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Scotland's green jobs conundrum:
how to better measure the employment impact of a low carbon future

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Making a difference to policy outcomes locally, nationally and globally

OCCASIONAL PAPER

Scotland's green jobs conundrum: How to better measure the employment impact of a low carbon future[1]

Grant Allan, Peter McGregor and Kim Swales

Abstract

The political ambition to turn Scotland into a low carbon economy, powered by renewable energy technologies, is driven, in part, by the belief that such a transformation will reindustrialise the country and generate tens of thousands of skilled jobs. This paper reviews Scottish energy strategy since 1999 and notes the stronger policy link in recent years between investment in low carbon and renewable energy and related employment growth. The evolution of this strategy has culminated in explicit, ambitious targets for green jobs created. However, defining low carbon and renewable employment is complex. Three recent estimates of such employment in Scotland came to quite disparate conclusions. There is an underlying problem: the current lack of appropriate disaggregation of such employment categories in the economic accounts. Were such disaggregation available, it would provide robust and reproducible measures of employment in defined activities. It would also identify the causal drivers of measured (current) employment and where these drivers lie on "temporary-long term" or "domestic-global" axes. Economic accounts, disaggregated in this way, would help demonstrate whether specific policy interventions are delivering the jobs forecast. In our view, greater conceptual clarity and a more significant allocation of resources need to be devoted to the measurement of activity and employment in low carbon and renewable activities in Scotland to allow any meaningful evaluation of strategy in this area.

1. Introduction

Renewable energy development in Scotland has accelerated rapidly over the last decade. Scottish renewable electricity capacity rose by 246% between 2003 and 2012 (DECC, 2013), while Scottish output from renewable heat capacity almost tripled between 2008/9 and 2012

[1] The authors acknowledge funding from the Scottish Government through the ClimateXChange programme. The opinions in the paper are the sole responsibility of the authors.

(Energy Saving Trust, 2013)[2]. Furthermore, the Scottish Government (2011) has set itself the target of meeting the equivalent of 100% of gross electricity consumption from renewables in Scotland by 2020 – as of 2012 around 39% of Scotland's consumption of electricity comes from domestic renewable generation – while the Scottish Government's target is for 11% of heat to come from renewable sources by 2020 (Scottish Government, 2009).

It is claimed that these major changes in the scale of low carbon and renewable energy production and use offer an opportunity for economic development and, in particular, employment benefits for Scotland. This is made explicit in the Scottish Government's (2011, p. 2) "Roadmap for Renewable Energy", which states that the renewables target to produce in Scotland electricity by renewables equal to 100% of Scottish consumption by 2020 is "…. necessary to reindustrialise Scotland through 21st century technologies and seize the opportunities to create tens of thousands of new jobs and secure billions of pounds of investment in our economy". The earlier "Low Carbon Economic Strategy for Scotland", (Scottish Government, 2011, p.6) states that "…. the move to our low carbon economy will be characterised by… the development of low carbon goods, processes and services which can generate economic wealth and create jobs for Scotland". That same document reported the possibility that "… jobs in the low carbon sector in Scotland could grow by 4% a year to 2020, rising from 70,000 to 130,000, over 5% of the Scottish workforce" (Scottish Government, 2011, p. 10).

These Scottish Government documents indicate anticipated employment benefits from low carbon and renewable energy development in Scotland of a substantial scale. There are however, several problems involved in identifying the level and nature of employment in such activities. These arise from three main sources: first definitional concerns – for instance, what activities are included, what are excluded?; second, methodological issues – how do you treat firms for which renewable and low carbon activities are only part of their total production; and third, data problems – are employment statistics available for Scotland at an appropriate level of sectoral disaggregation? The paper will make an initial suggestion that the disaggregation of official economic accounts which are currently produced for Scotland would allow many of these issues to be resolved. First, this would improve the basis on which policy decisions are taken, and second, this would allow for rigorous monitoring of progress towards the employment targets given above.

Three recent studies attempt to quantify what could be considered, on a broad definition, as employment in Scotland in renewable energy or low carbon activities. One study "Delivering the

[2] From a renewable heat capacity of 0.561GW in 2012, 2500GWh of heat was produced, equivalent to 4.1% of Scottish non-electrical heat demand (Energy Saving Trust, 2013).

ambition: Employment in renewable energy in Scotland" was published in May 2012 by Scottish Renewables (hereafter abbreviated to SR), a renewables industry support organisation. This draws on data from a targeted survey of member firms and estimates that there were 11,136 jobs in renewable energy in Scotland in 2011. [3]

"Growth Sector Statistics on the 'Energy (including renewables)' sector" is another relevant report. This frequently updated database uses official statistics from the Scottish Government (abbreviated to SG) to identify specific industrial activities. This source gives employment in energy (including renewables) in Scotland in 2012 as 63,400. Finally, in March 2011, Innovas Solutions (IS) published a report, "Scotland Low Carbon and Environmental Goods and Services sector study". This "IS" report, commissioned by the Scottish Government, produced a bespoke definition of "low carbon" activity using a range of survey and non-survey techniques. The estimate for low carbon jobs in Scotland in 2008/9 is 73,950. This report was used in the 2011 "Low Carbon Economic Strategy" for the scale of current and forecasted employment in low carbon activities in Scotland. As an indication of the order of magnitude of the range of estimates, they lie between 0.5% and 3.0% of total employment in Scotland.

The paper proceeds as follows. Section 2 outlines Scottish Government policy since devolution in 1999, focusing specifically on that relating to the economic development and employment ambitions for renewable and low carbon developments in Scotland.[4] These include the 2004 "Green Jobs Strategy" (Scottish Executive, 2004) and the "Low Carbon Economic Strategy" (Scottish Government, 2011). Section 3 explores three recent studies of employment in low carbon and renewable energy for Scotland, highlighting the definitional, methodological and data differences among the three papers. Section 4 discusses critical issues relating to the measurement of employment in the light of these studies. This includes suggestions for future analysis, with particular reference to the usefulness of disaggregated economic accounts (in particular with disaggregation of the electricity sector, including by generation technology) and indicates how these could improve the formulation of policy and measurement of activity in this area. Section 5 is a brief summary and conclusion.

