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Short communication

The evolution of green jobs in Scotland: A hybrid approach

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HIGHLIGHTS

- A "hybrid" approach estimates green jobs from bottom-up detail and top-down data.
- Illustrative results show the evolution of such jobs in Scotland from 2004 to 2012.
- Method provides policymakers a timely measure of the jobs success of energy policy.

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ABSTRACT

In support of its ambitious target to reduce CO_2 emissions the Scottish Government is aiming to have the equivalent of 100% of Scottish electricity consumption generated from renewable sources by 2020. This is, at least in part, motivated by an expectation of subsequent employment growth in low carbon and renewable energy technologies; however there is no official data source to track employment in these areas. This has led to a variety of definitions, methodologies and alternative estimates being produced. Building on a recent study (Bishop and Brand, 2013) we develop a "hybrid" approach which combines the detail of "bottom-up" surveys with "top-down" trend data to produce estimates on employment in Low Carbon Environmental Goods and Services (LCEGS). We demonstrate this methodology to produce estimates for such employment in Scotland between 2004 and 2012. Our approach shows how survey and official sources can combine to produce a more timely measure of employment in LCEGS activities, assisting policymakers in tracking, consistently, developments. Applying our approach, we find that over this period employment in LCEGS in Scotland grew, but that this was more volatile than aggregate employment, and in particular that employment in this sector was particularly badly hit during the great recession.

1. Introduction

Since the Kyoto agreement was signed there has been a significant global debate around reducing carbon emissions, and many regions and nations have adopted a target to reduce national greenhouse gas (GHG) emissions. In Scotland the target is to reduce GHG emissions by 42%, relative to 1990 levels, by 2020. Given that the energy sector is a major source of emissions, the Scottish and UK governments have introduced policies to develop renewable energy or low carbon technologies to help meet these emissions targets. A prime example of this is the Scottish Governments target to generate the equivalent of 100% of gross (Scottish) electricity consumption from renewable technologies by 2020. This target builds upon Scotland's existing high level of renewable generation capacity, and natural advantage in renewable resources, principally wind (on- and offshore), wave and tidal.

If this 100% target is to be met it is expected that the size of the Scottish Low Carbon Economy (LCE) will increase significantly with an associated increase in employment or so-called "green". The Scottish Government have made clear that their renewable electricity target is also required to assist in the "re-industrialisation" of Scotland (Scottish Government, 2011), and the Scottish Government have estimated that this sector could create an additional 60,000 jobs by 2020 (Scottish Government, 2010). Given these targets, it is important for policy makers to have robust measures of the employment in the LCE.

However, estimates of the number of such jobs vary greatly depending on the source. Principally, this is because estimates use different definitions of the LCE, producing a variety of estimates of

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the scale of employment (e.g. see Allan et al., 2014a). Classifying jobs in operating renewable electricity devices in Scotland as "green jobs" would likely be uncontroversial, the inclusion of other activities (such as jobs in the supply chain for energy technologies) may be more controversial and may be omitted in some measures of "green jobs".

A widely used definition – indeed one used by the Scottish Government (2010) – captures activities in "Low Carbon Environmental Goods and Services" (LCEGS). This covers a range of renewable, low carbon and environmental activities. The Scottish Government methodology produces an aggregate figure for employment in the LCEGS, however it is only for a specific period, usually a year, is costly to produce and is not typically produced on a regular basis.

In this paper we propose a methodology which can produce a time series of employment in LCEGS. Our method combines the detail from "bottom-up" surveys with "top-down" time series data from official surveys. We use industrial data on Scottish employment by sector alongside information from a regional UK survey of employment in LCEGS to track the evolution of LCEGS employment annually between 2004 and 2012 – a time of significant development of low carbon and renewable energy technologies in Scotland.[1]

The approach which we use was first proposed by Bishop and Brand (2013), who examined LCEGS employment in Plymouth, UK, focusing on a single year. We extend the approach firstly to the national (Scottish) level and secondly, to show the evolution of the total number of jobs in LCEGS activities ("green jobs") between 2004 and 2012. In doing so, we demonstrates how "bottom-up" and "top-down" data can be combined to produce a measure which can be updated frequently, can be used to measure progress towards targets for jobs in LCEGS and can be used to evaluate the employment "success" of energy policy.

