 15% by 2020 (UK Government, 2013). In this context, the European Renewable Energy Council (EREC, 2013) recently ranked the UK 25th out of the 27 member states on its progress in meeting the renewable energy target for 2020. In 2010 it was recorded that only 3.3% (54TWh) of energy consumption came from renewables and as a consequence the UK was the only country that did not achieve its first interim target under the Directive by the end of 2011 (4.04% for 2011 to 2012) (EREC, 2013).

Furthermore, in 2012 it was recorded that the contribution of renewable energy sources to electricity generation stood at a mere 11.3% (DECC, 2012).

As a result of the facts previously stated, the assessment of the employment impact of the growth in RES in the UK is highly complex, namely considering future support and investment in this sector remains uncertain. There are very few academic papers, relative to other EU countries, such as Germany that attempt to quantify the impact of RES on employment (e.g. Hillebrand et al., 2006; Lehr et al., 2008). Another country of interest is Scotland because it has enormous possibilities for on and offshore wind, wave and tidal energy and thus storing much of the UK's potential for RES generation. In this context, Allan et al. (2007) explored the likely implications of the increased use of alternative electricity generation technologies on the Scottish economy. The study utilised the IO model and reached the conclusion that although there will be a boost to employment, it will not necessarily be enough to offset the negative impacts that will be swallowed by the workers in the non-renewable energy sector.

The only comparable study that has been commissioned by the UK government was released in 2004 by a steering committee, which included the Department of Trade and Industry (DTI). DTI (2004) took an analytical approach using a survey-based model to derive employment estimates. The committee reckoned that the industry could sustain a total of 17,000 to 35,000 jobs per year up to 2020 if the aspirational goal of 20% renewable energy consumption was met. However, the reliability of DTI's findings are questionable given that RES has advanced considerably since 2004, along with the fact that the analytical approach is not ideal for making projections at the national level as it cannot account for indirect employment effects.

Albeit academic papers on the topic are far and few between, there are estimates that have been produced by interest groups. For instance, the Renewable Energy Association (REA), which is the largest renewable trade association in the UK, has been particularly vocal in promoting the employment potential benefits of RET. REA (2012) claims that in 2010/2011 the RES sector supported 110, 000 jobs and claimed that by 2020 it could support a staggering 400,000 jobs. However, REA's analysis is constructed mainly through the evaluation of business registers and case studies, therefore according to Breitschopf et al. (2012) '[t]his approach raises questions as to how companies active in the RES field were identified, how double counting was avoided or how the share of RES in turnover, exports and employment were estimated without surveying the companies'. Breitschopf et al. (2012) promote the use of the IO method in their 'methodological guidelines for estimating the employment impacts of using renewable energies for electricity generation' and whilst they do not provide a thorough analysis of the employment potential of RES in the UK, they do provide, as part of the annex, an illustration of how the IO method can be applied and found that in 2009 the 'British RES-E industry employed approximately 16,000 persons', which is a serious contrast to the REA (2012) figure of 110,000 for the following year.

At the other end of the spectrum the consultancy group 'Verso Economics' in 2011 claimed that for every job created in RES in the UK, 3.7 jobs will be lost elsewhere (Marsh and Miers, 2011). These forecasts were reached by conducting an IO analysis. Unlike other studies, Marsh and Miers (2011) attempted to calculate the net employment effect by comparing the amount of jobs created in RES to the amount of jobs that could have been created if the subsidies received by RES were spent elsewhere, i.e. on needed infrastructure projects.

Although it is no doubt important to calculate the net employment effects to get a comprehensive picture of how the workforce will be affected, doing so depends to a large extent on the ability to create a realistic counterfactual. In other words it is necessary to understand what would have been the case if investment in renewables did not take place. It is a task which requires a much deeper analysis than simply considering the opportunity costs of subsidisation or equating an increase in financial support for renewables directly with a decline in support for fossil fuels. Indeed given the uncertainty over future costs, both to renewables and fossil fuels and the volatile political climate in the UK with regards to energy policy, net estimates run the risk of becoming unpredictable.

4. Methodology

To generate employment figures, a vector of employment per unit of output is required. As already mentioned it is possible to get the amount of expenditure on the different inputs required per unit of expenditure from the IO table, including the input of labour. To therefore change the expenditure on labour into the amount of jobs needed per unit of output, information on the number of employees and average wage is needed for each sector. This information is not provided by the IO table but must be gathered from other sources.

The difficulty in arriving at the employment effects associated with electricity generation from RES is that published IO tables, including for the UK, currently only identify a single electricity sector and do not distinguish between electricity produced from different energy sources. Thus in their present form, IO tables cannot identify the number of jobs that are likely to be created from an increase demand for electricity generated from renewables, but only the impact of an increase in demand for electricity in general, regardless of whether it is from fossil fuels or alternative sources of energy.

One way in which this problem can be resolved is to decompose RETs into their various activities/components and associated costs, and then match these to the sectors identified in the IO table of the economy under analysis and exploit the relevant employment coefficients and multipliers to arrive at employment estimates (see e.g. Pollin et al., 2009; Garrett-Peltier, 2010; Tourkalis and Mirasgedis, 2011; Silva et al., 2012; and Oliveira et al., 2013). To do this, the approach provided by Breischopf et al. (2012) will be largely followed.