[3] Scottish Renewables have recently released an update for 2013 (O'Herlihy, 2014). We understand that the methodology used is equivalent to that used in the earlier publication. We therefore refer to the 2012 report throughout this document as it is closer in time to the other two papers. The update for 2013 reports FTE employment in Scotland's renewable energy industry as 11695, a rise of 5% on the 2012 estimate.
[4] Between the founding of the Scottish Parliament in 1999 and 2007, the executive branch was called the Scottish Executive. Since 2007, it has been referred to as the Scottish Government.

2. Low carbon economic strategy in Scotland since devolution

Table 1 shows the major Scottish Executive/Government policy documents since devolution in 1999 that relate to the link between low carbon or renewable technologies and economic development. Although the terminology differs over time, this includes strategy documents on "green jobs" and jobs in (or "in the transition to") the "low carbon economy".

Table 1: Major economic and energy strategy documents, 2001 to 2011

Year	*Economic strategy documents*	*Energy strategy document*
2001	"Smart, successful Scotland: ambitions for the Enterprise Networks" (Scottish Executive, 2001)	
2005	"Smart, successful Scotland update" (Scottish Executive, 2005)	"Green Jobs Strategy" (Scottish Executive, 2005) "Scotland's renewable energy potential: Realising the target" (Scottish Executive, 2005)
2007	"Government Economic Strategy" (Scottish Government, 2007)	
2008		"Framework for the development and deployment of renewables in Scotland" (Scottish Government, 2008)
2009		"Renewable Action Plan" (Scottish Government, 2009)
2010	"Low carbon economic strategy"(Scottish Government, 2010)	
2011	"Government Economic Strategy" (Scottish Government, 2011a)	"2020 Routemap for renewable energy in Scotland" (Scottish Government, 2011b)

The publication of "Smart, successful Scotland: Ambitions for the Enterprise Networks" set out the strategy to guide the operations of the Enterprise Networks (ENs) to deliver economic development to Scotland (Scottish Executive, 2001). The strategy was set around aspirations under "growing businesses", "global connections" and "learning and skills. Under the "Global success in key sectors" heading, the Scottish Executive (2001, p. 11) acknowledged that there were sectors in which restructuring may be appropriate "to meet changing global trading conditions" e.g. textiles and shipbuilding – and others, e.g. "key clusters where public participation could hasten the capture of value or Scottish leadership in that field". The report then lists "e.g. biotechnology (including marine applications), opto-electronics, food and drink, and the creative industries". There is no specific focus in the strategy at that time on energy or

low carbon activities. In fact, in this document there is no reference to the words "renewables", "energy", "emissions" or "carbon", indicating just how far the policy focus in Scotland has shifted in just over a decade.

In 2005, the Scottish Executive (2005, p.6) published its "Green Jobs Strategy" outlining the "green enterprise strategy for Scotland and provid[ing] strategic guidance for the Enterprise Networks". Recognising the diverse nature of the specific activities which might benefit from (and contribute to) sustainable development, the report lists a number of sectors in which there were "opportunities for existing businesses to diversify or expand their operations, and for new businesses to emerge" (Scottish Executive, 2005, p. 8). The sectors specifically named in the report were "renewable energy, waste management, recycling and the use of recyclates" as well as "biofuels, construction and sustainable design, organic farming, tourism and cleaner technologies" (Scottish Executive, 2005, p. 8). It can be noted that employment in such activities may be "green jobs" in the sense that employment in renewable electricity, for example, could displace employment in other (more carbon-intensive) forms of electricity generation. However, whether organic farming or waste management can be considered green is more contentious. Indeed, it is possible that one consequence of expanding the scale of such activities may be to increase emissions, indicating a move away from "sustainable development".

In terms of targets reflecting the policies introduced in the Strategy, the report is clear that measures of employment are not required: "…it is far from clear-cut to set targets for growth in green sectors. Quite apart from straightforward problems of data collection, the range of industries and activity covered within this strategy does not easily lend itself to setting useful or manageable targets…" (*ibid*, p. 31).[5] That being said, a review of the evidence before the Strategy was published, advised ministers that the economic potential could be significant:

> *"Over the long term, Scotland has the opportunity to emulate Denmark's success in the wind industry by supporting its embryonic, but world-leading wave and tidal renewable energy industry. In the short to medium term, offshore wind, clean technology and waste management and recycling also offer opportunities for job creation, building on existing competencies and capabilities. Jobs will be created in these high growth industries without intervention, but support will speed up this process and help Scotland to become internationally competitive"*
>
> (Scottish Executive Social Research, 2004, p. 28)

[5] The report argues that "…our aim for this strategy goes much wider than one or two selected industries and our vision is for a Scotland where all areas of business benefit" (Scottish Executive, 2005, p. 30-31)

The reluctance to quantify current or future employment in this area was reinforced by Jim Wallace, the Minister for Enterprise and Lifelong Learning (and Deputy First Minister):

> *"For example, someone could work for a company that is part of the supply chain for providing widgets for the Vestas factory at Machrihanish, which makes wind turbines and towers. Part of that company's work might involve making widgets for Vestas; other parts of its work might involve making widgets for someone else. I am not sure how that person's job could be defined as a green job. We could spend a long time debating what a green jobs is, but that would be time wasted. Instead, we should get on and deliver the policies, help and support for industry that will create jobs while delivering environmental benefit at the same time"*
>
> (Scottish Parliament, 2004)[6].