The paper proceeds as follows. The next section discusses different definitions of 'green jobs' and the ways in which they are measured. Section 3 gives details on the methodology used in this paper. Section 4 provides our results and discussion, and the final section provides our conclusions and policy implications.

2. Measuring "green" employment

Although measures to increase employment in "green" activities are a policy area for many countries and regions across the world, there are a wide range of definitions used to measure progress towards these goals. This occurs for a variety of reasons, which might be classified as either conceptual or empirical, and which are summarised in Sections 2.1 and 2.2, respectively, below.[2] In Section 2.3 we review previous estimates of LCEGS employment in Scotland.

2.1. Conceptual issues

There are two principle conceptual challenges. First, there is little agreement on which activities might be considered as "green". Furchtgott-Roth, (2012, pS50) for instance, writes that "no one knows what green jobs are". Noting the US Bureau of Labour Services definition as "jobs in business that produce goods or provide services that benefit the environment or conserve natural resources" leads to the apparent contradiction that, for example, in the case of two farmers producing the same crop, one would be classed as having a green job if that crop was used in biofuels, while the other would not be counted if her output was used in food production. As the worker may not necessarily know where her output will be used it makes it difficult to simply ask workers if they have what might be considered a "green job".

A second conceptual issue is with employment in the "supply chain". Workers employed in the operation of renewable energy facilities would, without controversy, be included in a measure of green jobs. However, this employment may require inputs from (and employment in) other sectors, e.g. installers of offshore wind turbines will require vessels, which will in turn require the production of metals, engines, and fuel and so on. It would not be natural to consider employment in these kinds of intermediate sectors as "green" jobs, but nevertheless they are part of the supply chain for these green activities.

Aside from these conceptual issues, and the empirical considerations which are the subject of the next section, there is another important issue to consider which is the language and implied definitions of "green jobs". For instance, some authors refer to the "low carbon economy" while others prefer the "low carbon environmental goods and services (LCEGS) sector" nomenclature (other names seen in the literature include the "clean economy", "green economy" or "green goods or services").

The LCEGS measure has become widely used in recent years in the UK (Innovas, 2009; kMatrix, 2010, 2011, 2012). This measure provides a "bottom-up" definition of employment across a range of activities and services, including through the supply chain, while also providing comparable estimates for other countries around the world. Perhaps part of the rationale for the LCEGS measure is to understand more about the parts of the economy which are undertaking work in the low carbon area, without placing restrictions on the precise industrial activities that are included. In other words, the use of the LCEGS definition perhaps represents a move away from a focus on decarbonising the domestic economy to maximising the economic benefit from publicly supported investment in the low carbon economy. Given the adoption of this broader LCEGS definition by the Scottish Government (and others), as we shall see in Section 2.3, it is the measure which we use here.

2.2. Empirical considerations

There are two broad approaches which have been used in the literature to date to measure the number of "green jobs" in an economy. We can classify these as those based on Standard Industrial Classifications and those based on surveys. We refer to these in the rest of the paper as "top-down" and "bottom-up" approaches respectively. This classification between top-down and bottom-up is merely used to illustrate the different ways in which estimates of "green" employment have been produced.[3]

First, the "top-down" measures use the classification of employment to industries which is compiled from official statistics covering the whole economy. By identifying specific industrial activities as "green" and tracking employment in these categories, such measures provide a regularly updated metric of employment

[1] Renewable electricity capacity in Scotland almost tripled between 2004 and 2012 while the amount of electricity from renewables increased from the equivalent of 14.1% of consumption in Scotland to 38.8% (Scottish Government, 2014).

[2] Allan et al. (2014a) contains a longer discussion of the issues raised in this section.

[3] Note that we omit from this *ex ante* studies of the potential employment impacts of changes in the energy sector, some of which use Input–Output models (e.g. Moreno and Lopez, 2008; Tourkolias and Mirasgedis, 2011; Markaki et al., 2013; Fanning et al., 2014; Cai et al., 2011), Computable General Equilibrium (CGE) approaches (e.g. Allan et al., 2014b) or other modelling techniques (e.g. Lehr et al., 2012). We note that reconciling *ex ante* predictions with *ex post* evaluations is an important area for future research, and that there has been considerable debate in the literature about whether "green" policies and increases in "green" employment create net additional jobs (see, e.g. Furchtgott-Roth, 2012 and Blyth et al., 2014).

