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Submission for Green Economy Committee Hearing

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This paper links three research centres: Imperial Centre for Energy Policy and Technology (ICEPT), Sussex Energy Group (SEG) and the UK Energy Research Centre (UKERC). The submission draws from the ongoing UKERC systematic review **Low carbon employment: the evidence for net employment creation from policy support for energy efficiency and renewable energy**
<http://www.ukerc.ac.uk/support/tiki-index.php?page=Low+Carbon+Jobs>

The review considers primary research that examines labour market impacts of investing in renewable energy (RE) and energy efficiency (EE). The research is due to be published later this year. This document provides a summary of key points, followed by more expansive detail on which these points are based.

Imperial Centre for Energy Policy and Technology (ICEPT) provides nationally & internationally recognised interdisciplinary research, policy advice and postgraduate training, specialising in the interface between technology and policy. We provide objective research, analysis and policy advice to governments, industry, NGOs, and other stakeholders.

The Sussex Energy Group (SEG) undertakes academically rigorous, inter-disciplinary research that engages with policy-makers and practitioners. The aim of our research is to identify ways of achieving the transition to sustainable, low carbon energy systems whilst addressing other important policy objectives such as energy security.

The UK Energy Research Centre, which is funded by Research Councils UK, carries out world-class research into sustainable future energy systems. It is the hub of UK energy research and the gateway between the UK and the international energy research communities. Our interdisciplinary, whole-systems research informs UK policy development and research strategy.

The Technology and Policy Assessment (TPA) function was established to meet demand from policymakers, industry and other stakeholders for independent, policy-relevant assessments that address key issues and controversies in the energy field.

Summary

- The review finds that academic research surrounding green jobs does not provide clear and simple answers. Evidence presents both positive and negative impacts of policy support for renewable energy (RE) and energy efficiency (EE) on employment creation.
- The evidence considered, in the form of academic papers, grey literature and consultancy documents varies significantly in quality and methodological approach.
- Unsupported job estimates that make their way into the media, only serve to obfuscate the realities of job creation through policy support.
- The best evidence is that which considers the full range of employment categories, including direct, indirect, induced and displaced employment impacts. Most research does not cover all of these employment types.
- To estimate 'net' employment creation displaced impacts must be considered. These include jobs that are destroyed through shifting jobs from one industry to another. For both RE and EE investments these are likely to be jobs in other energy generation sectors.
- To comprehend the scale of net employment creation associated with a particular investment a 'counterfactual' investment, which represents an alternative use of the finance, is used. It is important that such counterfactuals are appropriate.
- Input Output (IO) models are commonly used to estimate employment impacts. However, they tend to overestimate impacts as they assume that supply is passive, and that prices are not impacted by changes in supply and demand.
- The source of financial support is an important variable when considering job creation. The use of tax revenues for green investment is a key contention in the surrounding literature. Unfortunately most estimates of employment impact do not consider the source of financing.
- The source of finance (e.g. public or private) is also likely to affect the degree of 'leakage' of employment and economic impacts outside the local economy. If the financial revenues remain in the local economy a greater number of induced jobs will be triggered through increased local spending.
- A large amount of evidence exists for regions of the United States of America. There is, however, a paucity of literature on quantitative employment impacts in the UK.

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1. Introduction, job creation and displacement

The impacts of investment in green energy or energy efficiency on employment creation (or destruction) are disaggregated into several categories, which we must first define. These are presented in Table 1 for the case of developing a wind farm¹. The development of the project involves capital and operating expenditure, which provides a number of jobs. Some of the employment is in **direct** jobs, involving employment on the wind farm itself. Other employment consists of **indirect** jobs, involving the labour needed within the supply chain supporting the development. A third class of employment is described as **induced**, and relate to the additional jobs associated with the household incomes of those employed in direct and indirect employment (Figure 1).

Table 1 Definitions of direct, indirect and induced employment in the case of wind farm development

Direct employment	Indirect employment	Induced employment
Employment that is directly linked to the wind farm. These jobs include manufacturing the wind turbines, constructing the wind farm, operating the farm once up and running, dismantling the farm at the end of its life.	Supportive employment from industries whose output will provide materials and services. Such as steel for wind turbines and lawyers who draft the legal contracts.	Employment that is connected to the increased household income resulting from direct and indirect effects. Some fraction of the money received by direct or indirect employee wages will be spent in local businesses and shops.