After the 2007 elections, the incoming SNP government elaborated a "central Purpose", to "focus government and public services on creating a more successful country, with opportunities of all of Scotland to flourish, through increasing sustainable economic growth" (Scottish Government, 2007, p. vii). Under this framework, the 2007 economic policy listed five "Strategic Priorities"[7]. These were priorities "critical to the delivery of our Purpose" and "internationally recognised to be critical to economic growth"[8].

- "Learning, skills and wellbeing"
- "Supportive business environment"
- "Infrastructure development and place"
- "Effective Government"
- "Equity"

[6] There appears to be two parts to, what might be termed the "Wallace critique": first that definitional problems make it impossible to measure the number employed in green or low carbon employment, and second that – even if you could measure it – such a measure would not be useful in guiding policy. We hope to argue in this paper that both elements are incorrect.
[7] A sixth "Transition to a Low Carbon Economy" was added in 2011.
[8] In 2007 the Scottish Government also introduced the National Performance Framework, which saw the setting of "Purpose targets" in support of the central purpose shown above, covering areas of economic growth as well as Productivity, Participation, Population, Solidarity, Cohesion and Sustainability, as well as 15 National Outcomes – setting ambitions for the next ten years - and forty-five National Indicators to track progress.

Additionally, the document identified six "key sectors" which:

1. have the potential to be "international successful in areas of global demand";
2. are a "significant" part of (all areas) of the Scottish economy;
3. might encounter market failures in delivering future success or accelerating developments, which could be helped by government intervention (Scottish Government, 2007, p. 27).

The six specific "key sectors" identified were: "Creative industries (including digital content and technologies); Energy (with a particular focus on renewables); Financial and business services; Food and drink (including agriculture and fisheries); Life sciences (including biotechnology and translational medicine); and Tourism" (Scottish Government, 2007, p. 29).[9]

In explaining the rationale for this sectoral prioritisation, the same document notes that there will be a "… particular policy focus on a number of key sectors with high growth potential and the capacity to boost productivity, through enhanced support across the Strategic Priorities... [The aim is] to expand Scotland's areas of international comparative advantage… [by] building a critical mass of activity […] with government helping to create the right environment for their competitiveness and growth" (Scottish Government, 2007, p. 29).

The first Renewable Action Plan of June 2009 (Scottish Government, 2009) set out detailed actions and objectives for the short-term (i.e. up to 24 months) which would assist progress towards the Scottish Government's targets on renewable energy[10]. Actions were identified for the Scottish Government and other stakeholders, including private sector and other public bodies, including Scottish Enterprise, Highlands and Islands Enterprise, the Crown Estate and the Scottish Environmental Protection Agency. As a live document, this was regularly updated (Scottish Government, 2010a; 2010b; 2011a; 2011b).

After re-election in 2011, the SNP Government refreshed the Government Economic Strategy[11], and added an additional Strategic Priority – "transition to a low carbon economy".

[9] Higher Education ("Universities") was added as a seventh sector in 2011. The latest available annual data for 2012 indicate that 27% of employment in Scotland was in a sector identified here.
[10] The areas for short-term action included the following: Infrastructure, Supply Chain, Energy Consents and planning, Skills, Communities, Hydro, On- and Offshore wind, and Marine energy (Scottish Government, 2009)
[11] Additionally, in Scottish Government (2011c), "growth sectors" replaced "key sectors" while the definitions of these sectors remained the same (bar the name change for Tourism to "Sustainable Tourism").

In explaining this change, Alex Salmond noted in the foreword (Scottish Government, 2011c, p. 5) that Scotland had the:

> *"opportunity to reindustrialise the nation and create thousands of new jobs across Scotland. With the right incentives we now know that the low carbon sector could support 130,000 jobs by 2020 and we are determined to deliver on this ambition."*

This specific (130,000 jobs) figure comes from the 2010 "Low carbon economic strategy for Scotland" (Scottish Government, 2010), which – using the Innovas Solutions (2011) definitions of low carbon employment – estimated that the current level of employment of 70,000 could increase by "at least 60,000 by 2020" (Scottish Government, 2011, p. 13). The document reported that 26,000 of these additional jobs would be in renewable energy, 26,000 in low carbon technologies, and 8,000 in environmental management.

The above discussion has shown a growing focus over the period since 2001 on the employment gains to Scotland from renewable energy and low carbon technologies. This has evolved from what were initially non-specific ambitions for employment and economic advantages for Scotland in the 2004 Green Jobs Strategy to explicit targets for employment increases in specific activities by the end of this decade (in 2011's Government Economic Strategy), with the low carbon economy now a strategic priority of the Scottish Government.

3. Identifying low carbon activities in Scotland

3.1 Definitions

Section 2 outlined the growing emphasis on the potential employment opportunities from low carbon and renewable energy in Scotland. In this Section, we examine three widely publicised recent empirical estimates of employment in Scotland in such activities. However, there are substantial differences in their coverage of activities, which leads to significant differences in the estimates of total employment among the three studies. We begin with Scottish Renewables (SR, 2012).

SR (2012) seeks to estimate "employment in renewable energy in Scotland". Their definition covers a number of categories, including product design, development, operation and the "supply chain" for a number of renewable energy technologies.[12] They also estimate and include employment in renewable energy R&D in Scotland's universities, colleges and the

[12] We discuss the difficult question of what is, and what is not, part of the supply chain for these technologies in Section 4.

public sector. The publication notes that these employment data were obtained from a questionnaire, telephone, and online web search survey of more than 200 firms active in renewable energy in Scotland and was carried out by Scottish Renewables.

The SR report notes that "where a company has more than one area of activity, for example… offshore engineering, only the FTE posts directly supported by renewable energy development or renewable energy supply chain have been counted not the total employment in the firm" (SR,2012, p. 2). Firms surveyed by SR could include developers and operators, "as well as designers, manufacturers and fabricators of technologies and structures, civil and offshore engineering contractors, electrical network contractors, consultancies and other professional services" (SR, 2012, p. 2) although this is only an indicative list.