First, each RET needs to be divided into its different life cycle phases (e.g. installation, operation and maintenance) and then these phases need to be further decomposed into their respective activities/components. Through collecting information on the total expenditure connected to each life cycle phase, along with data on the cost share of each relevant activity/component as a percentage of the corresponding life cycle phase, it is then possible to calculate the total output (in £) of each of these relevant activities/components. The calculation is slightly different depending on the life cycle phase.

i) Manufacturing and Installation

Annual increase in MW installed × the investment cost per MW installed × the share of the cost component for the RET (minus the % of that share which actually comes from abroad and not produced as domestic output). (1)

When considering the domestic output related to manufacturing and installation, it must be remembered that this phase of the RET's life cycle is relatively short-lived. It is usually only relevant if there is an increase in installed capacity, which, for example, will require the construction of new plants or the expansion of existing ones. Hence, the reason why total expenditure of this stage is calculated as the total investment cost associated with the increase in installed capacity only (e.g. installed capacity of Year 2 minus that of Year 1). To then arrive at the domestic output of a particular activity/component that contributes to the manufacturing and installation stage, it is simply a matter of multiplying this investment cost by the share of it which is distributed to the specific activity/component, but also with care to subtract the part of that share which is actually spent abroad. For example, Wind Turbine Rotor Blades make up 8% of manufacturing and installation costs, however 90% of this is spent abroad on foreign output, meaning only 0.8% (10% of 8%) is spent on the production of the rotor blades as domestic output. It is essential that only domestic output is considered so that when using this data to calculate employment estimates, the number of jobs expected to be created within the UK are not overestimated.

ii) Operation and Maintenance

Total MW installed × the specific operation costs per MW installed × share of cost component (2)

To calculate the domestic output related to the operation and maintenance phase is less complicated, firstly because all related activities are typically domestic and therefore expenditure is not spent abroad on foreign output. Furthermore, activities related to operation and maintenance are in constant demand and not necessarily only when there is an increase in installed capacity. For this reason, total expenditure for this phase of the life cycle is calculated as the total operation costs associated with the total MW of electrical capacity installed. This calculation is then multiplied by the share of the individual cost components that contributes to the operation and maintenance phase, in order to arrive at the domestic output of each.

iii) Fuel input

Fuel × fuel cost (3)

Bioenergy, unlike other renewable energy sources, requires fossil fuel energy as an input into its production. Therefore, for this life cycle phase, the domestic output is equated to the multiplication of each fuel input by the specific fuel cost, whether this is for biogas, biomass co-firing, biomass small or large scale – all of which play a part in the UK's energy mix.
With the domestic output identified for each activity relevant to the specific stages of each RET, to then take advantage of the IO method, the output of these activities/components need to be allocated to the industries, as classified in the IO table, responsible for producing this output.

By matching the domestic output of each activity/component of a particular RET to the industries identified in the IO table, the labour coefficients corresponding to the relevant sectors can be exploited in order to then calculate the direct employment effects.
The calculation is the multiplication of each total change in output by the job creation ratio.

Marginal Increase in Employment = Marginal growth × (employment/total production) (4)

The total direct effect is therefore simply the sum of all marginal increases occurring in each relevant sector.
Then, to calculate the indirect employment effects connected to the increase in domestic output, the Leontief Inverse Matrix is needed. By converting the IO table into the Leontief Inverse Matrix, the employment multipliers relating to each industry involved in producing domestic output can be exploited. Again this needs to be done for all domestic output that is associated with a specific RET.

5. Data, assumptions and results

5.1. Data

Unfortunately the most recent IO table provided by the UK National Statistics Office is for the year 2005, since which RES has advanced substantially. The decision was therefore taken to use the Scottish IO table that was last updated for the year 2009. The World Bank (2011) acknowledges that IO data from one country can be applied to another to produce employment estimates so long as this application can be justified, i.e. the production processes (labour and capital inputs) are similar, which is the case when comparing the UK as a whole with Scotland.
Another issue that needed to be addressed before conducting the analysis relates to the classification system used to identify the different industries in the IO table. Both the UK and Scotland IO tables use 'Standard Industrial Classification' (SIC) codes as opposed to the 'Nomenclature statistique des activités économiques dans la Communauté européenne' (NACE) codes, with the latter being preferred by the EU and

used by the majority of member states. The data, however, used to determine the expenditures and cost components of each RET and the subsequent breakdown of these into their relevant industries is done so on the basis of NACE codes. To therefore make the data compatible, the industries of the Scottish IO table were changed in line with the NACE classification system. For example, industries classified as ‘36 - Iron and Steel’ and ‘37 - Other Metals & Casting’ by SIC coding, were merged together to form ‘27 – Manufacture of basic metals’, which is the NACE code for this industry. The data in the columns and rows of both sectors had to therefore be carefully merged together to make the new IO table. See Annex 1 for the full list of changes.

In line with the data available the baseline year of this study is 2009, from which projections are made for the year 2020. A full list of data sources used to construct the analysis in this paper can be found in Annex 2.

5.2. Assumptions

The Department of Energy and Climate Change have set a minimum target for renewables to deliver 29GW of electricity capacity in the UK by 2020 (an increase of 21 GW from 2009). Figure 1 shows how each RET is expected to contribute to the total installed capacity of electricity delivered by renewables in 2020.