Displaced jobs refer to those that are destroyed from moving economic activity from one sector to another. Following the above example of the wind farm, the investment in the wind farm reduces investment in other areas. Thus, it is likely that there will be a reduction in employment elsewhere (see Displaced and net employment section below for more details).

The relationship between these different categories and how each job type is calculated is presented in the following section.

¹ This economic classification holds for all types of employment including other 'green economy' employment such as solar farms or energy efficiency projects

2. Calculating employment impacts

To estimate the total gross employment associated with a renewable energy or energy efficiency investment we must identify and add direct, indirect and induced employment types together. This estimate only includes new jobs – displaced jobs are not accounted for.

Figure 1 Relationship between direct indirect and induced impacts



The number of direct jobs created by a new RE or EE project can be estimated by conducting a survey of companies involved in the associated construction and operation. The number of jobs is usually expressed as full-time equivalent (FTE).

Three models are typically used to estimate these wider employment impacts of investment: Input-Output (IO) models, Computable General Equilibrium models, and Econometric models.

IO models

IO models are most commonly used to measure the full economic impact of investment (including employment impacts) given their simplicity and transparency.

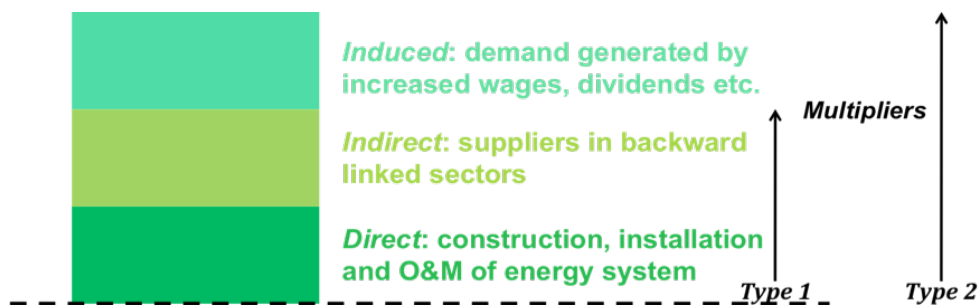
IO modelling begins with an IO table: a matrix of values which identifies the sectors of an economy, the economic input and output for each sector, and the economic relationship between each of these sectors through transactions. These tables are usually generated by public organisations and represent a “snapshot” in time (usually referred to by the year) for specific economic boundaries (e.g. the UK). The regularity with which these tables are updated and maintained can sometimes be an issue, with some tables several years out of date. Many economic regions of the world have no IO table.

IO models can calculate the effect of direct economic impacts on the backward-linked sectors (indirect impacts) and the spending effect (induced impacts). A ‘multiplier’ captures the factor of those impacts. Additional indirect jobs are calculated using a ‘Type I’ multiplier and induced jobs using ‘Type II’ multiplier (Figure 2).

For example, a construction company spends £100 million on steel. The manufacture of that steel creates several FTE jobs which can be attached to the value

of that steel (direct jobs). However, that steel required the mining, processing and transportation of ore, the smelting and rolling of steel and the forming and welding of steel into products suitable for the construction industry. These extra jobs (indirect jobs) are also associated with the steel's value and that factor increase in jobs is represented by the Type I multiplier. Finally the workers employed in all of these jobs receive wages which they will spend on typical household expenditure, supporting a range of other businesses which create a number of extra jobs (induced jobs). The factor increase which accounts for the addition of indirect and induced jobs to direct jobs is represented by the Type II multiplier. Therefore, it can be said that by spending £100 million on steel the construction company have created not only the jobs required to manufacture the product purchased, but also a proportion of the jobs associated with that steels supply chain, and a proportion of the jobs associated with the household expenditure of direct and indirect employees.

Figure 2 Relationship between direct indirect and induced impacts and type I and II multipliers



However, the use of steel in another industry, such as shipbuilding may lead to greater job creation. Thus to understand the *scale* of job creation a 'counterfactual' investment scenario is used to provide a hypothetical alternative (see Displaced jobs and net employment section below).