Table 2 shows how the total employment given in the SR report is broken down by technology and activity. The largest single entry is "grid", which SR notes will principally be the grid upgrade work driven by onshore wind generation, while onshore wind itself is the second largest employment category.

Table 2: SR definition of employment in renewable energy in Scotland, by technology

Technology	Employees
Bioenergy	1,410
Grid	3,223
Solar and heat pumps	161
Hydro	503
Onshore wind	2,235
Offshore wind	943
Wave and tidal	521
Working across multiple sectors	1,231
Higher and Further Education	757
Public Sector	152
Total	**11,136**

Source: Scottish Renewables, Delivering the ambition: Employment in renewable energy in Scotland

SG (2013) pulls together information from official statistics and is maintained by the Scottish Government as part of the regularly updated "Growth Sector Statistics Database". "Energy (including renewables)" is one of the six "Growth Sectors" identified by the Scottish Government in the 2011 Government Economic Strategy (Scottish Government, 2011). These sectors are identified and monitored using the Standard Industrial Classification 2007 (SIC07), which is the

basis for official statistics on the UK and Scottish economies. These data are collected as part of the annual ONS "Business Register and Employment Survey". The categories identified within the "Energy (including renewables)" Growth Sector, together with the employment in each of these categories in 2012, are shown in Table 3. Clearly, this definition is much broader than that used by SR (2012): it includes, but is not restricted to, the renewables sub-sector of energy activities.

Table 3: SG definition of "Energy (including renewables)" growth sector

SIC 2007 code	Sector name	Employment, 2012
05	Mining of coal and lignite	1,800
06	Extraction of crude petroleum and natural gas	9,100
09	Mining support service activities	18,700
19	Manufacture of coke and refine petroleum products	500
20.14	Manufacture of other organic based chemicals	1,000
35	Electricity, gas, steam and air conditioning supply	14,600
36	Water collection, treatment and supply	3,200
38.22	Treatment and disposal of hazardous waste	1,500
71.12/2	Engineering related scientific and technical consulting activities	12,300
74.90/1	Environmental consulting activities	700
	Total	**63,400**

Source: Scottish Growth Sector Database, November 2013

As Table 3 shows, all employment under each SIC sector is identified as being engaged in "Energy (including renewables)" work. This could be an appropriate assumption for workers employed in the extraction of fossil resources (SIC05), however it will not be the case that all workers employed in "Engineering related scientific and technical consulting activities" (71.12/2) will be employed solely by energy activities, since we know that this category includes land surveying activities, geological surveying etc. Secondly, the selection of categories for inclusion in the "Energy (including renewables)" grouping demonstrates the difficulties in using SIC to classify energy and renewable activities to specific sectors. Activity in renewable electricity, for instance, which would be expected to be included in these definitions – and will be part of SIC35 – are not separately identified in the SIC categories listed.

The first thing to note about the IS paper (Innovas, 2011) is that the definition used is wider than that used by SR.[13] The IS paper acknowledges that "it has proven difficult for the public sector

[13] A good summary of the approach of Innovas is provided by Bishop and Brand (2013).

support organisations to develop strategies and action plans that could be implemented successfully" (Innovas,2011, p. 94). They use a broad definition "with the flexibility to encompass new and emerging technologies… [and] mature technology areas" (Innovas, 2011, p. 94). Specifically, the IS paper considers activities under three high level ("Level 1") categories. These are "low carbon technologies", "renewable energy technologies" and "environmental goods and services", with a total of 23 "sub-sectors" at "Level 2", below the three higher level classes.

The Level 1 "renewable energy technologies" category, for example, includes Level 2 activities related to development of renewable technologies, and "renewable consulting". Under the Level 1 "low carbon", classification, Level 2 sub-sectors such as carbon capture and storage, carbon finance, alternative fuels and building technologies are included. The third Level 1 category – "environmental" – includes Level 2 activities from waste management and water treatment and supply, to environmental consultancy and recycling. The 23 Level 2 sub-sectors are further disaggregated down to a total of "2,400 Level 5 sub sub sub sub sectors" (Innovas, 2011, p. 94), with analysis done at level 1 or level 2, but firms matched to an activity at the lowest level, enabling this report to be a "bottom-up" analysis of the size of activity.

The publication gathers market and firm-specific data from firms involved in each of the categories defined at the lowest level possible. Firms are included if they are active at the "level 5" categories, either as a specialist firm – whose primary activities are in an identified and defined category, or if the firm is assigned to the "supply chain" definition, where it meets one of the following conditions:

- "Companies that only provide end-use low carbon, renewable energies or environmental products and services;
- companies who are 100% providers of components or inputs into sub assemblies or final low carbon products;
- companies (who amongst other activities) provide components or inputs into sub assemblies or final assemblies of low carbon products and services [for at least 20% of their sales activity]."

(Innovas, 2011, p. 89)

The total employment in Scotland estimated for each of the sub-sectors at level 2 is shown in Table 4.

