THE MYTH OF GREEN JOBS

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Foreword by David Henderson

The Global Warming Policy Foundation
GWPF Report 3

GWPF REPORTS

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ISBN: 978-0-9566875-3-1

Contents

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Foreword

In relation to climate change issues, there is an official policy consensus. The consensus is virtually world-wide, and has now been in place for over 20 years. The measures which reflect it have largely focused on 'mitigation' – that is, on curbing emissions of (so-called) 'greenhouse gases'. Ambitious long-term targets have been set for 'decarbonisation' of economies, and an array of policies is already in place with more of the same in prospect. A transformation of world energy systems is envisaged.

The generally accepted rationale for these far-reaching actions is that they are necessary, or at any rate highly desirable, to avert the threat of dangerous global warming. Within this approach, it is admitted that the required mitigation measures involve higher costs, of energy in particular: in themselves, in isolation, they would make the world somewhat poorer. But the official policy consensus holds that these costs, while uncertain and possibly substantial, are known to be greatly outweighed (or overshadowed) by what would without them be the costs (or risks of disaster) from global warming. Mitigation policies, despite their costs, are thus seen to yield a clear net benefit to the world.

In recent years, however, a different way of thinking has emerged and gained ground. Within it, mitigation policies are seen as involving not just costs to be borne for reasons of prudence, but rather a new path to prosperity. 'Green growth' is put forward as the key to sustained economic progress and the creation of new jobs.

Gordon Hughes's paper offers a powerful critique of this way of thinking, focusing chiefly on the claims made for job creation. He deals with the arguments on two different levels.

The first level is that of projects or programmes. Here he makes the fundamental point that in appraising these, prospective labour inputs are to be viewed as a cost not a benefit: labour costs should be counted as such, along with other inputs (such as energy). Hughes notes that if the objective of policy is to reduce CO2 emissions, the right course of action is to minimise the costs of any such reduction; and these include the costs of labour.

A second level is that of the economy as a whole – the possible macroeconomic effects of green energy policies. It is here in particular that green growth (and green energy) policies are now seen as intrinsically positive, through creating new opportunities for productivity-enhancing investments linked to a combination of rapid technological advances, higher energy efficiency, and expanding international markets.

In that context, Hughes makes a key point which is often overlooked. He says, correctly, that 'there is no general reason to assume that future technical progress and improvements in efficiency will favour renewable sources of energy over non-renewable sources'. As to the notion of gaining a new range of profitable exports, he reviews specific areas and finds that they 'provide no evidence that the UK can acquire a long-term comparative advantage in the manufacture of renewable energy equipment by any combination of policies that are both feasible and affordable'.

While the supposed large gains from green energy policies appear as illusory, the costs are well authenticated and heavy, for reasons that Hughes spells out in relation to power generation. He concludes that, on present plans, 'the wholesale prices paid for electricity and other large users will increase by at least 100% and more likely 150% over the next 5-8 years'. He notes the obvious and worrying implications for output, exports and employment in British manufacturing industry.

An indirect but potentially serious consequence of continuing officially-induced higher energy prices, as Hughes points out, is that the trend rate of inflation is pushed up. Meeting official inflation targets will thus require stricter monetary policies to hold in check other forms of price increases, with probable negative effects on aggregate output and employment.

Current renewable energy policies are no more than an unnecessarily costly means of achieving given emissions reductions. The idea, now embraced by Her Majesty's Government, that officially-created higher energy costs open up exciting new prospects for growth and jobs, is an illusion which this paper dispels effectively.

David Henderson

August 2011

Summary

1. Meeting the UK Government's targets to reduce CO2 emissions by relying upon green energy will be very expensive. To mobilise support for this spending, government bodies and lobby groups have been making increasingly extravagant claims about its supposed economic benefits. The usual formula is to claim that a proposal or policy will "create" some number of jobs and, perhaps, stimulate the future development of competitive industries.
2. The first observation is that job creation has no merit as a basis for judging policy. Total income, or value-added, or welfare is what matters, not the number of jobs. If this were not the case, why not employ 50% more workers to produce the same output and reduce all wages by one-third? Employing more people involves costs including loss of leisure or alternative output, travelling to work, extra consumption, etc. This is only worthwhile if the extra output produced by the workers is valued more highly than these costs.
3. A second observation is that there are no sound economic arguments to support an assertion that green energy policies will increase the total level of employment in the medium or longer term when we hold macroeconomic conditions constant. Yes, more people may be employed in manufacturing wind turbines and constructing wind farms, but this neglects the diversion of investment from the rest of the economy. We must look to macroeconomic and labour market policies to influence the level and composition of employment.
4. Careful investigation of the impact of green energy policies on the labour market shows a very different picture from that depicted by enthusiasts and lobbyists. The key lies in the fact that green energy is highly capital-intensive. As an illustration, the target for generating electricity from renewable energy sources will involve a capital cost that is 9-10 times the amount required to meet the same demand by relying upon conventional power plants. There is not even a substantial saving in operating costs because the limited reduction in fuel consumption is largely offset by higher operating and maintenance costs.
5. Naturally, spending £120 billion - mostly on offshore wind farms - rather than £13 billion on conventional power plants will increase demand for labour in construction, turbine manufacture and related sectors, provided we ignore the diversion of funds from other spending to finance renewable energy projects. About 35% of total investment is translated, directly or indirectly, into wages and salaries. This is similar to other business investment, but the equivalent share for other forms of infrastructure or government services is nearly 70%.
6. If green energy projects are entirely financed by diverting money

from other forms of business investment, the immediate impact will be approximately neutral but both productive capacity and employment incomes will be lower in the medium or longer run. In practice, however, a significant part of the cost falls on the taxpayer, through a variety of disguised subsidies, with the consequence that spending on public services and capital projects will be lower. This will reduce either employment or employment incomes in the short and long run.

7. It is argued that green energy policies will promote innovation and the development of new industries. Almost every country in the world wants to claim the same benefit, so the numbers do not add up. Total employment in manufacturing wind turbines, solar cells, etc is small when compared with employment in the manufacture of conventional equipment for power generation and transmission. Some small countries – Denmark or Israel – have gained an initial advantage but this is rapidly disappearing as factors such as skills, transport costs, local demand and existing patterns of specialisation reassert themselves. For the longer term, there is little doubt that the primary beneficiary will be China. That is already apparent from the way the market is developing.

8. The focus on capital spending in the short and medium term gives a very partial view. The wholesale prices of electricity and other sources of energy must rise by 100% or more to cover the much higher capital and operating costs of renewable energy. Since other countries are not following the same route, the burden of adjustment will fall heavily upon workers in sectors producing traded goods and services. In sectors accounting for about 40% of employment in manufacturing and related industries, the prospective increase in energy costs amounts to more than 10% of current wages and salaries.

9. Manufacturing activities account for little more than 10% of total employment in the UK and they do not set the general level of wages, so the response to this change is likely to be contraction and relocation of production rather than a reduction in wages. In terms of the labour market, the gains for a small number of actual or potential employees in businesses specialising in renewable energy has to be weighed against the dismal prospects for a much larger group of workers producing tradable goods in the rest of the manufacturing sector.

10. A further consideration is that the Bank of England is required to set monetary policy to meet an inflation target. Policies to promote renewable energy will add 0.6-0.7 percentage points per annum to core inflation from now to 2020. To meet the inflation target, non-energy core inflation must be lower than would have been the case without these policies, requiring tighter monetary policies, which will cause a significant loss of GDP over this period.