IO models have several drawbacks. First, they implicitly assume fixed technical coefficients², meaning that the economic impact of an increase in household income from £10 to £20 is the same as the impact of household income from £110 to £120. In reality, as householder income increases, the patterns of spending and saving are likely to change, from spending on essential items to luxury items and increased saving. Second, there is an assumption that demand is exogenous, or outside the model, and that supply passively responds to demand. In reality, as demand increases, price will also increase. Subsequently, supply and demand will both respond to this price shift. Using employment as an example, if there is a sudden demand for wind farm engineers the average wage for that employment might

² Type II multipliers assume fixed coefficients in endogenous, typically, household, consumption.

increase, either reducing the numbers of people employable for a given cost, or increasing the cost of projects.

It has been suggested that these issues creates a positive bias, where the type I and II multipliers overestimate the total economic or employment impacts.

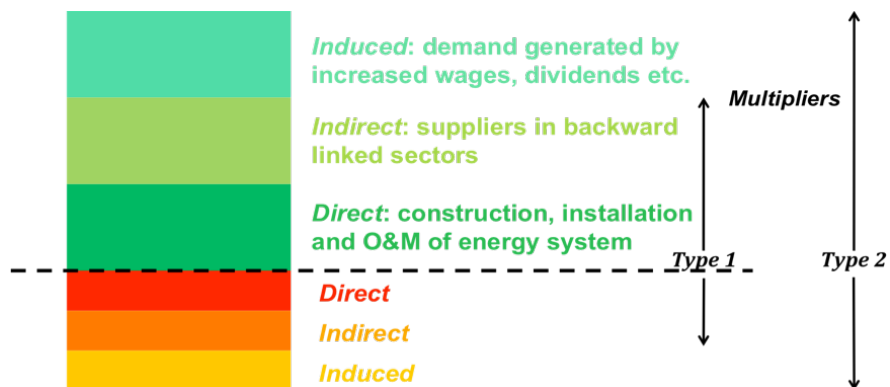
CGE and Econometric models

CGE and Econometric models provide an alternative to IO and deal with some of the limitations identified above. First, these models are dynamic, and calculate changes in economic variables over time. This allows them to include dynamic pricing, where the impact of supply and demand can impact on price. These models can also account for non-linear relationships between household income and induced impacts. However, these models are significantly more complex and significantly less transparent, limiting their use in many instances. It is notable that there is no firm quantitative understanding of the differences between model types.

Displaced jobs and net employment

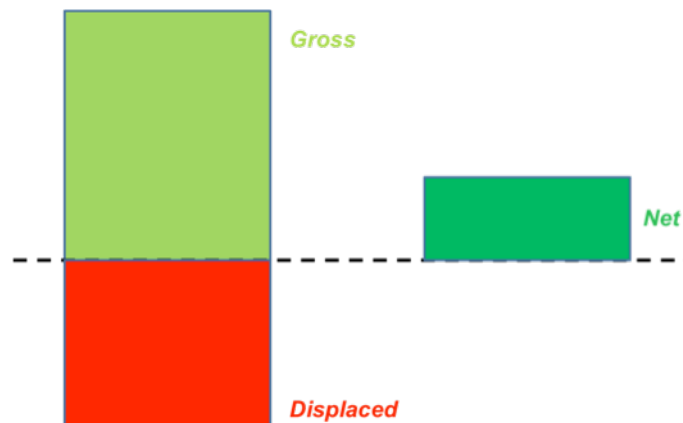
As discussed, with new economic activity the employment that is created can displace employment from other sectors or industries. For example, if an economy invests in new electricity generating capacity in the form of wind turbines, it may reduce the available capital for coal fired power stations. We can count the employment that would have been generated at a coal-fired plant as displaced employment and we refer to this as a ‘displaced’ impact (Figure 3).

Figure 3 Relationship between direct, indirect, induced and displaced impacts; type I and II multipliers; and displaced jobs.



Net employment is calculated by subtracting the displaced employment from the gross employment (being the sum of direct, indirect and induced employment) (Figure 4).

Figure 4 Relationship between gross employment, displaced employment and net employment.