(e.g. Bureau of Labour Statistics, 2010). Pew Charitable Trust (2009), for instance, take this kind of approach to count the number of green businesses in the U.S., summing firms across 74 categories. These estimates of the number of green businesses have subsequently been used by Yi (2014) to understand the drivers of green business growth across US states, while Yi and Liu (2015) use the same SIC approach to measure green employment in China.

The "top-down" approach has the advantage of being based on regularly updated and robust statistical measures of economic activity. A significant drawback however is that all activities within each SIC is considered as "green". The Scottish Government classification of "Energy (including renewables)" for instance, counts employment in the SIC code – "Engineering related scientific and technical consultancy services" (SIC71.12/2) – while only a portion of activities in this sector will be for "green" activities. This "all-or-nothing" approach is therefore problematic in practice, and is one of the advantages of the hybrid approach that we explain in Section 3.

Second, there are "bottom-up" surveys of employment in specific green or renewable industries; these have been widely used and cited. These surveys require a careful consideration of the boundaries of the survey. A critical distinction lies between the count of direct jobs (i.e. jobs in specific activities, e.g. offshore wind operation), indirect jobs (i.e. jobs supported elsewhere in the economy through the intermediate inputs required in, e.g. the offshore wind sector) and induced jobs (i.e. jobs supported by the spending of income earned in the economy from the activities (direct and indirect) supported by the sector of interest (Wei et al., 2010).

Examples of this kind of "bottom-up" study include Llera et al. (2010) and Blanco and Rodrigues (2009). Llera et al. (2010) estimated the number of direct jobs in renewable energy on a regional economy, and show the importance of having detailed survey data. Blanco and Rodrigues (2009) meanwhile surveyed firms in the wind industry in the EU and established that there are 50,000 direct jobs in the wind energy sector in the European Union.

In order to get a measure of the employment *indirectly* supported through the supply chain, Blanco and Rodrigues (2009) use input–output (IO) employment multipliers to estimate that in total around 100,000 jobs were directly and indirectly attributable to the wind energy sector in Europe. An alternative to using IO methods to quantify the jobs indirectly supported by the sector, would be to survey the supply chain directly. This is the approach that Scottish Renewables (2012) took. Through surveying firms across the renewable energy sector in Scotland, they discovered that there were 11,136 such jobs.

Definitional boundaries are critical to survey based approaches. Some measures of "direct" jobs appear to include employment that should more appropriately be considered as employment in the supply chain, e.g. construction firms involved in production of the raw material for a turbine may be counted as "direct" jobs, rather than (more correctly) as activity supported indirectly through the activities of renewable energy (Wei et al., 2010). This issue was clearly present in the Scottish Renewables (2012) study where, of total number of jobs in renewable energy in Scotland, some 30% were in the area of grid extension and upgrade work. These jobs were, in essence, construction jobs rather than "green" jobs.

Alternative "bottom-up" measures of employment such as the employment in Low Carbon Goods and Services (LCEGS) (e.g. Innovas, 2009, Bishop and Brand, 2013) have the scope to capture total employment across identified green activities without being constrained to using top-down SIC categorisations. Additionally, by identifying activity across a wide range of areas connected to the "green" economy, the LCEGS measure itself covers total employment and so does not require the use of IO approaches, which are not always available for many regions or nations. Although this definition has been criticised by some for a lack of transparency, reproducibility and coverage of new firms in the "green" economy (Shapiro et al., 2014), it provides a widely used measure of employment in the green economy.

2.3. Estimates of LCEGS employment

Innovas (2009) provides a "bottom-up" estimate of the size of the LCEGS sector in the UK. This gathered primary data from over 720 sources and covered all the sectors which contribute to a low carbon economy, including research/development and the supply chain (Innovas, 2009). Only companies where at least 20% of their outputs contributed to the LCGES were included in the report.

Their report identified three main sectors of the LCEGS; Environmental (including waste, recovery, and recycling and environmental consultancy), Renewable Energy (including technologies) and Emerging Low Carbon Technologies (including building technologies). These sectors were further split into 23 sub-sectors and 2,490 individual activities. The final report estimated the overall size of the UK LCEGS sector (including the number of green jobs) in the 23 identified sub-sectors, as well as a regional breakdown (providing an estimated 75,170 jobs in Scotland in 2007/08). This was a resource intensive study, as bottom-up studies are, and produced a large amount of data. Replicating this study to produce up to date estimates, even on an annual basis, would be a similarly time intensive activity.