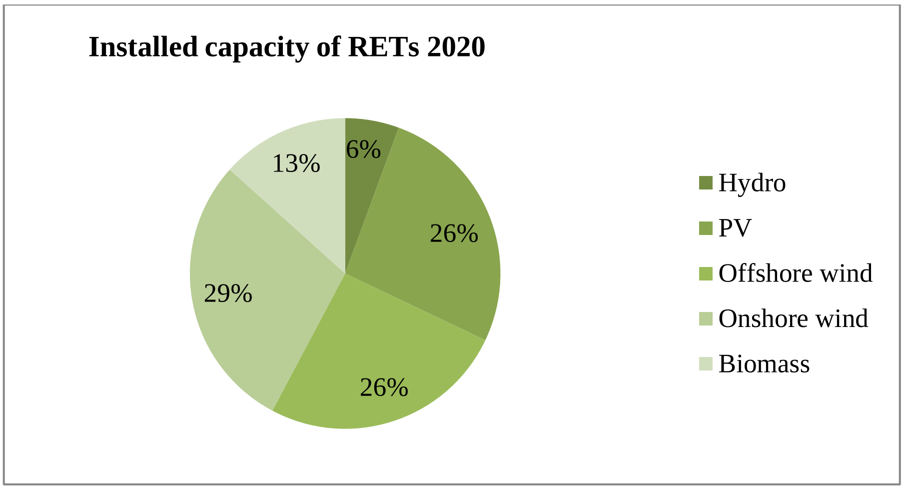

Figure 1. Installed capacity of RET in 2020 (Source: DECC, 2013)

Onshore wind is expected to have the largest installed capacity at 13 GW, shortly followed by Photovoltaic - PV (11.9GW) and offshore wind (11.6 GW). This is quite a difference from 2009, when after onshore wind, biomass and hydro power had the greatest electric capacity, whereas PV accounted for less than 1% of the total. The contrast is the result of the fact that there is a lot of potential for deploying offshore wind, and also PV due to technological advances, whereas options to increase installed capacity of hydropower are already said to be mostly exhausted with it being the longest established RET in the UK.

Nonetheless, when looking to the actual electricity generated for the year 2020, which is expected to be approximately 102 TWh, biomass produces the most electricity (35% of total generated from RETs), followed by onshore and offshore wind energy. PV accounts for only 9% of expected electricity generation. Generators do not operate at their full capacity and in some instances do not generate electricity at all at given times of the year or day. The reasons are manifold, ranging from cost considerations to the conditions of the power plant. One of the main reasons as to why biomass is expected to generate more electricity than wind or PV, despite having a smaller installed capacity, relates to the fact that wind and PV technologies heavily depend on weather conditions to generate electricity whereas biomass does not. RET such as tidal and geothermal are not included as part of the renewable energy mix for 2020 as they are only now starting to move from proto types to the project development stage in the UK (DECC, 2012).

5.3. Results

From our analysis it is estimated that there will be 95,999 jobs, with 65,323 direct and 30,676 indirect, associated with the increase in installed capacity of RET in 2020. Figure 2 shows the total number of jobs by life cycle phase projected for the year 2020. The installation of new facilities accounts for the majority of jobs with both direct and indirect totalling to 59,290. When comparing the number of direct jobs created due to installation of new facilities compared to those in operation and maintenance, the results confirm that the installation and construction of new facilities is generally more labour intensive as already discussed. The indirect employment effect is understandably larger for the installation compared to operation as the demands on the supply chain are likely to be much greater due to the need for different materials and services to construct the new facilities. Given that fuel is only an input for bioenergy, the number of associated jobs is relatively small, with a total of 10,044, when compared to the other phases of RET.