Table 4: IS employment by activity – level 2 sub sectors, 2008/9

		Employment
Environmental sub-sectors	Air pollution	1,010
	Environmental consultancy	570
	Environmental monitoring	110
	Marine pollution control	90
	Noise and vibration control	120
	Contaminated land	815
	Waste management	3,650
	Water and waste water	6,200
	Recovery and recycling	5,810
Renewable energy technologies	Hydro	305
	Wave and tidal	55
	Biomass	6,060
	Wind	8,030
	Geothermal	4,910
	Renewable consulting	360
	Photovoltaic	2,440
Low carbon technologies	Alternative fuel vehicle	4,890
	Alternative fuels	17,780
	Additional energy sources	980
	Carbon capture and storage	505
	Carbon finance	120
	Energy management	1,150
	Building technologies	8,000
Total		**73,960**

Source: Innovas (2011), Table 3.2, p.37

3.2 Identifying overlaps between definitions

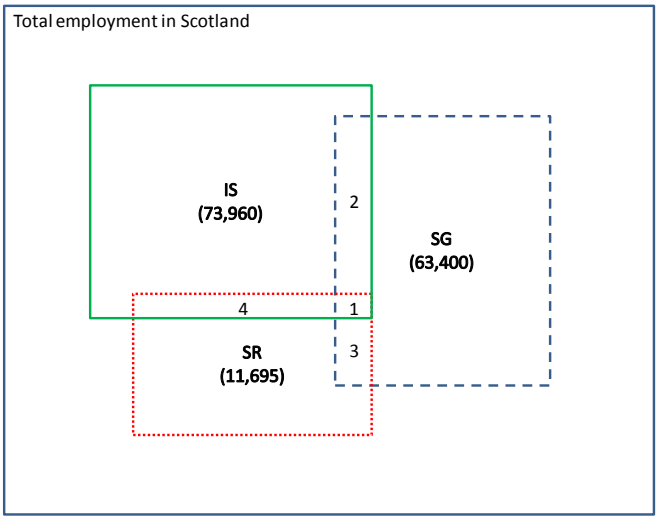
We note that the coverage of each of these three studies is not intended to apply to identical activities. For instance, as seen above, the SG measure includes activities which are explicitly

non-low carbon and non-renewable – for example coal mining, extraction of crude petroleum and mining support activities – and so are not captured in other estimates. SR focus on renewable energy, with what seems like a particular focus on electricity. SI on the other hand have a broader coverage of environmental, renewable and low carbon activities. Additionally – and as we will return to in Section 4 – the surveys differ in whether they attempt to capture purely employment that is in low carbon or renewable activities, as distinct from the "supply chain", i.e. employment which is not itself either renewable or low carbon but which produces outputs, and which may be considered to be "supported" by those activities. Finally, we ignore – at this stage – any differences in the estimates of employment in similar-sounding activities between the studies, and return to this point in Section 4[14].

The relationship among the coverage of these three studies is illustrated in Figure 1. The outer box equates to all employment in Scotland, while employment captured within each report is represented as covering a subset of the total. From Figure 1, it is clear where there is overlap among the coverage of each of the studies. These areas are not to scale; rather the Figure's purpose is simply to illustrate the relationship among, and the scope for overlaps between, the coverage of the three studies.

The areas of overlap are numbered 1 to 4, while that part of Scottish employment that is included in only one of the studies, but does not overlap with one of the other reports, is labelled with the abbreviation for the relevant study, e.g. SR, SG or IS.

Figure 1: A schematic of overlaps in employment between definitions



[14] For example, there are 22,160 jobs identified in Innovas (2001) in the level 1 category of "renewable energy technologies", however Scottish Renewables (2012) identify a total of 11,136 jobs in renewable energy in Scotland.

Starting with area '1', these are employees whose activity is counted in all three papers. From our assessment of the definitions, it seems likely that area 1 will include employees tasked with operating and maintenance work on existing renewables energy facilities as well as those working on renewable energy consultancy activities. Area '2' relates to employment which is captured by SG and IS, but not SR. This area contains employment which relates to the treatment of hazardous waste and water collection and treatment. It also covers all environmental consultancy work (not including renewable energy, which would be captured in SR). Interestingly, it also includes employment in Scotland's nuclear facilities, which are captured in the electricity sector of SG's definition, and which are also a "low carbon" activity in the IS report.

Area '3' activities are those which would fall under the SR and SG (but not IS) definitions. It is our understanding that this area includes the share of employment in the maintenance and updating of the electricity grid that would be associated with accommodating increased renewables generation within Scotland (although it is difficult to determine if these activities are included in the IS definition). Area '4' contains those employees who are not captured by the SG study but will be included in SR and IS. Such activities would include workers in the pre-operational stages and development and construction of renewable energy capacity. These workers will be classified outwith those industries identified in SG, and could be in areas such as renewable energy device manufacturing.

It is also interesting to note those activities which remain in non-overlapping areas. For instance, the SR area includes those in the public sector and higher and further education activities, whose activities are related to renewable energy. These are not counted elsewhere under the classifications used. The SG area will include those working in "Mining support service activities", "Mining of coal and lignite", and "Extraction of crude petroleum and natural gas". Furthermore, the employment in electricity generation in SG includes that in the coal and gas facilities in Scotland. Activities in IS which are not captured elsewhere include building technologies, air pollution, alternative fuel vehicles and recovery and recycling activities.

4. Discussion

In Section 3, we noted that there are important differences in the coverage of employment in low carbon and renewable activities within the three recent studies. In this section, we make some observations about these current estimates of the level of employment in low carbon or renewable activities in Scotland.

First, we acknowledge the potential value of accurately measuring the employment in renewable or low carbon activities. Policy makers needing to compare the impacts of, for instance, replacement of existing electricity generation would benefit from having advice on the employment impact of that activity, and the potential impact on competing technologies (most obviously in cases where, for instance, policymakers may be evaluating the employment impacts of new fossil or renewable technologies). In such a case, of course, the policy maker would require information on the employment impact of the fossil technology.

Second, there are a number of well-established techniques which have been used to examine the impact of particular activities on an economy; the most widely applied being Input-Output (IO) analysis (Miller and Blair, 2009). This approach is based around a set of industrially-disaggregated economic accounts for a specific economy, showing the interrelationships among economic sectors – identified for example by their SIC codes – and the links between these sectors and the demand for those industries' outputs, which might be local (e.g. households' or government) or non-local (i.e. exports).