According to the Scottish Government (2010) low carbon employment in Scotland (under the LCEGS definition) at that time was 70,000, and could increase by "at least 60,000 by 2020". It was further estimated that by 2015 the LCE of Scotland will comprise 10% of the total economy, and be worth around £12 billion in 2015–16 (Scottish Government, 2010). The estimated increase of 60,000 jobs by 2010 was anticipated to comprise 26,000 jobs in renewable energy, 26,000 in low carbon technologies and 8,000 in environmental sector.

3. Methodology used for study

Our proposed approach is to take the benefits of top-down data and combine these with bottom-up data to produce a regularly updating series of the number of jobs in the LCEGS sector in Scotland. Specifically, we wish to take the features of top-down data – particularly its coverage of employment in all sectors of the whole economy and that such statistics are regularly updated - and of the detail of bottom-up data to construct what we term a "hybrid" approach. The advantage of this method over the bottom-up approach is that it is less resource intensive than an annual survey, while it is also possible to produce updated estimates of the LCEGS.[4]

In our hybrid approach, SIC code data are used, in conjunction with other data sources, to determine the share of activity in each sector related to the LCEGS, in order to calculate the overall size of LCEGS jobs. The primary source of input data for our method was four-digit SIC (2003) codes. SIC coding in this format has 515 separate activities, many of which will be not relevant to the LCEGS sector. Thus the first task was to filter the SIC codes to identify those codes which contributed to the LCEGS. These were identified in the Red Group (2011) report, which can be used in our measure

[4] Since these measures are based on estimates of the share of activity in each SIC involved in the LCEGS, as opposed to surveys of firms in each SIC code sector, these estimates are likely to be less accurate than the bottom-up estimates.

for Scotland. From carrying out this filter, we identified that 141 (or 27.3%) SIC activities can be identified as being part of the 23 sub-sectors in the LCEGS definition.

Once filtered, a mapping was carried out to identify the percentage of employment in each SIC code which constituted LCEGS employment to the 23 LCEGS sub-sectors. The first part of this task was to determine exactly which of the green SICs contributed to each of the sub-sectors. For each of the sub-sectors between 5 and 36 SIC activities were involved. One example of this is in the air pollution LCEGS sub-sector where there are 8 specific SIC activities, ranging from manufacture of non-domestic cooling and ventilation equipment, to foreign affairs.

With this mapping from SIC to LCEGS definitions, we then calculate the (percentage) contribution from each SIC activity to each of the sub-sectors. This was achieved by combining some of the information from the RED report with information from the bottom-up Innovas (2009) study. The equation below was used to calculate the contribution of each SIC activity to each of the LCEGS sub-sectors.

$$SICpercentage = \frac{SICcontribution_{total}}{LCEGSJobs_{total}}$$

Initially it was assumed that the mapping for Scotland would be the same as that for the South West of England. In practice for most of the sub-sectors that this was a reasonable assumption. For instance, if Red Group (2011) identified that 2% of activity/employment in an SIC in the South West was part of an LCEGS category, then our first ("unscaled") approach assumes that the same share of employment in that SIC in Scotland could be considered as part of employment in that LCEGS category. The South West of England has a similar population to that of Scotland (5 million) and they have several industries in common, with renewables and the low carbon economy playing a major role in both. The calculation was then repeated using SIC employment figures for each year between 2004 and 2012 to produce the "unscaled" estimates of the evolution of employment in LCEGS in Scotland over this period.

However, using our "unscaled" mapping, our estimates of LCEGS employment in Scotland in 2007, 2008 and 2009, was overestimated compared to the count of LCEGS in Scotland produced by Innovas (2009) for these years. The largest discrepancy was in two LCEGS categories: "vehicle fuels" and "other fuels" which were nearly twice as large. Some of the SIC codes within these categories include oil- and chemical-related activities, which are a significantly greater in absolute terms in Scotland than the South West of England. We would expect therefore that (while there is no reason to assume that such SICs will not undertake activities which would classify them under the LCEGS definitions) it is likely that a smaller percentage of activity under these SICs would be appropriate to be classified as LCEGS for Scotland.

Therefore a new mapping – which we refer to as "scaling" – was carried out whereby the percentage of each SIC activity relating to (only) these two LCEGS subsectors was updated using the equation below[5]:

$$SICpercentage_{new} = SICpercentage_{old} * \frac{LCEGSjobs(Innovas)}{LCEGSjobs(Calculated)}$$

This produces two series: a "scaled" and "unscaled" series for LCEGS employment in Scotland between 2004 and 2012. We explore trends in this series in Section 4.