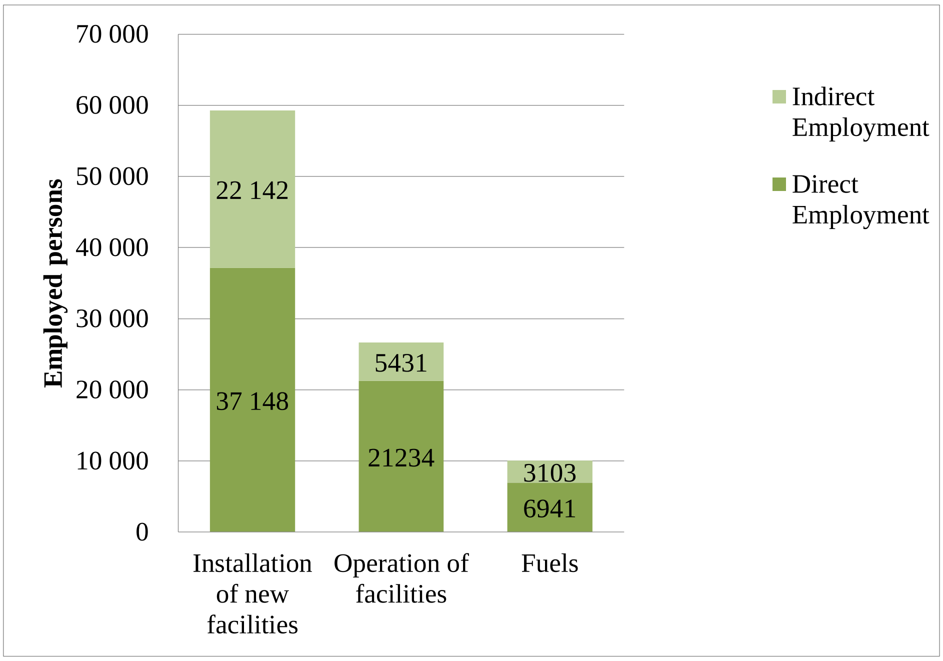

Figure 2. Total employment by life cycle phase in 2020

When comparing the number of potential employed persons in the year 2020 to the baseline year in 2009, which can be seen in Figure 3, there is a substantial increase of approximately 69,366 more jobs resulting from an increase in installed capacity of RETs.

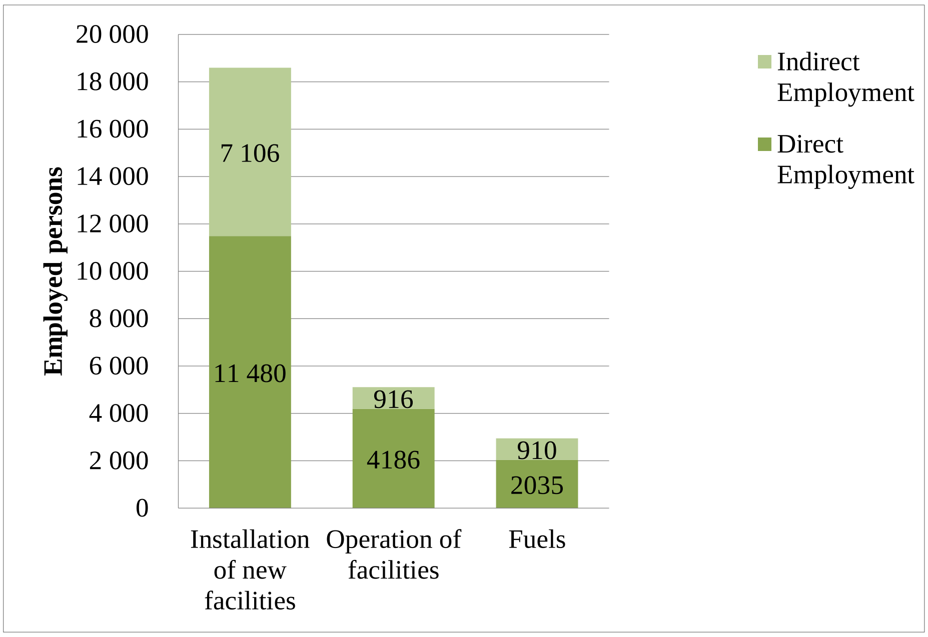

Figure 3. Total employment by life cycle phase 2009.

Figure 4 breaks down the number of jobs by technology in order to see which renewable energy source is expected to create the most jobs in the year 2020. Although installed capacity of onshore wind and PV is greater than for offshore wind, the latter technology is expected to create the largest number of direct jobs when considering those in installation and operation combined. This is because offshore wind is one of the most physically demanding RET to construct as well as operate, especially the further offshore and remote the marine environment is within which wind farms are being built.