IO analysis has practical uses for both accounting and modelling purposes. IO can be used as an accounting tool to demonstrate the specific scale of employment in (appropriately defined) low carbon and renewable energy technologies. Indeed, Scotland has advantages over many regional economics in having IO accounts produced on a regular basis (e.g. Scottish Government, 2014). The key step would be to have an appropriately disaggregated set of IO accounts, such as – for example – between generation and non-generation activities firstly, and then between different generation technologies. All are currently aggregated together in the Electricity sector of the industrial accounts. Such a disaggregation is, in principle possible and has been carried out previously for Scotland in an illustrative analysis (Allan et al, 2007). That paper identified that there were significant differences across electricity generation technologies in their "embeddedness" with the rest of the economy through their supply chain, and that there was not a systematic difference between renewable or non-renewable generation technologies in this aspect.

Such a disaggregation of generation technologies could usefully address many of the questions which the studies reviewed above seek to explore: the scale of existing employment in renewable and low carbon electricity in Scotland; how many jobs are supported (and in which sectors) across the Scottish economy as a whole through renewable and low carbon electricity in Scotland. In IO terminology, the former would be the estimate of the "direct" employment, which the latter could separately identify the "indirect" – those employed due to the demands for intermediate inputs of the renewable and low carbon electricity activities, and the knock-on impacts on the sectors in Scotland which provide those inputs – and "induced" employment in Scotland – those additionally employed due to the expenditure of (wage) income earned in

these activities, and in the sectors also indirectly affected by the renewable and low carbon electricity sectors. Indirect and induced employment, as well as direct, is widely reported in academic studies of low carbon and renewable activities (e.g. Madlener and Koller, 2007, Wang et al, 2013).

An observation from three studies above, in particular SR (2012) is that the employment in renewable or low carbon activities may stimulate additional employment throughout the economy through the supply chain – outside the sector itself – and therefore as part of the indirect or induced economic activity related to these activities. The definition of SR, and to an extent IS, appear to include employment in the supply chain given than they include, for instance, project management, operations and maintenance, and construction activity related to renewable energy developments. It is likely therefore that it would be inappropriate to apply an IO multiplier to these estimates, as this would involve double-counting and seriously overestimate the level of employment supported by these activities in Scotland.

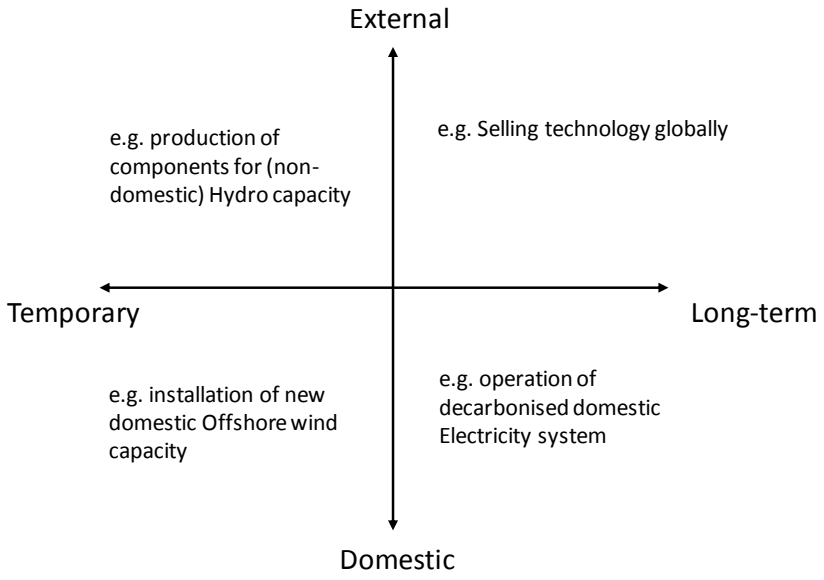
Additionally, IO accounts with environmental indicators assigned to specific economic activities, i.e. SIC codes, can be used to link economic and non-economic variables, such as pollution, waste or environmental damage (see for example, Turner, 2006). With this disaggregation – as currently exists for Scotland (Allan *et al*, 2007) – the policy maker could understand the economic as well as environmental consequences of replacing, for example, coal generation with onshore wind production. Such a set of disaggregated economic accounts could be used clearly to model the economic and environmental consequences of alternative generation mixes for electricity production.

Such a set of disaggregated economic-environmental accounts would also be able to make clear the carbon-content (for example) of each sector. This would not simply be carbon-intensity of the sector itself, but would take account of that sector's links to other parts of the economy (and the carbon embodied in those connections). For instance, while a sector may have a relatively "green" production process – and thus have a low carbon-output coefficient – the true carbon intensity of production (and the geographic distribution of environmental and economic activity) would be revealed by taking account of carbon embodied in sectoral inputs (including imports); and may even allow for the alternative identification of low carbon activities.

Further, appropriately extended IO accounts could identify the nature and causes of economic and environmental activity through "attribution analysis" under, for example, a Production- or Consumption Accounting Principle (PAP/CAP) (e.g. McGregor et al, 2008**)**. This would allow for the systematic tracking of the links between economic activity in Scotland (including employment) and its local (i.e. Scottish) environmental impact; which is the *prima facie* rationale for the Scottish strategies under the low carbon economy described in Section 2.

Thirdly, and developing on the notion of extended IO accounts, an appropriately disaggregated set of economic accounts would allow the identification and tracking of the causes of that activity, e.g. the drivers of the level of employment in renewable electricity. There are perhaps two dimensions to this worth noting, which we represent on a twin-axis diagram with "temporary-long term" and "domestic-global" on the axis. These are shown graphically in Figure 2, where (purely illustrative) examples of activities are placed in one of the four quadrants.