11. The cumulative impact of current policies will amount to a loss of 2-3% of potential GDP for a period of 20 years or more. In the next 5-8 years a part of this cost may take the form of higher unemployment, because that

is an important element of the mechanism by which tighter monetary policies lower the core rate of inflation. After 2020 the main effects will fall on incomes rather than employment.

12. The merits of policies to promote a switch to renewable energy should be assessed by considering the average cost of reducing CO_2 emissions in this way. This average cost exceeds £250 per tonne for the shift from conventional to renewable electricity generation without considering the macroeconomic consequences.
13. The decision to sacrifice at least 2% of GDP to reduce the UK's emission of CO_2 by about 23 million metric tons per year, less than 4% of total emissions of greenhouse gases in 2008, is a choice that must ultimately be made by the public. They will have to bear the costs via lower real disposable incomes and higher prices. Claims by politicians and lobbyists that green energy policies will create a few thousand jobs are not supported by the evidence. More importantly, they are irrelevant when considering the choice that has to be made. Sadly, the claims seem intended to divert attention from the consequences of setting arbitrary and poorly-considered targets for renewable energy.

1. Introduction

In recent months the public has been bombarded with claims that some environmental policy or project will "create" hundreds, thousands or millions of jobs, in addition to reducing emissions of carbon dioxide. These claims are made by a variety of official bodies as well as by groups or businesses interested in promoting particular policies or projects. Examples of such claims made by politicians and official bodies include assertions that:

- meeting targets for renewable energy in the Europe Union will create 2 million jobs across the EU (the EU Commission);
- a Green Deal involving insulation of houses, the installation of smart meters and other energy saving measures will create up to 250,000 jobs in the UK (Chris Huhne, Secretary for Energy and Climate Change); and
- the development of renewable sources of electricity generation in Scotland will create 7,000 jobs (the Scottish Government).

Even worse, the claims are becoming steadily more hyperbolic with an escalation in the numbers of green jobs being claimed for various policy initiatives being multiplied by 2, 4 or even 10 times.

With such over-heated rhetoric it is necessary to take a step back and consider what basic economic principles tell us about claims for large scale job creation linked to policies intended to promote renewable energy, energy conservation or generally reduce CO2 emissions. There are three key questions that have to be addressed:

Question 1 – Why would or should the creation of jobs be seen as a reasonable basis for assessing the merits of economic or, even more, environmental policies?

The point of environmental policies is to achieve a higher level of environmental quality. Some people take the view that a pristine environment has an inherent value without consideration of any impacts on our well-being. Economic analysis has tended to focus on environmental quality as a factor determining human welfare. In either case, it is possible to assess the extent to which particular policies contribute to one or more goals that can be identified and, in principle, measured.

From this perspective, whether or not environmental policies lead to higher employment is entirely incidental to the main goals of green energy policies. Indeed we can go further. Job creation is a cost, not a benefit, of such policies. It involves the use of resources which could have been devoted to other ways of improving the environment or human wellbeing.

Question 2 – If job creation is a relevant basis for assessing the potential impact of environmental policies, are there sound reasons to believe that green energy policies can lead to an increase in the total level of employment?

This goes beyond the conventional calculus of employment in industries that are directly or indirectly engaged in the supply of renewable energy or other green goods and services to take account of the diversion of finance and other resources from other activities.

Question 3 – Is there any convincing evidence that the green energy policies being implemented in the UK and the EU will actually lead to higher levels of total employment, either in the short term or long run?

This is an empirical question, which can only be answered by careful consideration of the impact of green energy policies on the energy sector, energy users and the whole economy. Claims about green energy and job creation rely heavily upon anecdote, speculation and assertion, so no weight can be attached to figures that are not supported by a proper analysis of the mechanisms by which green job creation is supposed to occur.

The economic reasoning required to answer these questions is outlined in the sections that follow, but the simple answer may be summarised as No in each case. But, then, if (a) job creation is not a sensible goal for economic or environmental policies, and (b) there is little doubt that green energy policies are both expensive and more likely to destroy rather than create jobs, the obvious follow-up question is why so much weight is given to claims about green jobs.

One view is that such claims offer an optimistic vision for uncertain times. Proponents believe that a rapid transition to reliance upon renewable energy is essential for environmental and other reasons. However, the costs of the transition will be high and there seems to be no widespread public acceptance of the consequences of the adjustments involved, especially in hard economic times. So, the logic is that the costs of adopting renewable energy will be offset by job creation, which is simply assumed to be a good thing without explaining why.

Another point must be kept in mind. Few proponents will devote much time to the jobs created by their favoured policies or projects when these appear to have a good justification in their own right. No one points to the number of jobs created by improving the quality of education or health care. It is only when we encounter proposals whose merits are somewhat more questionable that vigorous efforts are made to construct arguments about the associated economic benefits.

Claims about green job creation offer a story about our economic future. In simple terms, the story is that the future economic prospects of rich market economies will be undermined by the economic success of countries like China, India and others. The suggestion is that the solution lies in promoting innovation and it is claimed that green technologies offer an opportunity for such innovation. The whole argument is nonsense and is based on the worst kind of "do-it-yourself economics". Countries are not companies and do not compete with each other in any meaningful way. There is no UK plc. In the medium and longer term, the average level of real incomes in any country depends upon investment and factor productivity, while economic history shows that (typically) more than 90% of the benefits of innovation accrue to consumers through lower prices rather than to producers. Nonetheless, the vision appeals to politicians and commentators when there has been a general loss of confidence in economic prospects, so it is necessary to examine whether it has any relevance to the UK's future economic prospects.

In the sections which follow I will consider each of the questions that were outlined above. The assessment of the actual impact of green energy policies on UK employment relies upon detailed empirical work presented in a separate paper titled '*Why is wind power so expensive?*' which will be published by the Global Warming Policy Foundation in September 2011.

2. Is job creation a good basis for assessing economic policies?

I will start with a simple parable. Suppose we are considering the adoption of two varieties of wheat. The varieties are identical in all respects – yield per hectare, fertiliser and machinery requirements, environmental impact, nutritional value, ease of use, etc – except that Variety A requires an input of 50 hours of labour per hectare of land over the course of a crop year, whereas Variety B requires an input of 100 hours of labour. Thus, planting 100,000 hectares of land to Variety A would "create" half the number of jobs as planting Variety B. Does this mean that economic policy should encourage the adoption of Variety B in preference to Variety A? Of course, the question answers itself: it would be an absurd distortion of economic criteria to argue that Variety B should be preferred on the grounds that it has a higher labour requirement. Anyone inclined to dispute this statement should first replace all references to labour by references to energy or capital and explain why it would be more desirable to adopt a technology that requires more energy or capital without any reduction in other costs.

Yet this is exactly the argument that is being put forward by the promoters of green energy, albeit in a disguised form. The central point of my parable is that the labour inputs required to grow the wheat are a cost – both for the farmer and for the whole economy. Even if there is widespread unemployment or under-employment, there is still a cost to planting the more labour-intensive variety. At the very least there is a loss of leisure, but more usually the employment of more labour will involve a variety of additional costs including transport, higher consumption of other goods and services, lower household production, etc. In economic terms, the opportunity cost of employing labour is not zero.

The real income – and ultimately the well-being - of a country depends upon the productivity of the labour, capital, land and natural resources used to produce goods and services, provided that those goods and services are valued either in the market or by the final users in the case of non-market activities. Using more labour – or capital - than necessary to produce wheat or electricity serves no purpose and simply reduces net incomes and the benefits of economic activity. It cannot be a sensible goal of policy to achieve that outcome.