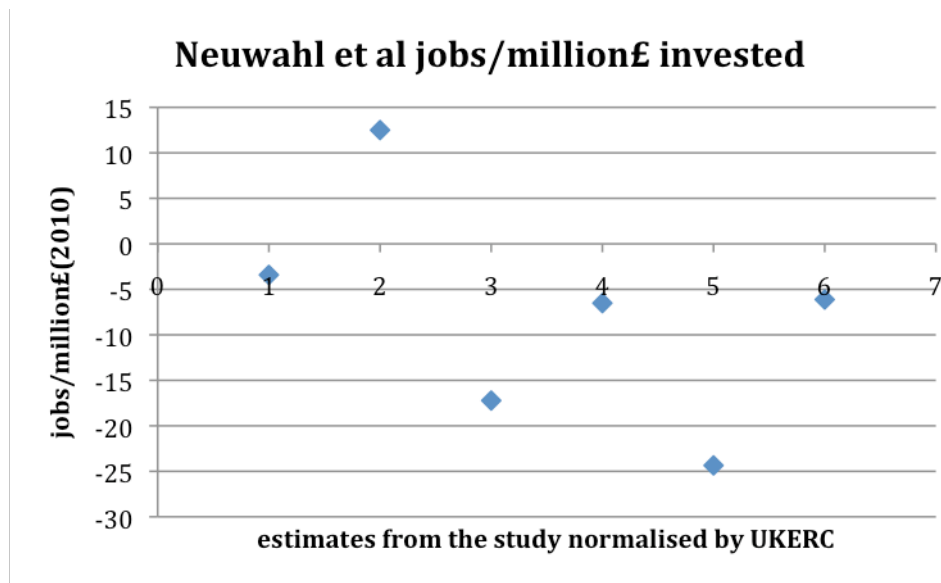


In some cases, policy makers have a choice between a number of investment options. To gauge which option leads to greatest number of jobs counterfactuals are used. The counterfactuals could include investment in two different RE projects of same total economic cost, investment in renewable and fossil fuel fired electricity generation projects of same total economic cost, or investment in electricity generation project measured against investment in energy saving or demand reduction projects. Other counterfactuals could also be considered including investment in non energy infrastructure projects, or the economic and employment impacts of a tax cut. However, in some instances the investment decision is in part directed by other considerations, such as to meet future electricity demand. In this case it is necessary to consider only those counterfactuals that are appropriate, therefore excluding non-energy counterfactuals. It is notable that most studies do not provide adequate and/or appropriate counterfactuals to support their investment decision.

A study that deals with displaced employment impacts and is included in the systematic review is Neuwahl et al³. This study considers the replacement of diesel with biodiesel across the EU25. The modelling carried out for the study finds that the displacement effects of jobs in diesel and related industries leads to a negative net impact in the majority of cases (5 out of 6 estimates) (Figure 5). However, this net change in jobs is relatively small (+/- 300,000 against a base case of 200 million jobs in the EU25). Hence the authors conclude that the other benefits associated with the replacement of fossil fuels with biofuels (reduced pollution, fuel security etc) would, in their view, outweigh the potential loss of jobs. The models job estimates reflect different policy scenarios and assumptions.

³ Neuwahl, F., Loschel, A., Mongelli, I., Delgado, L., (2008) Employment impacts of EU biofuels policy: Combining bottom-up technology information and sectoral market simulations in an input-output framework.

Figure 5 Neuwahl study results – net job creation through replacement of fossil fuels with biofuels.



Methodological limitations

Few studies consider all impacts, including direct, indirect, induced employment effects and displaced effects. Research that does consider these different types and alternatives and uses the appropriate models to do so should be given most credence.

In practice, IO modelling is the dominant approach in the RE/EE literature – and for estimating employment impacts more generally. As mentioned IO models are fixed price, fixed coefficient, demand driven, economy-wide simulation models that can provide highly disaggregated projections for industry, government and households. These provide an upper limit on employment impacts because they do not allow for price adjustment and factor substitution.

A substantial fraction of the green employment studies are ‘grey literature’ from industry, government or NGO sources. Many of these appear partisan and reach predictable conclusions given the source. There is a clear need for a greater number of peer-reviewed studies in this area.

3. Issues in estimating employment impacts

The UKERC review has considered a wide range of relevant literature on employment creation through RE and EE investments. The findings fall along a continuum, including both positive and negative impacts on net employment through investment in RE and EE. In aggregate, the research findings tend towards the positive. Nevertheless, the range of estimates of employment impacts is very wide, reflecting the range of ways in which they are assessed. As such, it is very hard to make meaningful comparisons between the different studies. The range difference in studies is driven by a variety of assumptions, including: geographical location,

technology, institutional environment, tax regime, local labour force skills levels, and counterfactual.