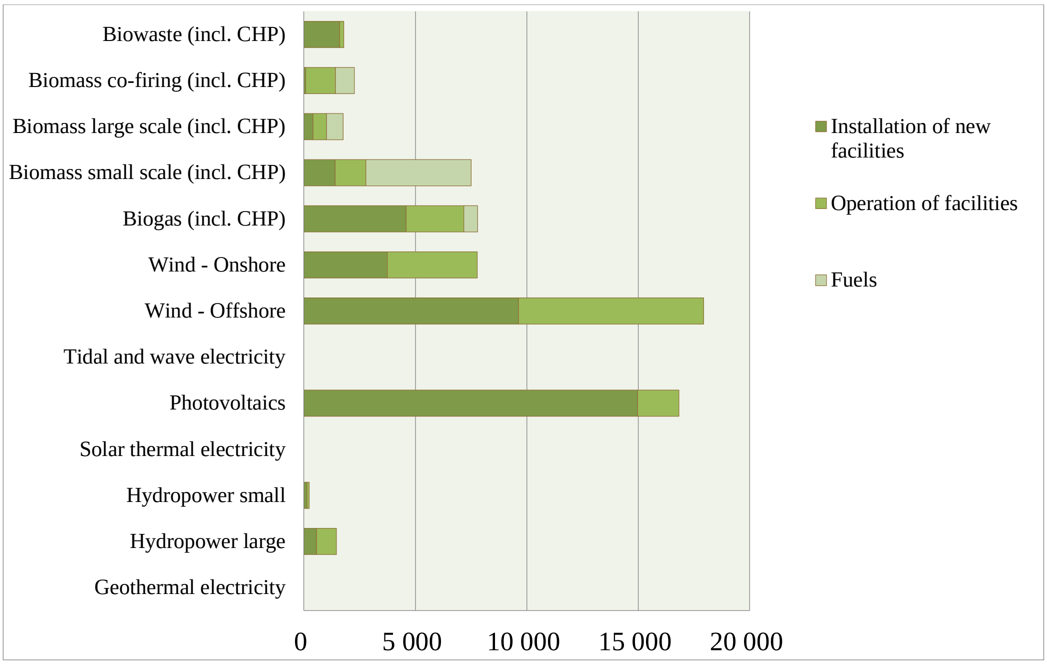

Figure 4. Total direct employment by technology

When considering jobs in installation only, PV is associated with the highest level of employment. This is most probably because it has the biggest hike in installed capacity compared to 2009, but also because the deployment of this technology in the UK is relatively new and therefore cannot benefit from efficiencies that come with experience. Moreover its deployment is likely to be widespread rather than concentrated in specific areas, as is the case with wind power, and thus will demand more labour. Employment associated with hydropower is expected to be much lower than for the other RETs. Again this relates to the fact that only a minimal increase, approximately 888MW in installed capacity is predicted compared to the year 2009.

Figure 5 shows the number of indirect jobs associated with each RET. For all technologies, the indirect effect is smaller than the direct employment effect. The indirect effect is largest for PV due to the heavy demands that installation will place on the supply chain. In general, the installation of new facilities is the cause of most indirect employment effects, with the exception of biomass small scale whereby more jobs are created indirectly as a result of fuel input.

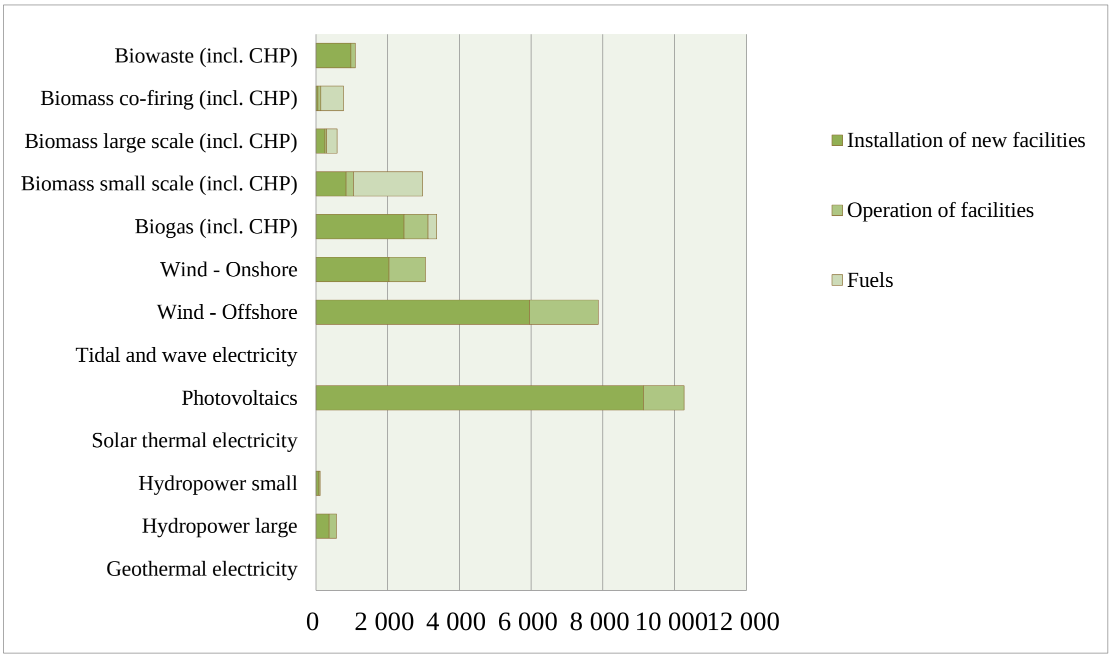

Figure 5. Total indirect employment by technology

Overall PV is expected to create the largest number of jobs with a total of 27,085. However, when considering which technology has the highest employment enhancing potential it is actually bioenergy that takes the lead. Bio waste and biogas produce the highest number of operation and maintenance jobs per unit (MW) of installed capacity. Similarly per each unit of increased installed capacity for the year 2020, biomass co-firing, followed by biomass large and small scale can expect to employ (directly and indirectly) the largest amount of workers in installation. Bioenergy is different to other renewables, such as wind, in the sense that the energy source needs first to be cultivated. Extra labour input is therefore needed in the feedstock production, harvesting, processing and haulage of bioenergy, which is probably one of the main reasons it is found to be more labour intensive than other RET. On the other hand, onshore wind and hydro-power require the least amount of employees per unit of installed capacity, therefore implying that technologies which have been established for longer in the market tend to require less labour input, for example, as they have learned how to become more efficient.

The employment estimates provided for the year 2020 are based on the assumption that each individual RET target will be met. However, if each RET met it's individual target then total installed capacity would be substantially more than the minimum goal set by the government of 29GW by 2020.
Therefore a sensitivity test was conducted that estimates what the possible employment effect would be if electric capacity of RET combined for the year 2020 was 29GW only. It has been assumed that the shares of each RET in the total installed capacity of renewables remains the same in the sensitivity test as projected above, but the total capacity of each RET is reduced.

Figure 6 shows that if total installed capacity of renewables for 2020 is 29 GW, then there would be approximately 59,143 employed persons as a result, which is considerably less than the 95,999 originally estimated.