The objection to this parable may be that I am interpreting the effects of job creation in too literal a manner. From this perspective, the real point of job creation is not using more labour inputs to produce the same output but that either (a) it is the route by which the total level of income and economic activity can be increased, or (b) the future productive capacity of the economy will be enhanced even if there is no immediate increase in output. A fashionable variant of this argument is that having a (useful) job is an important element in determining an individual's happiness and, thus, collective well-being.

Still, none of these arguments imply that job creation is a proper basis for judging economic policy. It is the things which are associated with employment – the production of valuable goods and services, the acquisition of useful skills or self esteem, the contribution to family or society – that may or may not justify projects or policies. Net job creation provides a mechanism by which the goals of economic or social policy may be achieved; it is not an end in itself.

One reason why employment on its own is not a suitable goal for economic policy is that it is easy for any government to create jobs. If tax revenues can be raised or money borrowed, workers can be added to the public payroll or otherwise contracted to provide a whole range of services from providing care to the elderly to filling potholes in roads. The constraint on the level of overall employment is not the capacity of the public sector to create jobs, but the willingness of the public to pay for these jobs through their taxes or charges for the services provided.

Green energy programmes are intended to meet basic requirements for electricity, heat, transport and other purposes while reducing the impacts on the global environment and natural resources associated with conventional energy production and use. At present, all forms of green energy tend to be substantially more expensive than conventional energy, so there is a trade-off between higher costs and lower emissions. This trade-off is not specific to green energy, since there are many ways of reducing emissions of greenhouse gases. Hence, the starting point of any assessment of such programmes should be the total cost per tonne of carbon dioxide saved – or its equivalent - which will be incurred by relying upon different measures or policies to reduce emissions.

The labour inputs required, for example, to manufacture wind turbines enter this assessment as a cost not a benefit. To reformulate the parable, let us suppose that we have two designs of wind turbine which have the same performance and reliability and can be manufactured and maintained at identical costs of materials and other inputs. However, Design A requires 10,000 hours of labour input (directly or indirectly) per MW of capacity while Design B requires 20,000 hours. Again, it would be absurd to suggest that Design B should be chosen in preference to Design A on the grounds that it will create more employment.

Public policies with respect to green energy ought to focus on reducing emissions at the lowest cost. This should be the position of both advocates for environmental improvements and those doubtful about their benefits. For the first group, lowering the cost of reducing emissions will make it more likely that greater reductions could be considered. For the second group this will, at least, minimise the economic cost of policies that may be considered misconceived. Thus, without taking any position on the merits of green energy policies, any appeal to employment creation as a justification for such policies does not assist in identifying which forms of green energy offer the most cost-effective ways of improving the environment.

That, of course, may be the whole point. A sceptic about such lobbying for public support might reasonably conclude that any policy advocate or project promoter who relies upon claims about job creation to justify their favoured form of green energy has a weak case to make on the fundamental merits and economics of the policies or projects that are being promoted.

3. Can green energy policies create jobs?

Despite the strong arguments for concluding that employment creation is not directly relevant to a proper assessment of green energy policies, the appeal to do-it-yourself economics is remarkably resilient. Almost every project promoter in the green energy sector makes some claim about the number of "additional" jobs that would be "created" by its project. So the next question is whether such claims can have any substance as a general proposition, i.e. before we examine the details of the specific claims.

It is easy for lobbyists to claim that they are "creating" jobs which are, in practice, nothing more than the by-product of economic growth or demographic change. For example, the total population of the UK is growing slowly while the proportion of the population aged 65+ is also increasing. Businesses that provide goods and services for the elderly – from shops to nursing homes – are bound to expand and there is likely to be an increase in the total number of people employed by such businesses. In the energy sector, the replacement of old power plants by new plants – a regular and inevitable process linked to technological change and the physical or economic life of equipment – is used to justify claims about job creation. Of course, in all such cases the decline in employment at plants and/or activities that are being displaced is studiously ignored, so that the "creation" of new jobs may not reflect trends in employment – either in aggregate or in the sector concerned.

To understand whether claims for job creation could be valid it is necessary to put the issue in a macroeconomic context. Is there any reason to believe that green energy policies could increase total employment in the national economy in the medium or long run? We know the macroeconomic framework – including inter alia fiscal policy, monetary policy and exchange rates – does have an effect on total employment. Further, certain policies which affect the structure and operation of the labour market may have quite long term effects on total employment.

In contrast, green energy policies will have no permanent effect on how the labour market functions. Their effects are manifested in other ways – primarily in the level and distribution of real incomes and consumption. To illustrate the point, consider current policies to encourage the development of wind farms to produce electricity, replacing power from gas or coal plants. These policies affect many people in the longer term – i.e. after construction is complete:

- Landowners with windy sites will receive rents for leasing their land to wind operators.

- Local workers will be employed to maintain the wind turbines, while those who might have been employed at gas or coal plants will have to seek other employment.

- Domestic and industrial customers will pay higher prices for their electricity. This will teduce spending on other goods and services. In some cases, companies may close down their operations in the UK or invest elsewhere.

- Higher electricity prices will reduce company profits, so companies will pay less in corporation and other taxes. In addition, they may be less inclined to increase wages or take on new employees.

- Imports of coal and gas will be lower so that the long run exchange rate will be higher, reducing incomes and profits for businesses which export goods and services or which compete with imports. On the other hand the users and consumers of imported goods and services such as travel and consumer durables will be somewhat better off.

None of this will have any significant effect on the level of employment in the longer term. If the UK meets its target for renewable energy in 2020, it will not have higher or lower unemployment than it would have had if no such targets had been promulgated. Workers and shareholders in companies that have to pay higher electricity prices will be worse off. Some workers may lose their jobs, but other job opportunities will be created by companies taking advantage of the lower level of real wages. The overall impact of the policy will fall on incomes and the real standard of living of different groups in the population.

Since green energy policies do not affect the level of employment in the medium and long run, claims that such policies will create jobs are either misconceived or refer to a temporary impact on employment while the economy is experiencing cyclical unemployment during an economic downturn. Such temporary effects are possible because macroeconomic shocks can cause substantial unemployment while labour markets adjust to new economic conditions. The period since 2008 has shown how the collapse of a credit bubble leads to a rapid increase in unemployment due to the loss of jobs in construction and related activities without offsetting adjustments in other sectors. But neither past experience nor the current situation gives any reason to believe that the increase in unemployment is permanent.

Under normal macroeconomic conditions the level of job flows – workers leaving jobs and others starting new jobs – is much higher than the stock of unemployed workers. Most workers who change jobs are never registered as being unemployed. Nonetheless, small variations in the average length of time between leaving one job and finding another can lead to large variations in the number of people who are temporarily unemployed while looking for work. This type of unemployment is often referred to as "frictional unemployment", reflecting the fact that no market can perfectly match people looking for jobs with employers looking for workers.

Frictional unemployment may persist if employers lose confidence in their capacity – or do not have the resources required - to deploy additional workers usefully. Further, workers may resist a reduction in real earnings even when the market-clearing level of earnings has fallen. These factors will slow the process of adjusting to macroeconomic shocks. Nonetheless, over a period of months or years frictional unemployment will tend to return to its normal level. Green policies will do nothing to accelerate such adjustments if we hold general macroeconomic conditions constant. Indeed, they are only likely to slow up the process of adjustment by creating additional uncertainty and costs for potential employers.