We encountered further issues with the SIC-based employment series for Scotland. From 2008 the SIC series was on a different industrial basis (SIC2007) than prior to this point. The 4-digit SIC2003 format has 515 separate activities whereas the newer 4 digit 2007 format has 616, the increase in SIC activities being attributed to the economy changing overtime and more industries being created as technology advances. We use a conversion matrix (National Statistics, 2004) to construct a consistent time series covering the period prior to 2007, including weighting SIC codes between the two basis and calibrating our results to available figures for common years. Additionally, the choice of time period is chosen as eight years, which gives sufficient space to assess the trend in LCEGS jobs. Also, the Innovas (2009) report provides a robustness check (and the scalars demonstrated above) from the middle of this period. It is likely that the further the distance from the survey date, the less reliable the estimates of LCEGS employment are likely to be. This suggests the useful complementarity between updates from the hybrid method, and regularly revised (but less frequent) LECGS surveys.

[5] $LCEGSjobs(Innovas)/LCEGSjobs(Calculated)$ for the years 2004–2007 used the 2007 Innovas "scaling factor" and 2009–2012 used the factor from the report for 2009.

4. Results and discussion

The objective of the study was to determine the number of jobs in LCEGS in Scotland and how this number had evolved between 2004 and 2012. In the previous section two methods (scaled and unscaled) were described and both can be used to provide estimates for the number of LCEGS jobs. The unscaled method gives an estimate of 92,653 jobs in 2012, whereas the scaled method gives an estimate of 75,561 in the same year. As discussed in detail earlier, the difference between the two approaches is principally due to differences in the number of jobs estimated in the alternative fuels and other fuels LCEGS sub-sectors. Fig. 1 shows the level of LCEGS jobs estimated from the "scaled" and "unscaled" estimates for 2004 to 2012 and the figures from the Innovas report for Scotland which provides job numbers for 2007–2009.

Fig. 2 shows aggregate ("scaled" and "unscaled") employment in LCEGS in Scotland indexed from its 2004 value. This shows that, on both series, there is an increase in employment in LCEGS over the period as a whole. The "scaled" estimate of employment increases by 1.7% over this period, while the "unscaled" estimate increases by 5.54%.

While this increase would be expected, due to the policy emphasis given by the UK and Scottish Government to developments in this area, it is interesting to note that employment in LCEGS sectors is not immune from the general economic climate; for instance, between 2008 and 2010 employment in LCEGS activities declined. Indeed from Fig. 2 we can see that the "scaled" estimate suggests that in 2010 employment in LCEGS was actually lower

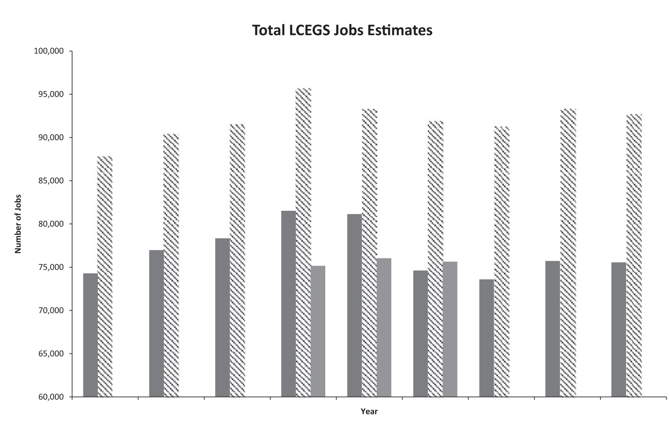

Fig. 1. Total number of green jobs in Scotland 2004–2012.

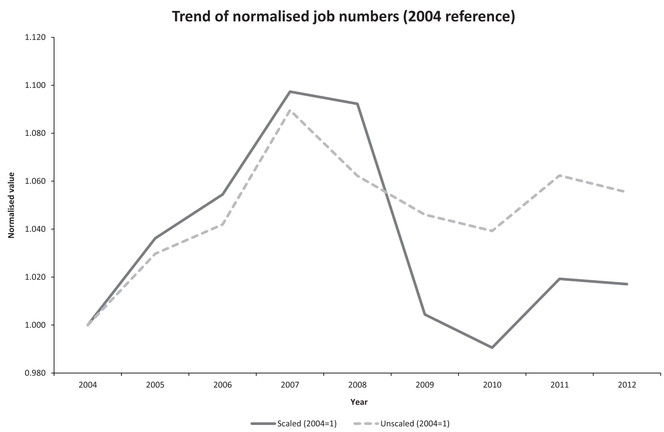

Fig. 2. Normalised variations of green jobs 2004–2012.