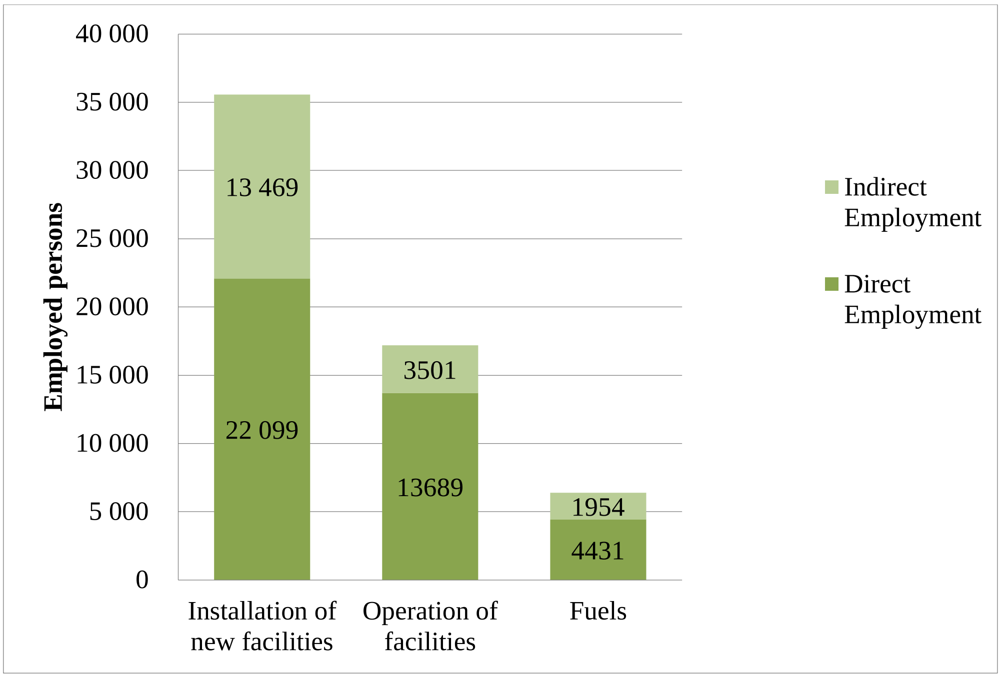

Figure 6. Employment effect with 29GW installed capacity

6. Conclusions and future work

As a means to prevent climate change, along with establishing increased energy security, the EU set member states ambitious targets to increase the share of electricity generated from renewable energy technologies by the year 2020. Particularly since the release of these targets, policy-makers, interest groups and academics alike have made the claim that the exploitation of RES in power generation will lead to the creation of an incredibly large number of jobs and will act as critical stimulus for Europe's wavering economy. However, such claims have come under increasing attack by critics who argue that the employment benefits have been largely overstated.

Given that policy decisions are influenced by provided employment estimates, this thesis has sought to discover whether such estimates are indeed accurate and whether, as a consequence, policy makers are sufficiently aware of what the likely impact will be on the workers. By taking the UK as a case study, this thesis provided an assessment of the impact RES-E targets will have on employment. By conducting an analysis based on the IO approach, the job creating potential of each RET in the UK was projected for the year 2020.

It was found that if each RET met its individual target for installed capacity by 2020, then the industry would support, directly and indirectly, just under 100,000 jobs. Whilst the employment implications of exploiting renewables in the power sector are undoubtedly significant and could prove to be of real benefit to the UK workforce, when comparing the number of jobs estimated in this thesis to estimates such as those made by REA, the impact appears modest.

The REA claims that there could be a total of 400,000 jobs associated with RES by 2020. A small fraction of REA's estimate relates to jobs borne out of an increase in the use of renewables for heat and transport, which were not accounted for in the analysis of this paper. However, the fraction is not large enough to account for the discrepancy between the results. For example, in the same report the renewable trade association estimated that already in 2010/11 wind power and its supply chain accounted for 31,400 employed persons in the UK, which is only slightly less than the projected employment figure given in this paper for wind energy in the year 2020 (36,619 jobs), when installed capacity is forecasted to be much greater. It is possible that REA's estimates are higher because they include induced employment effects – employment arising from increased demand for other goods and services because of the increase in purchasing power (income) of workers directly and indirectly employed by RES – yet without a detailed outline of the methodology, the reason for why REA's estimates are comparatively larger remains unclear.

Thus in making the comparison it becomes apparent that current published employment estimates, such as those provided by REA, are presenting an 'overly optimistic' impression of the potential benefits a move to a low carbon economy will have on the workers (Lambert and Silva, 2012). Employment estimates need to be made more transparent so as to avoid the argument made by critics like Hughes (2011) that the British public are being 'bombarded' with 'hyperbolic claims' about the 'hundreds, thousands, millions of jobs' renewable energy can support without providing hard factual evidence.

The employment estimates presented in this paper are based on the assumption that the 2020 renewable energy targets for each technology will be met and therefore should be considered as a best-case scenario. In reality, with the UK government failing to keep on top their renewable commitments, the number of jobs associated with renewable energy could be considerably less than forecasted, as the sensitivity test shows.