Not all unemployment is purely or predominantly frictional. The term "structural unemployment" is used to refer to a longer term mismatch between the skills, location, and other characteristics of job seekers in relation to what employers are looking for. This is partly reflected in the number of long term unemployed – people who have been looking for work for a minimum of 6 or 12 months. Another component of structural unemployment consists of people who have given up looking for work - including some who may be registered as suffering from various disabilities plus others who have retired early or who are engaged in unpaid activities but might prefer to take on a paid job. Again there are no reasons to believe that green energy policies will have a significant impact on the level of structural unemployment. This will only occur if the requirements of any new jobs match the skills, location, etc of those who are unemployed. Otherwise, the policies will simply lead to a displacement of jobs with a minor or zero effect on unemployment.

An alternative route by which these policies may generate additional employment in the short run is if they serve as a vehicle for delivering a broad macroeconomic stimulus to the national economy. In that case, the proviso of holding macroeconomic conditions constant does not apply. But no disinterested economist would regard investment in renewable energy or housing insulation as a good way of boosting aggregate demand. Fiscal changes, such as the 2008 cut in VAT, or a temporary boost to public spending on transfers or fixing social infrastructure are much more effective in this respect. The period required to get significant investments in renewable energy off the ground is a minimum of 3 years and more typically 5 years.

These arguments imply that, at best, green energy policies may have a very small impact on the total level of UK employment in the short run and little or no impact in the medium or longer term. Applying any reasonable economic criteria, such policies are a really poor way of allocating public money (through subsidies) or private resources (through higher energy prices) to create jobs at the macro level – i.e. for the UK as a whole or for the EU.

All, then, we are left with is the possibility that green energy policies may have an effect at local or regional level in areas with high structural unemployment. But this argument presumes that the job opportunities associated with green energy arise in locations where people with suitable skills are experiencing high levels of unemployment. If that is not the case, the "creation" of new jobs will actually amount to a displacement of other employment opportunities.

Consider the example of Scotland, which is most enthusiastic about the potential benefits of job creation associated with the development of renewable energy. Its unemployment rate in 2010-11 has been very close to the average for the UK as a whole. Within Scotland the highest unemployment rates by local authority are in North Ayrshire, Glasgow City and West Dunbartonshire – none of them candidates for the development of onshore wind farms and all of them at some distance from the primary sites for offshore wind farms. Neither is there any strong evidence that Scottish manufacturing businesses, who account for little more than 7% of Scottish jobs, would gain a significant boost from the capital spending on wind farms.

Another region with high expectations of job creation associated with renewable energy is the North East, but again the figures don't add up. It has the highest unemployment rate in the UK with particular concentrations along the coast in districts such as Middlesbrough, South Tyneside and Hartlepool. Still, the notion that there is a large pool of unemployed or discouraged skilled workers who could be employed in manufacturing wind turbines is not consistent with the development of the regional labour market over the last 30 years. Manufacturing now accounts for only 11% of total jobs in the region. As elsewhere in the UK, most unemployed or discouraged workers have limited skills and require substantial training or other assistance to hold down skilled jobs in manufacturing.

For the UK as a whole, we need to apply a basic test of cost-effectiveness. Is the number of jobs generated by green energy policies greater than if equivalent funds had been allocated to direct intervention in the labour market, for example through spending on job-related training and other measures? At local level there is a concern that spending on training and other labour market interventions might ultimately benefit other regions because workers with improved skills might choose to move elsewhere in search of work. Linking support to specific investments reflects a view that not all benefits – or jobs – should be weighted equally. In such cases, local impacts are treated as being more important than spill-over effects outside the locality. From a national perspective that cannot be right, but it is a very strong element in the arguments concerning support for specific projects.

The observation that training and similar labour market measures may be more effective ways of reducing structural unemployment than support for specific environmental or industrial projects leads on to another important point. Training and similar policies stimulate outcomes that go far beyond their impact on the level of unemployment. Their benefits may take many forms including (a) higher incomes for those who receive the training, (b) higher output of goods and services from the same inputs of labour and other factors, and (c) improved quality of personal or community services. Often, the division of the aggregate benefits between more jobs and higher real incomes or quality of life is difficult to predict and may be affected by unforeseen exogenous factors.

Two conclusions follow for any assessment of green energy policies.

- If the primary objective of such policies is to reduce CO_2 emissions, then we should seek to minimise the costs of meeting that objective, including any wages for jobs directly or indirectly linked to the project.[1]
- If, instead, the goal of the policies is to increase real incomes and improve human wellbeing, then job creation is an irrelevant measure of their benefits. The criterion should be to select the options which generate the highest level of net benefits, treating both employment and environmental externalities as costs to which appropriate weights are applied to reflect the social opportunity costs of paying wages or emitting CO_2 and other greenhouse gases.

[1] There is an argument, which is sometimes used in cost-benefit analysis, that the "social" cost of employing workers or paying wages is less than the money cost. The argument may be relevant when there is large structural unemployment, but most careful assessments suggest that any gap is likely to be small and would only apply to limited categories of unskilled employment. This does not alter the basic fact that job creation is a cost, not a benefit, of such policies.

4. How might green energy policies affect incomes and the labour market?

The conclusion that green energy policies will not have any significant impact on the level of total employment in the medium and longer term is less important than the broader impact of such policies on incomes and the labour market. For anyone with an interest in the future development of the UK economy, a key issue may be put as follows:

Given a standard set of assumptions about macroeconomic variables – GDP, investment, inflation, etc – how will the implementation of green energy policies affect the demand for labour? If they are likely to increase the overall demand for labour, then this will tend to increase real wages and the share of employment income in GDP. If they are likely to reduce the overall demand for labour, then real wages will be lower in future along with the share of employment income in GDP.

As explained above, claims about job creation rely upon a faulty description of the way in which labour markets work. It is adjustments in real wages that matter in the medium and longer term, whereas changes in the total level of employment are transient and depend upon the way in which labour markets respond to external shocks. Changes in labour market policies will affect the speed and nature of the adjustment to shocks of all kinds, including those associated with the adoption of green energy policies. However, the nature and direction of those shocks matter because policies that tend to reduce the demand for labour will leave most people worse off, even if the level of employment does not change.

Hence, in the remainder of this paper I will consider how green energy policies will affect the demand for labour and, thus, the total level of employment income holding GDP constant. I will build up the analysis in stages by widening the scope of the impacts considered, starting with the direct demand for labour in the energy sector and culminating by considering economy-wide effects. For purposes of illustration I will concentrate mainly on policies that are designed to promote electricity generation from renewable sources of energy instead of fossil fuels. Green energy policies are only relevant if the renewable option would not be viable without some form of support, so the nature and level of any support is crucial. It may take the form of explicit subsidies or a variety of indirect subsidies linked to mechanisms designed to meet targets for generation from renewable sources.

Any analysis must be based upon some clear basis for comparing like with like. This is not straightforward when considering types of electricity generation that differ in terms of their load factors, intermittency, capacity to meet fluctuations in demand, etc. Most comparisons published by advocates of green energy adjust generating capacity for differences in assumed load factors.[2] The average load factor for onshore wind farms in the UK is significantly less than 30% - in some cases it is less than 20%. In contrast, a new gas-fired unit operating on base load may be expected to operate for up to 85% of hours in a year. Adjusting for differences in typical load factors but nothing else, one might compare a gas plant with a generating capacity of 500 MW with wind turbines with a capacity of at least 1400 MW producing the same amount of electricity over a typical year.