Geographical leakage

Geographical leakage reflects loss of employment or investment in a regional economy to another. A number of studies consider different ways of structuring a project so as to localise the beneficial employment effects. In most cases, if an economy has diverse industries it will benefit more from investments as more of necessary services can be provided within the local economy.

It should be highlighted how important the economic boundary is when estimating job creation. If the economy in question is at the local level, the impacts of the investment may lead to a significant increase in local revenue. For example, a new biomass plant that has been financed from sources outside of the economy may increase local jobs by an order of magnitude if the plant is located in a rural area. That withstanding, as mentioned above, a small economy is unlikely to have the diversity of industry as a large one. Thus it is likely that a significant proportion of the investment will be leak outside the region. When it comes to the international and international economic level, these issues become more pronounced, and it can be quite complex determining whether industry investments in a region lead to a net increase in employment and/or economic growth.

Ownership and financing

Several reports discuss this as an important variable and may have a significant impact on the location of economic impacts. For example, small-scale projects are more likely to be locally owned and financed. In this case very little of the economic impacts will leak. Large-scale projects on the other hand, are more likely to be owned and financed by large companies, who distribute the economic benefits further afield (see Lantz 2008)⁴.

Rose et al (1982)⁵ found a significant amount of the total financial benefits were leaked out of the economy through payments to shareholders. A number of US studies explore different financing options that demonstrate the impact of the source of financing and ownership on local employment and economic impacts.

Different sources of investment also impact on who will benefit from the employment creation. If schemes are financed through the private sector the burden on public expenses is less. However, a full economy wide analysis of this should be made to ensure that paying the profit required by the private sector does not end up costing more, potentially leading to a reduction in employment.

⁴ Lantz, K. (2008) *Economic development benefits from wind power in Nebraska: a report for the Nebraska Energy Office*

⁵ Rose, A. et al (1982) *Modern energy region development and income distribution: An input-output analysis*

Employment lifetime

Short-term start-up employment and longer-term sustainable employment have been highlighted as being distinct, and it was noted that these are often combined in quantitative estimates. This obscures their relative difference, preventing analysis on the difference between capital intensive projects and operation and maintenance intensive projects.

Many studies attempt to estimate employment impacts over long time horizons – e.g. to 2030. But uncertainties compound as the time horizon extends. Such estimates are contingent upon assumptions about economic growth, energy prices, the evolution of costs for the relevant technologies (e.g. learning economies). These assumptions vary widely from one study to another and sensitivity tests are not always employed.

Hillebrand (2006)⁶ makes the point that an investment in RE will lead to a short-term spike in employment creation. Thus, the stimulus associated with this investment is short lived, and the long term trend in employment is not significantly affected.

Crowding in or crowding out investment?

There is some debate as to whether government support for RE or EE will encourage additional private investment (crowd in) or discourage private investment (crowd out). Whether government investment will crowd out or crowd in private investment depends on the macroeconomic conditions at the time, including how much capital is available and how liquid the employment market is.

Labour market conditions

Many studies point out the link between the construction industry and unemployment. However, it is important to consider current labour market conditions when considering whether the unemployed are suitably trained to carry out particular types of employment.

4. Conclusions

The impacts of RE and EE investments vis-à-vis job creation are complex to calculate. They require, not only a firm understanding of the sectors under consideration and the specific RE/EE projects in question, but also a clear idea of labour market dynamics, and an awareness of the different sources of finance and their characteristics used to fund the investment.

⁶ Hillebrand, B. (2006) *The expansion of renewable energies and employment effects in Germany*

Estimating the number of jobs associated with an investment is only half the story. Displaced jobs have to be accounted for. Without considering these jobs we are left with no view of how many jobs are lost through the movement of finance from one area of the economy to another.

Economic boundaries play an important role in determining net job creation. It is important that those who use job creation estimates take into consideration the economic boundary of the research.

Models vary considerably, and in almost all cases models develop their own unique assumptions – relevant to their scenario. The bespoke nature of models makes it difficult to make meaningful comparisons between different models.

There is a paucity of research focusing on the UK. It would be beneficial if research programmes used similar models that compared multiple counterfactuals, enabling valid comparisons to be made.