Furthermore, the analysis showed that the majority of jobs would be in the installation of the new facilities, and therefore many of these jobs are likely to be only temporary, as opposed to in operation and maintenance, where the jobs are usually more permanent. Unless the installed capacity of renewables continues to increase at the same rate beyond 2020, then RES will not be able to sustain the high number of jobs predicted by the analysis, as jobs in installation and construction will be reduced once the extra capacity has been fully built.

Finally, it can also be inferred from the analysis that the labour intensity of renewables tends to decline as experience in installing and operating the technology increases. As hydropower and onshore wind have been deployed in the UK over a longer period, these technologies have become more efficient with time, both because of improved capabilities and technological advances, which means they require less labour input per MW of installed capacity. Therefore, given that IO analysis assumes that the technological coefficients are fixed, including the labour coefficient, it is possible that the number of jobs in 2020 will be less than predicted in this paper, as newer technologies such as offshore wind and PV learn how to use less labour to produce the same amount of output.

This paper has brought to light the urgent need for more robust data on RES in the UK. The lack of clarity and consensus over employment estimates stems largely from unreliable and missing statistics on the sector. Whilst this study provides employment estimates in order to develop a better understanding of the situation in the UK, these estimates are only as good as the data that underpins it. Further effort to revise and collect data that is necessary for producing employment estimates is therefore encouraged so as to put an end to the disparities currently haunting the literature. For example, an up-to-date IO table and cost structures of RET would help to improve the accuracy of estimates which are derived from an IO analysis. Ideally IO tables would be expanded to allow for the inclusion of RES as its own separate industry. Though this recommendation is unlikely to be met any time soon, the UK and Scottish National Statistics Office certainly ought to consider using the NACE classification system when constructing the tables to allow for cross country comparisons to be made with more ease.

Despite the fact that the analysis presented in this paper only calculated gross employment estimates, it is recommended that future research is concentrated also on establishing the net effects. It was previously argued that recent attempts to provide net employment estimates in the UK are not overly reliable. This was partly concluded because such estimates have been made without adequately taking into account the different factors, such as induced effects, which could influence the results, but also partly because the current uncertainty surrounding the UK's renewable energy policy makes such kind of an analysis near impossible.

With the Electricity Market Reform still under negotiation, it is not yet clear what the 'strike price' will be that subsequently determines the size of the FIT paid to generators for producing renewable energy. Without knowing the kind of financial support that will be provided to RES in the future - nor without knowing whether this will lead to less money being made available for investment elsewhere, or if it will lead to the reduction of subsidies currently paid to the fossil fuel industry - it is very difficult to contemplate how many jobs (or potential) will be lost as a consequence of the transition. The need for a stable policy environment is therefore crucial not only for ensuring any employment benefits are optimised but also to enable a full assessment of what the expected consequences, both positive and negative, will be for employment.

By identifying the number of jobs that will be created and what kind of jobs they are, i.e. whether in construction, operation etc., it is important to then know what type of skills are needed to perform these roles. However, thus far, this kind of information has been limited – largely because of the unpredictability associated with the transition and also because it is likely that the skill needs will be different according to local contexts (OECD, 2012).

At a general level, it has been acknowledged by organisations such as the OECD (2010) that there will be a need for highly skilled and qualified labour (OECD, 2010). As with any structural change the speed and the extent of the transition will depend considerably on how well technical skills are aligned to new job requirements; researchers and innovators will be needed so that low carbon ideas can be easily brought to market; and workers with technical capabilities will be needed to put these ideas into practice. However along with the need for high skilled workers, there will also be a demand for low skilled workers. First, in the short term, in jobs associated with construction and manufacturing; and second, in the long term, as the employment effects are expected to 'trickle down' to society at wide, with every job set to become a 'green' job. To therefore ensure new demands are met and that the labour force are ready to take advantage of new opportunities, it is important that further research is carried out that can map out the specific skill sets which will be required.

Finally it is increasingly recognised that along with determining the quantitative impact on employment, the qualitative impact also needs to be addressed to fully appreciate the consequences of moving to a low carbon economy. There tends to be an assumption in much of the past literature that green jobs are also of good quality that are well paid and with good working conditions (GHK, 2008). However 'one of the greatest risks is that, in our haste to create a large quantity of new green jobs, we pay too little attention to their quality' (Mattera, 2009) - 'green' after all does not necessarily mean social. Although there have been a number of case studies, particularly by trade unions which have been produced in recent years, it is important that research continues to look at the qualitative and social impacts. Whilst a quantitative analysis, as presented in this paper, provides a significant and vital step towards understanding the employment effects of switching to a low carbon economy, it is important to go beyond the numbers to truly understand how the transition will impact the workers.