Unfortunately, as explained in detail in the background paper, this is only a part of the story. Most forms of renewable energy are intermittent sources of generation – you get electricity when the wind blows or the sun shines, and not otherwise. To meet hour-to-hour variations in demand for electricity, for every 100 MW of wind generation capacity it is necessary to have backup capacity, usually provided by gas-fired plants, of 80-100 MW to meet demand during periods when demand is high and the wind is not blowing, as in the UK during December 2010. Backup electricity tends to be expensive per MWh, because the plants do not run much, and the plants have low thermal efficiency because of the costs of starting up and running down.[3]

There is not just a requirement for backup capacity. Nuclear and clean coal plants are designed to operate almost continuously – on base load - for economic and technical reasons. With large amounts of wind capacity there may be surplus power when the wind is blowing and demand is low, so either wind or nuclear plants will be constrained in the amount they can operate. Relying upon wind power will undermine the financial viability of nuclear and clean coal, but allowing such plants to run will further reduce the load factor for wind plants.

The heart of the problem is simple and inescapable. Electricity demand varies greatly over time – daily, weekly and seasonally. Renewable and other low carbon sources of generation are highly capital-intensive and relatively inflexible. The attraction of fossil fuels has always been that they provide the flexibility required to meet fluctuations in demand. There are alternative sources of flexibility – e.g. pumped storage - but they are expensive and/or unattractive for the UK. The figures in the background paper demonstrate that a proper like-for-like comparison requires an investment of about £9.5 billion in wind generation plus associated infrastructure per £1 billion of investment in gas-fired generation.[4] The costs of operations and maintenance excluding fuel are also much higher for renewable energy than for gas-fired plants, especially for offshore wind plants. Higher non-fuel operating costs may be offset by a saving in fuel costs, but the extent of the saving is far from certain because

[2] The load factor for a generating plant is calculated as the total electricity generated in a year (in MWh) expressed as a percentage of the amount of electricity that it would generate if it operated at full rated capacity for 24 hours a day, 365 days a year. No plant achieves a load factor of 100% because of interruptions for maintenance or seasonal variations in demand. Base load plants are electricity plants that operate practically all of the time that they are not being maintained. Typically this will correspond to a load factor of 85-90%.

[3] The problems of backing up intermittent supplies of renewable electricity are not unique to wind power. Two major electricity markets that rely heavily upon hydro power – Brazil and California - have experienced major disruptions in the last decade because of a combination of droughts, mismanagement and a lack of alternative sources of generation when hydro sources could not meet peak demand for electricity. All electricity systems require a margin of spare capacity in reserve to meet peaks in demand or plant breakdowns. However, the margin has to be much greater for most renewable sources of generation than for systems based on fossil fuels.

gas-fired plants used as backup consume up to twice as much gas per MWh of electricity as the most efficient type of gas-fired plants and the fuel cannot be purchased in the most economic way.

There is another dimension to comparisons between alternative ways of generating electricity. Advocates of renewable energy often rely upon projections of performance and costs in future rather than as they are today. In such cases we must be very careful to use such projections in a consistent way. As a matter of fact, the thermal efficiency and overall reliability of new fossil fuel generating plants are much higher than the equivalent parameters for their predecessors 10 or 20 years ago.[5] For example, the thermal efficiency of new gas-fired generating plants has improved from less than 50% to close to 60% over 20 years, but similar improvements have occurred for coal plants as well. New design standards and better operating performance mean that emissions of various pollutants have fallen even more. Experience has shown that such improvements are likely to continue and this must be taken into account when carrying out comparisons. Thus, there is no general reason to assume that future technical progress and improvements in efficiency will favour renewable sources of energy over non-renewable sources.

Proper like for like comparisons put a rather different complexion on claims that investments in renewable energy will generate X thousand jobs – or, more accurately, increase the demand for labour by this amount. We must start with some broad numbers. In order to meet the UK government's target for renewable electricity generation for 2020, it will be necessary to invest about £120 billion at 2009 prices in renewable generation over a period of 8 years in addition to the replacement and/or expansion of non-renewable generation capacity. Over 2006-09, total investment in electricity, gas and water averaged £7.6 billion per year at 2009 prices, while the average value of total business investment over the same period was about £142 billion per year at 2009 prices. Hence, the additional investment required to meet the renewable generation target is close to 1 year's business investment outside the electricity sector. This is bound to have important macroeconomic consequences.

First, adding 200% to historic levels of investment in the energy sector will create supply bottlenecks and demand-driven inflation for capital goods. Either the planned increase in capacity will not occur or it will prove to be much more expensive than the base costs suggest. Second, this amount will represent a diversion of more than 10% of non-electricity business investment into renewable energy, unless there is a significant reduction in household or government consumption to finance an increase in total investment expenditure.

[4] This estimate is conservative because it does not allow for the reduction in the average load factor for wind plants if new nuclear and/or clean coal power plants receive guarantees that they will operate on base load as suggested in recent government proposals.

[5] The thermal efficiency of a generating plant is the proportion of the total energy content of the fuel that is converted into electricity. Holding other parameters constant, a higher thermal efficiency translates to lower costs and lower emissions of CO_2 or other pollutants per unit of electricity.

At this scale, the classic assumptions of a small intervention in a large economy do not apply. These permit economists to assume that any macroeconomic effects can be set aside, thus focusing attention on the immediate direct or indirect consequences of the policy. However, in this case the consequences of who is to pay for the policy, and how, are crucially important because the economic effects arise from a shift in business investment from other activities to renewable energy. Thus, analysis of the impact of green energy policies on the labour market has to proceed in a series of steps.

Direct and indirect effects. The starting point is the demand for labour in the construction and operation of electricity generating plants. This covers (a) employment in the construction industry when the plant is being built, (b) employment in the manufacture of capital goods – wind or gas turbines, boilers, generators, associated transformers and switching equipment, transmission lines, controls, etc – required for the programme, and (c) employment in operating the plants and providing the inputs they consume These calculations apply not only to renewable energy plants but also to other sectors of the economy from which investment has to be diverted. They are examined in Section 5 below.

Technology and comparative advantage. It is claimed that promoting the adoption of renewable technologies will lead to the development of experience, skills and long term comparative advantage in the industries which supply the technologies. This is, of course, simply a modern variant on the old "infant industry" argument for protection and/or industrial subsidies. The traditional argument was that providing financial support or protection for an industry today will enable it to achieve economies of scale or improvements in efficiency (learning by doing) that will confer a (more or less) permanent advantage in future.

The modern variant of the infant industry argument in the environmental context is known as the Porter hypothesis since Michael Porter has argued that the early adoption of strict environmental standards – for example, low emissions of air pollutants such as sulphur dioxide or nitrogen oxides – had enabled countries such as Japan and Germany to acquire a comparative advantage in supplying environmental technologies. Thus, the initial costs of early adoption were offset by the longer term contribution to national income from the comparative advantage they acquired. The classic version of the infant industry argument is viewed with considerable scepticism by most economists because the conditions under which it provides a genuine case for financial or other assistance are very restrictive. Yet it remains popular among those who wish to advocate public support for new or old industries. I will return to this in Section 6.