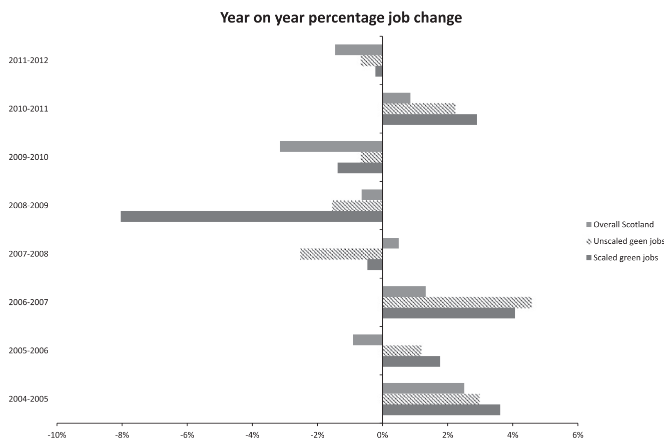

Fig. 3. Annual percentage change in LCEGS and total Scotland employment.

than in 2004.

Fig. 3 shows the annual change for the aggregate“scaled” and “unscaled” estimates of employment alongside the annual change in employment for the Scottish economy as a whole. We see that employment in LCEGS activities was more volatile than overall Scottish employment. In only two years (2009–10 and 2011–12) was the employment change in Scotland as a whole smaller – in percentage terms – than LCEGS employment. It is possible that this observed pattern is due to a “portfolio” effect operating on total Scottish employment, compared with the smaller number of sectors which are included within the LCEGS definition.

5. Conclusions and policy implications

This paper sought to provide empirical evidence for Scotland on the size of employment in low carbon activities, and create a trend series over a period of significant change to the Scottish energy sector. To do this, we extend the hybrid approach of Bishop and Brand (2013), combining the quality of bottom-up surveys with the timeliness and whole-economy coverage of official statistics, classified by industrial sector. This has produced a timely approach to track developments in employment in these activities.

Our results show that between 2004 and 2012 employment in LCEGS categories in Scotland grew, and that this was more volatile than aggregate employment in Scotland. Our estimated trend series, however, reveals how the “Great Recession” beginning in 2008 hampered the growth of employment in LCEGS. While it is not possible to determine what level employment in the low carbon economy might have reached in the absence of the Great Recession, the methodology employed here does allow us to measure the impact that it had on jobs in the LCEGS sector in Scotland. Our approach also enables us to track developments in Scottish LCEGS activity more generally, and in a timely manner.

In a never ending quest to demonstrate the importance of government action in supporting or creating or rescuing jobs, the debate about the employment impacts of the renewable energy sector is starting to resemble a old fashioned English auction with constantly rising “bids” for the number of jobs being supported. This is silly. One would expect that as the renewable energy sector continues to develop and reach technological maturity, the balance of employment in this sector will move from building renewable energy devices to maintaining and servicing them; as a result the number of people involved in such activities will decline.

To see this issue more clearly, consider what we know about the growth of renewable energy generation activities. These activities comprise one part of the broader LCEGS, and we can see that the growth rate of LCEGS jobs appears to be much lower than the growth rate of the installed capacity of renewable generation. In fact between 2007 and 2012 the number of LCEGS jobs declined whereas the installed capacity of renewable generation in Scotland more than doubled. This may well be symptomatic of a broader trend in LCEGS activities, as these activities reach technological maturity.

As a result, rather than focussing on the aggregate number of jobs, policymakers could better focus their attention on the types of jobs being created and supported, and the wider spillover effects in the economy. What can the growth of the LCEGS sector do to increase human and physical capital in the country? How can our developments and expertise in this sector be best exported to other countries? This wider debate needs to be had. However for as long as we have “green job” targets we will need a means to measure progress towards these. What we have demonstrated in this paper is a pragmatic, transparent and robust methodology for the production of timely estimates of employment in the LCEGS, which we believe is an improvement on what is currently available in this debate.

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