Figure 2: A typology of drivers of low carbon employment and illustrative activities



With regard to the "temporary-long term" axis, it would be useful to know if the estimated employment was due to activities which are likely to persist or ones which are temporary in nature. There may be significant employment that is supported by *installation* of low carbon technologies, for instance, while some drivers could be more permanent in nature, such as, in maintenance of existing capacity. This would be helpful for understanding the likely degree of permanence and likely duration of employment. Additionally, if construction and installation of capacity is projected to continue into the medium-term, the employment implications of this could be quite different.

With regard to the "domestic-global" aspect, this is concerned with whether the employment is supported by domestic or overseas drivers. While it might be the case that the domestic market provides a natural (pre-commercial and early development) area for new technologies, Scotland certainly aspires to enhancing export activity through, for example, renewables and low carbon

technologies and services. Quantifying the share of supported employment and activity due to non-domestic drivers would be a very useful piece of information to policy makers. In particular, it would allow for better prediction of the impact that changes in the type and levels of drivers could have on low carbon employment in a region. For instance, understanding that region A has employment supported by activities in region B, but those activities are likely to end soon, region A can plan for the change in activity. For renewable electricity, for example, information on exports of electricity as well as exports of the technology would be profoundly helpful for policymakers.

Finally, such a set of environmentally extended economic accounts would have clear usefulness as the basic dataset for economic modelling. A range of economic approaches, including IO, Social Accounting Matrix (SAM) and Computable General Equilibrium (CGE) modelling approaches use an economic dataset as the basis for more complex analysis of the consequences for the economic system of policy or non-policy disturbances. Some example of these techniques include the impacts of carbon taxes (Allan *et al*, 2014), the impacts of expenditures related to new renewables technologies (Gilmartin and Allan, 2014; Allan *et al*, 2013) or the "recycling" of non-wage incomes from renewable energy back into the local economy where a facility is locally owned (Allan *et al*, 2011).

5. Conclusions

Since Scottish devolution in 1999, there has been a focus on delivering economic and employment gains from low carbon and renewable energy activities in Scotland; with the focus heightening since 2011 when "transition to a low carbon economy" became one of the "strategic priorities" of the Scottish Government. However for a multitude of reasons (i.e. definitional, methodological and data limitations), there is no single "correct" measure of employment in low carbon and renewable energy activities, giving rise to a variety of alternative approaches. This paper has examined in detail three recent and widely publicised estimates of employment in such activities in Scotland. We have found that while definitions vary, the scale of employment in such activities is relatively modest as a whole – less than 3% of all Scottish employment[15].

However, our review also suggests that there are significant difficulties in quantifying employment in Scotland which is related to the development of "low carbon" or "renewable" technologies or policies. These difficulties should not mean that such ambitions are without merit. The quality of such estimates would undoubtedly be improved through linking

[15] For comparison purposes, 7.0% and 14.9% of employment in Scotland in 2012 was in "Construction" and "Banking, finance and insurance" industries respectively.

employment statistics to (sectorally disaggregated) economic accounts for Scotland. This would provide a solid empirical, reproducible and consistent basis for the estimation of jobs in any identified economic activity, and the level of employment in the supply chain (using techniques standard in the literature).

Focused disaggregation of these economic accounts, for example, by disaggregating the Electricity sector by generation technology and distinguishing transmission, distribution and supply, would identify the specific linkages of renewable and non-renewable generation and could be used systematically to link economic and environmental activity in Scotland. A detailed set of economic accounts could also provide both a basis for alternative definitions of "low carbon" activities, based upon the carbon intensity of employment, and to identify the specific local and non-local drivers of employment. Additionally, environmentally extended IO accounts would provide a coherent set of statistics with which to track the environmental consequences of economic activity – which is central to the rationale for government policy in low carbon and renewable energy. Additionally, our discussion identifies where current estimates were unable to provide useful information, such as the source of the activity creating the identified jobs and whether this was temporary or permanent. The importance of low carbon and renewable energy developments for the economic ambitions of the Scottish Government requires the development of a robust database to monitor developments in energy sectors and sub-sectors, both to provide a baseline and assess progress towards targets for employment, and additionally to shed light on the effectiveness of Scottish Government policy in this area.

References

Allan, G.J., Lecca, P., McGregor, P.G. and Swales, J.K. (2014), "The economic and environmental impact of a carbon tax for Scotland: A computable general equilibrium analysis", *Ecological Economics*, **Vol. 100, p. 40-50**.

Allan, G.J., Lecca, P., McGregor, P.G. and Swales, J.K. (2013), "The economic impacts of marine energy developments: A case study from Scotland", *Marine Policy*, **Vol. 43, p. 122-131.**

Allan, G.J., Gilmartin, M., McGregor, P. and Swales, J.K. (2012), "Report on the evidence for net job creation from policy support for energy efficiency and renewable energy: An appraisal of multi-sectoral modelling techniques", Working Paper commissioned by the UK Energy Research Centre.

Allan, G.J., McGregor, P.G. and Swales, J.K. (2011), "The importance of revenue-sharing for the local economic impacts of a renewable energy project: A Social Accounting Matrix approach", *Regional Studies*, **Vol. 45, No. 9, p. 1171-1186**.

Allan, G.J., McGregor, P.G., Swales, J.K. and Turner, K. (2007), "The impact of alternative electricity generation technologies on the Scottish economy: an illustrative input-output analysis", *Proceedings of the Institute of Mechanical Engineering: Part A, Journal of Power and Energy*, **Vol. 221, p. 243-254**.

Bishop, P. and Brand, S. (2013), "Measuring the low carbon economy at the local level: A hybrid approach", *Local Economy*, **Vol. 28, no. 4, p. 416-428**.

Brookings Institution (2011), "Sizing the clean economy: A national and regional green jobs assessment", published by Metropolitan Policy Program at Brookings, published 13th July 2011, available online at http://www.brookings.edu/~/media/series/resources/0713_clean_economy.pdf

Bureau of Labor Statistics (2013), "Employment in green goods and services – 2011", published 19th March 2013, available online at http://www.bls.gov/news.release/pdf/ggqcew.pdf (accessed 7th February 2014).