Changes in production and spending. The Porter hypothesis is only one element in the larger set of adjustments that will follow the implementation of policies to promote renewable energy. With no change in overall economic activity, investment in wind farms, accompanied by higher energy prices, must result in lower levels of real income, investment and consumption in the rest of the economy. The path of adjustment will depend upon a variety of internal and external factors, but the inevitable outcome will be a reduction in economic activity in sectors that are relatively energy-intensive (relative to the outcome with no intervention), together with lower spending on non-energy consumption and investment.

Renewable energy is highly capital-intensive, so once the initial program of investment is complete the diversion of spending required to cover its costs will certainly reduce the demand for labour in other sectors of the economy, though the adjustments may be complex. Further, labour income will be lower than it would have been without intervention, simply because there is an economic cost – called its deadweight loss – involved in promoting specific outcomes or technologies beyond what would be efficient after allowing for external costs. As an illustration, the current renewables obligation is simply a disguised tax which transfers resources from energy users to landowners and others who control renewable energy assets that count under the scheme. Since the scheme is essentially arbitrary, it involves a substantial deadweight loss that is reflected in real incomes.

Macroeconomic impacts – inflation. Up to this point the analysis has rested on an assumption that the overall level of economic activity is not affected by policies to promote renewable. For most microeconomic policies this is a reasonable basis for examining their effects. However, in this case there is a significant macroeconomic impact that must be examined.

The green energy policies proposed by the UK government will have a large and permanent effect on energy costs in the UK. These must be passed on to consumers if the policies are to achieve their goals, so the underlying rate of consumer price inflation will be significantly higher than would have been the case had the policies not been implemented. Under a monetary regime in which the Bank of England is required to target a 2% rate of inflation, this means the rate of inflation excluding energy costs must be reduced in order to meet the target. Hence, it is necessary to consider the impact on GDP of monetary policies designed to restrain non-energy price inflation in order to achieve to the Bank of England’s target.

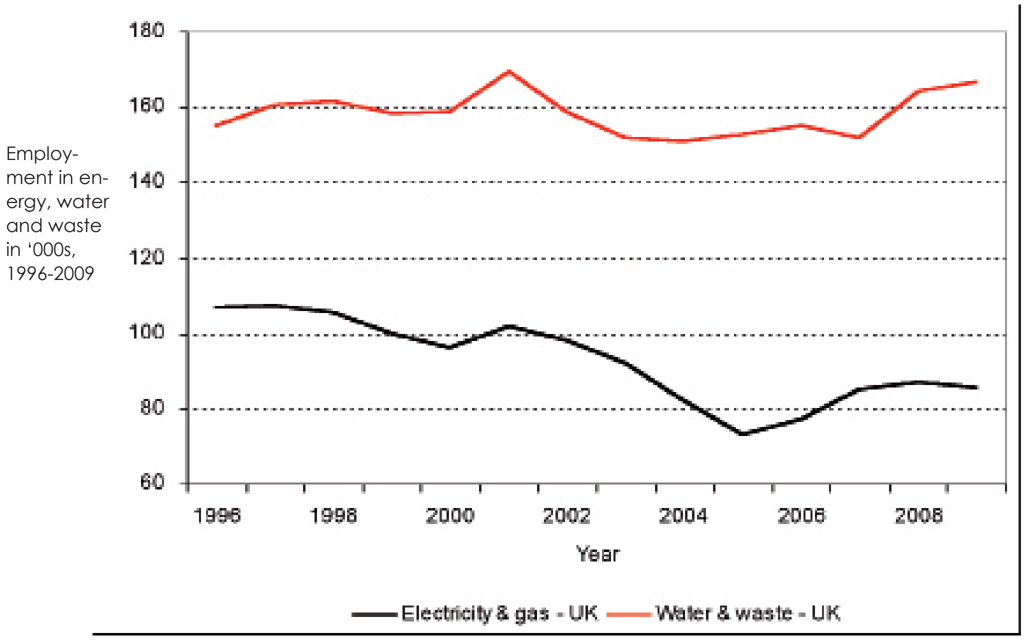
5. Direct and indirect employment

As a starting point it is important to have a sense of the actual number of people who are directly employed in sectors that would be affected by renewable energy or other green projects. The main sources of data are incomplete and use definitions that have changed over time. Figures from the Quarterly Labour Force Survey show that UK employment in electricity & gas, which covers both electricity generation and networks, fell by about 20%, from 106,000 in 1996-98 to 86,000 in 2007-09 – see Figure 1. As a comparison, employment in water and waste services was stable at about 160,000. Figures from the Annual Business Inquiry/Survey show that electricity production accounts for about 25% of the total for electricity and gas – with reported employment of 20-25,000 for 2003-07. In terms of direct employment, this is a very small sector, while recent trends suggest it is likely to get smaller rather than larger.

In rich, post-industrial economies, it is very unusual for new technologies to lead to an increase in the number of people directly employed in providing energy services if the amount of energy consumed is held constant. A simple illustration is the introduction of "smart" electricity meters and their extension to "smart" electricity networks. The essence of the investment in both metering and network management is to provide both consumers and network operators with better information on electricity use. This would allow them better control over both the amount and timing of consumption in a way that reduces the total amount of energy use and the peaks in consumption that lead to very high costs, often associated with the use of generating plants that emit the most.

FIGURE 1

Employment in energy has fallen since 1996, whereas it has remained stable for water and waste



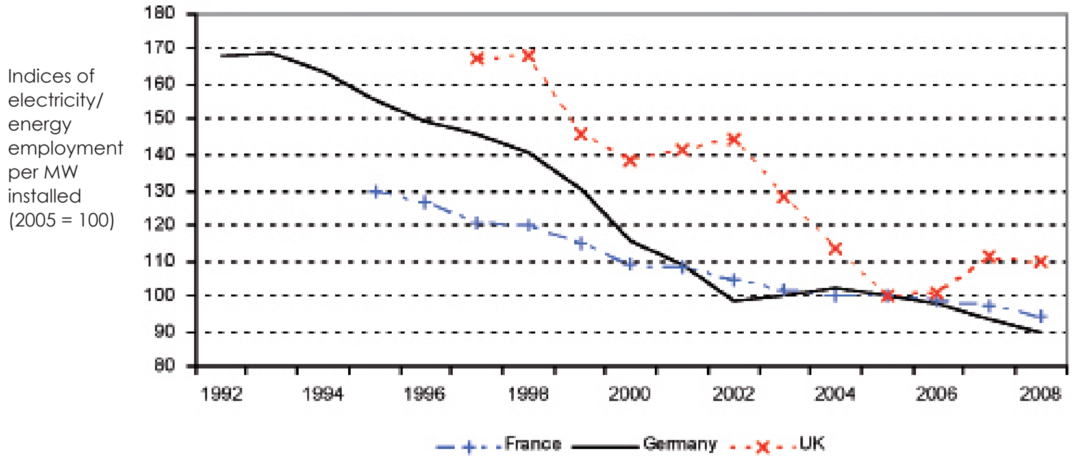
Source: Based on Quarterly Labour Force Survey

Investment in smart metering has been presented as a way of generating green jobs and the US stimulus program of 2009 included funding of about $4 billion for the installation of smart meters. Some simple calculations by a specialist in the field – Sharan (2010) – show that the net effect of this spending over any period longer than 1-2 years would lead to a significant fall in total employment in electricity metering, including installation and production. Even allowing for different practices in the UK, the same conclusion applies to the proposal to install smart meters for UK electricity customers before 2020. In Italy, Enel undertook a large program of installing smart meters, which are not accessible to customers, simply because of the saving in the costs of meter-reading and maintenance.