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Annex 1

SIC 2007 Code		NACE Code	
Agriculture	1	01	Agriculture, hunting and related service activities
Forestry planting	2	02	Forestry, logging and related service activities
Forestry harvesting	3		
Fishing	4	05	Fishing, operating of fish hatcheries and fish farms;
Aquaculture	5		
Coal & lignite	6	10	Mining of coal and lignite; extraction of peat
Oil & gas extraction, metal ores	7	11	Extraction of crude petroleum and natural gas;
Other mining	8	14	Other mining and quarrying
Mining Support	9		
Meat processing	10	15	Manufacture of food products and beverages
Fish & fruit processing	11		
Dairy products, oils & fats processing	12		
Grain milling & starch	13		
Bakery & farinaceous	14		
Other food	15		
Animal feeds	16		
Spirits & wines	17		
Beer & malt	18		
Soft Drinks	19		
Tobacco	20	16	Manufacture of tobacco products
Textiles	21	17	Manufacture of textiles
Wearing apparel	22	18	Manufacture of wearing apparel
Leather goods	23	19	Tanning and dressing of leather
Wood and wood products	24	20	Manufacture of wood and of products of wood
Paper & paper products	25	21	Manufacture of pulp, paper and paper products
Printing and recording	26	22	Publishing, printing and media
Publishing services	66		
Coke, petroleum & petrochemicals	27	23	Manufacture of coke, refined petroleum products
Paints, varnishes and inks etc	28	24	Manufacture of chemicals and chemical products
Cleaning & toilet preparations	29		
Other chemicals	30		
Inorganic chemicals, dyestuffs	31		
Pharmaceuticals	32		
Rubber & Plastic	33	25	Manufacture of rubber and plastic products
Cement lime & plaster	34	26	Manufacture of other non-metallic mineral products
Glass, clay & stone etc	35		
Iron & Steel	36	27	Manufacture of basic metals
Other metals & casting	37		
Fabricated metal	38	28	Manufacture of fabricated metal products,

SIC 2007 Code		NACE Code	
Machinery & equipment	41	29	Manufacture of machinery and equipment n.e.c.
Computers, electronics & opticals	39	30	Manufacture of office machinery and computers
Electrical equipment	40	31	Manufacture of electrical machinery and apparatus
Film video & TV etc	67	32	Manufacture of radio, television and communication
Broadcasting	68		
Computers, electronics & opticals	39	33	Manufacture of medical, precision
Motor Vehicles	42	34	Manufacture of motor vehicles, trailers
Other transport equipment	43	35	Manufacture of other transport equipment
Furniture	44	36	Manufacture of furniture; manufacturing n.e.c.
Other manufacturing	45		
Electricity	47	40	Electricity, gas, steam and hot water supply
Gas etc	48		
Water and sewerage	49	41	Collection, purification and distribution of water
Construction - buildings	52	45	Construction
Construction - civil engineering	53		
Construction - specialised	54		
Building & landscape services	90		
Repair & maintenance	46	50	Sale, maintenance and repair of motor vehicles
Wholesale & Retail - vehicles	55		
Wholesale - excl vehicles	56	51	Wholesale trade and commission trade
Retail - excl vehicles	57	52	Retail trade, except of motor vehicles and motorcycles
Repairs - personal and household	102	52	
Accommodation	64	55	Hotels and restaurants
Food & beverage services	65		
Rail transport	58	60	Land transport; transport via pipelines
Other land transport	59		
Water transport	60	61	Water transport
Air transport	61	62	Air transport
Support services for transport	62	63	Supporting and auxiliary transport activities
Travel & related services	88		
Post & courier	63	64	Post and telecommunications
Telecommunications	69		
Financial services	72	65	Financial intermediation
Insurance & pensions	73	66	Insurance and pension funding
Auxiliary financial services	74	67	Activities auxiliary to financial intermediation.
Real estate - own	75	70	Real estate activities
Imputed rent	76		
Real estate - fee or contract	77		
Rental and leasing services	86	71	Renting of machinery and equipment without operator
Computer services	70	72	Computer and related activities
Information services	71		
Research & development	82	73	Research and development

SIC 2007 Code		NACE Code	
Legal activities	78	74	Other business activities
Accounting & tax services	79		
Head office & consulting services	80		
Architectural services etc	81		
Advertising & market research	83		
Security & investigation	89		
Business support services	91		
Public administration & defence	92	75	Public administration and defence
Education	93	80	Education
Veterinary services	85	85	Health and social work
Health	94		
Residential care	95		
Social work	96		
Waste	50	90	Sewage and refuse disposal, sanitation
Remediation & waste management	51		
Membership organisations	101	91	Activities of membership organisation n.e.c.
Creative services	97	92	Recreational, cultural and sporting activities
Cultural services	98		
Gambling	99		
Sports & recreation	100		
Other professional services	84	93	Other service activities
Employment services	87	93	
Other personal services	103	93	
Households as employers	104	95	Private households with employed persons

Annex 2

Data type	Source
Capacities, generation and fuel input of RE facilities 2009 • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Department of Energy and Climate Change. Digest of UK Energy Statistics. Chapter 6 Capacity of, and electricity generated from, renewable energy sources. https://www.gov.uk/government/publications/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Breitschopf et al. (2012)
Output of the RE industry by technology, imports, exports	Breitschopf et al. (2012)
Cost structures • Shares of cost components • Allocation to industries according to the IO model	RES Employ assumptions based on various technical studies
Input-output table of Scotland 2009	Scotland National Statistics Office
Industry specific employment data	
• Employment by industry	Breitschopf et al. (2012) and Scotland National Statistics Office
• Employment per unit of output	Own calculation
• Number of employees by industry	Scotland National Statistics Office
• Compensation of employees	Breitschopf et al. (2012) and Scotland National Statistics Office