Energy Research Centre's (UKERC) Technology and Policy Assessment theme, September 2012, available online at http://www.ukerc.ac.uk/support/tiki-download_file.php?fileId=2760

DECC (2013a), "Renewable electricity in Scotland, Wales, Northern Ireland and the regions of England in 2012", September 2013, online at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244732/1_regional_renewables_2012.pdf (accessed 4th September 2014)

Energy Saving Trust (2013), "Renewable heat in Scotland, 2012", a report by the Energy Saving trust for the Scottish Government, June 2013, online at file:///C:/Users/hbs02109/Downloads/Renewable+Heat+Report+2012.pdf (accessed 4th September 2014)

Innovas Solutions (IS) (2011), "Scotland Low Carbon and Environmental Goods and Services sector study", Innovas Solutions, March 2011, available online at http://www.scotland.gov.uk/Resource/Doc/344829/0114756.pdf

Jones, C. and Munday, M. (2010), "Tourism satellite accounts for regions? A review of development issues and an alternative", *Economic Systems Research*, **Vol. 22 (4), p. 341-358.**

Madlener, R. and Koller, M. (2007), "Economic and CO2 mitigation impacts of promoting biomasss heating systems: An input-output study for Vorarlber, Austria", *Energy Policy*, **Vol. 35. p. 6021-6035**.

McGregor, P.G., Swales, J.K. and Turner, K. (2008), "The CO2 'trade balance' between Scotland and the rest of the UK: Performing a multi-region environmental input-output analysis with limited data", *Ecological Economics*, **Vol. 66, No. 4, p. 662-673**.

Miller, R.E. and Blair, P.D. (2009), Input-Output Analysis: Foundations and extensions, 2nd Edition, Cambridge University Press, Cambridge.

Scottish Parliament (2004), Official report: Wednesday 24th November 2004.

Scottish Executive (2001), "Smart, successful Scotland: ambitions for the Enterprise Networks", Scottish Executive, January 2001, available online at http://www.scotland.gov.uk/Resource/Doc/158455/0042945.pdf, accessed 4th September 2014

Scottish Executive (2005) "Measuring progress towards a smart, successful Scotland: 2005, December 2005, available online at http://www.scotland.gov.uk/Publications/2005/12/0195717/57189, accessed 4th September 2014

Scottish Executive (2005), *Going for green growth: a green jobs strategy for Scotland*, Scottish Executive, June 2005.

Scottish Executive Social Research (2004), "Green jobs strategy review", published 12th August 2004, available online at http://www.scotland.gov.uk/Resource/Doc/17002/0029575.pdf, accessed 7th February 2014

Scottish Government (2007), "Government Economic Strategy", November 2007, available online at http://www.scotland.gov.uk/Resource/Doc/202993/0054092.pdf, accessed 7th February 2014

Scottish Government (2008), Framework for the development and deployment of renewables in Scotland, MONTH 2008

Scottish Government (2009), "Renewable Heat Action Plan for Scotland: a plan for the promotion of the use of heat from renewable sources", November 2009, available online at http://www.scotland.gov.uk/Publications/2009/11/04154534/0, accessed 4th September 2014

Scottish Government (2009), Renewable Action Plan, June 2009, available online at http://www.scotland.gov.uk/Resource/Doc/278424/0083663.pdf, accessed 4th September 2014

Scottish Government (2010a), Renewable Action Plan: Update, January 2010, available online at http://www.scotland.gov.uk/Resource/Doc/300481/0093782.pdf, accessed 4th September 2014

Scottish Government (2010b), Renewable Action Plan: Update, July 2010, available online at http://www.scotland.gov.uk/Resource/Doc/320290/0102435.pdf, accessed 4th September 2014

Scottish Government (2011a), Renewable Action Plan: Update, January 2011, available online at http://www.scotland.gov.uk/Resource/Doc/917/0113041.pdf, accessed 4th September 2014

Scottish Government (2011b), Renewable Action Plan: Update, March 2011, available online at http://www.scotland.gov.uk/Resource/Doc/917/0115603.pdf, accessed 4th September 2014

Scottish Government (2011c), "Government Economic Strategy", September 2011, available online at http://www.scotland.gov.uk/Resource/Doc/357756/0120893.pdf, accessed 7th February 2014

Scottish Government (2010), "A low carbon economic strategy for Scotland", November 2010, available online at http://www.scotland.gov.uk/Resource/Doc/331364/0107855.pdf, accessed 7th February 2014.

Scottish Government (2011), "2020 routemap for renewable energy in Scotland", June 2011, available online at http://www.scotland.gov.uk/Resource/Doc/917/0118802.pdf, accessed 4th September 2014

Scottish Government (2013), "Growth Sector Statistics on the 'Energy (including renewables)' sector", available online at http://www.scotland.gov.uk/Topics/Statistics/Browse/Business/Publications/GrowthSectors

Scottish Government (2014) Input-Output tables and multipliers for Scotland 1998-2011, July 2014, available online at http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Downloads, accessed 4th September 2014

Scottish Renewables (SR) (2012), "Delivering the ambition: Employment in renewable energy in Scotland", Scottish Renewables, May 2012, available online at http://www.scottishrenewables.com/publications/employment-renewable-energy-scotland/

Turner, K. (2006), "Additional precision provided by region-specific data: The identification of fuel-use and pollution-generation coefficients in the Jersey economy", *Regional Studies*, **Vol. 40, NO. 4, p. 347-364**.

Wang, C., Zhang, W., Cai, W. and Xie, X. (2013), "Employment impacts of CDM projects in China's power sector", *Energy Policy*, ***Vol. 59, p. 481-491***.

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