For electricity generation there has been a clear trend in OECD countries towards fewer but more skilled employees per MW of generating capacity over the past two decades. Detailed analysis for the US shows that the average number of employees per MW fell by about 50% from 1990 to 2003 after controlling for other factors – Shanefelter (2008). This is equivalent to a trend increase in productivity of 5.2% per year. The trend was accompanied by a rather slower increase of 2.0% p.a. in real terms in the average annual wage of employees. A part of this shift in employment was associated with the deregulation of electricity markets and the separation of generation from network operations, which encouraged operators to reduce costs. Nonetheless, the same trends are apparent even in states that did not restructure their utilities.

The decline in average employment per MW of generating capacity has occurred in Europe as well, though the data is not so precise. Figure 2 shows indices of labour hours worked per MW with 2005=100 for France, Germany and the UK. In Germany the labour input refers to the electricity generation, transmission & distribution, while for France and the UK the coverage is electricity and gas. Except in France, with its strong public sector culture, employment per MW of installed capacity has fallen at 4-5% per year, considerably faster

FIGURE 2
Employment per MW of generating capacity in Europe has fallen since the mid-1990s



Source: Based on Eurostat data.

than the increase in demand for electricity. This trend is likely to continue, so any expectation of an increase in direct employment in the electricity sector must depend upon an increase in the level of installed capacity per MWh of electricity demand, i.e. on a fall in the utilisation of generating capacity.

Turning to indirect employment, the crucial issue is the demand for labour associated with investment in generating plants, including any transmission that may be required. Table 1 provides basic information on the costs of building and operating different types of power plants, including an indicative breakdown of costs between various components. This is used to estimate the employment income generated in the UK by the construction of power plants as shown in Table 2.

The direct employment income generated by investment in power plants is about 20% of total investment for all technologies other than solar power – Part A of Table 2.[6] Given the differences across projects and the inevitable uncertainties in the raw data, the amount of direct employment income per £1 billion of investment is similar for renewable energy (other than solar power) and conventional forms of electricity generation.

Part B of Table 2 looks rather deeper by taking account of induced spending, i.e. not just employment income associated with the construction of plants and the manufacture of turbines, generators and other equipment but also the wages and salaries paid by domestic (UK) suppliers of parts and equipment

TABLE 1

Indicative capital and O&M costs for electricity generation

Technology	Operating life	Overnight capital cost	Fixed O&M cost	Variable O&M excl fuel	Indicative composition of overnight capital costs (%)				
	Years	£ mln per MW	£ 000 per MW per year	£ 000 per GWh	Construction	Boilers, turbines, etc	Mechanical & electrical	Solar equipment	Other
Nuclear	60	2.68	43	2.3	15-20%	50-55%	5-10%		20-25%
Coal - advanced	35	1.47	28	1.6	15-20%	55-60%	15-20%		5-10%
Gas - combined cycle	35	0.61	14	1.6	20-25%	50-55%	10-15%		10-15%
Gas - single cycle	30	0.40	9	3.9	20-25%	50-55%	10-15%		10-15%
Wind - onshore	25	1.30	13	0.0	15%	60-65%	15%		5-10%
Wind - offshore	25	2.72	63	0.0	25-30%	50-55%	15-20%		5-10%
Solar photovoltaic	20	4.00	20	0.0	10-15%		25-30%	45-50%	10-15%
Solar thermal	20	3.35	50	0.0	5%	15%	10-15%	55%	10-15%
Biomass	35	2.58	49	5.2	15-20%	55-60%	15-20%		5-10%
Reservoir hydro	50	2.58	13	5.5	50-60%	10-20%	10-15%		15-20%
Pumped storage hydro	50	2.58	13	5.5	50-60%	10-20%	10-15%		15-20%

Source: Capital and O&M costs based on Mott Macdonald estimates for DECC.
Composition derived from detailed project costs.

[6] The estimates in Part A of Table 2 cover wages, salaries and other labour costs for employment directly generated by investment projects – i.e. paid to workers directly employed in construction or the supply of equipment and services.

[7] The estimates in Part B of Table 2 cover wages, salaries and other labour costs for all types of direct and indirect employment including, for example, those working for the suppliers of construction materials or in producing inputs directly or indirectly used in manufacturing equipment for the plants.

TABLE 2

Wages & salaries enerated by capital investment in power generation (£ million per £1 billion of capital investment)

	Construction	Boilers, turbines, etc	Mechanical & electrical	Solar equipment	Other	Total
A. Direct capital spending						
Nuclear	32	110	11	0	57	210
Coal	32	121	26	0	19	198
Gas	42	110	19	0	32	202
Wind - onshore	28	131	22	0	19	200
Wind - offshore	42	110	26	0	19	197
Solar - photovoltaic	23	0	41	33	32	129
Solar - thermal	9	31	19	39	32	130
Biomass	32	121	26	0	19	198
Hydro	102	31	19	0	44	196
B. Direct & indirect capital spending						
Nuclear	73	165	17	0	95	350
Coal	73	181	40	0	32	325
Gas	93	165	29	0	53	340
Wind - onshore	62	196	34	0	32	325
Wind - offshore	93	165	40	0	32	330
Solar - photovoltaic	52	0	63	49	53	217
Solar - thermal	21	47	29	57	53	206
Biomass	73	181	40	0	32	325
Hydro	228	47	29	0	74	378

Source: Author's calculations using UK Input-Output statistics for 2008.

to turbine manufacturers and so on along the chain of economic activity.[7] The primary difference between the direct and total effects of investment is the substantial increase in wages and salaries for hydro power plants. This is a consequence of the large share of construction in the total cost of hydro plants. The way in which figures are recorded means that direct demand for labour by construction firms is modest, but they rely heavily upon purchases of inputs and services which are quite labour-intensive.

Again, the figures do not justify any conclusion that investing £1 billion in renewable energy projects will create a higher level of employment income than spending the same money on conventional power plants. Solar power stands out as having a relatively low share (20-22%) of total employment income in investment while hydro power has a relatively high share (38%). The shares of total employment income for other forms of generation fall in a narrow range for 32% to 35%.

Translating these figures to estimates of the demand for labour depends upon the distribution of skills and average earnings across sectors. In 2008 average labour costs per employee were relatively high in the manufacture of boilers & turbines at about £32,000 per year per full-time employee and lowest in construction and business services (Other) at £26-27,000 per year per full-time employee. These differences imply that the total demand for labour for hydro plants is about 13,600 job-years per £1 billion of investment – while it is significantly lower for wind plants at about 10,700 (onshore) – 11,100 (offshore) job-years per £1 billion of investment. Overall, the differences in labour-intensity between different renewable technologies are much more important than the differences between renewable and conventional forms of generation.

Two simple conclusions follow from this analysis.

- If stimulating the demand for labour is really an important consideration in shaping future policies towards power generation, then priority ought to be given to the development of hydro plants. For example, a combination of nuclear and pumped storage hydro plants would meet demand for electricity with lower CO_2 emissions and greater employment income than relying upon wind turbines with gas backup. Of course, there are many difficulties of land use for pumped storage schemes, but it is odd to favour the use of land in upland and scenic areas for wind turbines but to resist its use for hydro plants.

- Claims that the impact of renewable energy on the demand for labour must rest on the scale of the investment that is required. Naturally, spending roughly £9.5 billion on building wind farms or other forms of renewable generation to meet the UK's future electricity demand to match £1 billion spent on gas-fired power plants will lead to higher payments of wages and salaries linked to investment in electricity generation. However, since the cost has to be funded by diverting resources from other investments, this tells us nothing about the net effect of investing in renewable energy for the economy in aggregate.

The net effect of reallocating finance from other investment to renewable energy will depend on what kinds of investment are displaced by the capital requirements of renewable energy. If all of the finance is reallocated from business investment, then there will be a small increase in employment income from about £310 million per £1 billion of investment to about £330 million. Alternatively, the government seems to view investment in renewable energy as making up for capital spending in the public sector and on housing. In that scenario, employment income will fall by 15-20% from £380-410 million per £1 billion of investment. Overall, it is reasonable to conclude that the net impact on employment income may be relatively small and is quite likely to be negative under current economic conditions. There is no basis for making the suggestion that investments in renewable energy will lead to significant increase in the total demand for labour in the UK.

The economic effects of Mr. Huhne's Green Deal, a programme to upgrade building insulation, are even more transient and uncertain. The whole point of insulation is that it is passive and requires no continuing expenditure after the initial cost has been incurred. Any impact on the demand for labour will be purely temporary during the period of installation, so this leads us on to the indirect employment linked to the purchase of materials and any investment in capital assets. Even these effects are likely to be quite small because it will be financed by reallocating money that might otherwise have been spent on construction services and similar activities.

The employment data in Figure 1 have another lesson if the impact of environmental policies on the demand for labour were to be used as a serious criterion in selecting policies. The environmental sector which employs the largest number of workers is waste management and recycling. Direct employment for 2005-07 in recycling alone was very similar to that for all electricity generation and much larger than for renewable electricity. If recycling makes economic sense, then it would be worth paying workers to separate and manage waste of various types. Instead, authorities responsible for waste management attempt to rely upon unpaid labour inputs from households, companies and others. The labour input for waste separation alone is similar to the transitory increase in employment claimed for Mr. Huhne's Green Deal. This example demonstrates that arguments about job creation in relation to green energy are both incoherent and opportunistic, because no attempt is made to apply them systematically across a range of green policies.

6. Infant industries and the Porter hypothesis

Talk of smart networks, wave power, geothermal engineering, and similar technologies seem intended to give the impression that green projects involve investments in new technologies of a highly sophisticated character. This is largely wrong, as may be illustrated by a few examples.

(a) The most expensive environmental investments in the power sector over the 30 years have involved the (retro-)fitting of equipment to reduce the amounts of particulates, SO2 and NOx emitted by coal-fired plants. While some of the components involve highly sophisticated engineering, the majority of the costs have been incurred for conventional civil works and chemical engineering. These projects are no more, but no less, high tech than modern chemical plants or oil refineries.

(b) Modern wind turbines may look more sophisticated than old windmills, but the basic technologies are mature and widely available around the world. Most of the cost of building new onshore wind farms is spent on civil works, transformers, switchgear and transmission lines – all standard bits of modern industrial technology. For offshore wind farms you have to add the element of anchoring the turbines to the sea bed, technology that originates in offshore production of oil and gas.

(c) Carbon capture and storage (CCS) involves a combination of chemical engineering and gas transmission & storage but in the opposite direction.

(d) As noted, the Green Deal is largely a programme of building insulation combined with the installation of smart meters. Insulation has been promoted by UK Governments consistently over the last 40 years. The materials are standard and the additional employment differs little from any other forms of building maintenance.

These examples make a simple point. Even sophisticated environmental technologies are rarely new because they involve a direct extension of existing technologies from well-established industries. In most cases they require major investments in large scale but conventional civil works or construction. There are a few technologies that can be characterised as genuinely different

– certain forms of solar power, wave power, and nuclear fusion – but, sadly, many of them have remained technologies of the future for several decades. Environmental technology is not new in the sense of quantum computing or genetic engineering. If it is to work reliably on a large scale, it must be based upon established engineering principles and practice.

This observation matters because green programmes do not, as is often claimed, create new sources of competitive advantage for industries and countries. Most civil works and construction is local and will generate employment for suitably qualified workers living close to the investment. On the other hand, many types of machinery and similar capital goods can easily be traded over long distance. Even though wind turbines may initially be manufactured in countries with local demand due to investment in wind farms, this factor is rapidly overtaken by a re-assertion of conventional manufacturing skills and economies of scale in the relevant industries – electrical or mechanical equipment, chemical engineering, building materials, etc. It is easy to mistake a temporary bias in favour of local suppliers while experience is being built up and equipment is being standardised with a permanent source of comparative advantage.

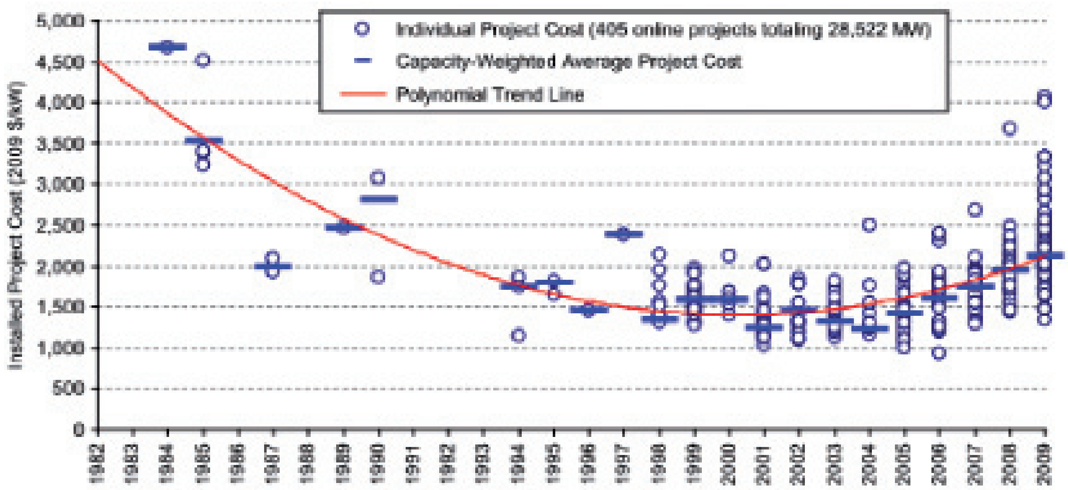
This leaves variants of the Porter hypothesis. As explained earlier, this is a version of the infant industry argument for protecting or subsidising industries, so it is not special to environmental technologies. An essential element of the hypothesis is the assertion that the real cost of producing inputs or capital equipment will fall relative to other technologies and/or other countries. This leads to the claim that a manufacturing industry may be uncompetitive today but will become competitive – in some sense – in future. In such cases, the correct economic test is to treat support as an investment that is required to generate a proper rate of return from higher employment, taxes or incomes in future.

There are two reasons why costs might fall as claimed. One is by gaining economies of scale as production increases. The second is through what economists call learning by doing. The idea is that producers learn how to organise production more efficiently and perhaps how to produce better or more reliable products. The phenomenon is well-documented and has certainly operated in the manufacture of equipment such as combined cycle gas turbines (CCGTs).

The unit cost of wind turbines and solar photovoltaic modules has certainly fallen over the last decade. The difficulty for advocates of the Porter hypothesis is partly that the same process has occurred for other technologies as well – notably for gas-fired plants – and may be expected to continue. Second, the relevant industries are much larger today than they were 10 years ago and there is little evidence that there are large additional economies of scale or learning to be gained, except perhaps for solar thermal equipment. Indeed, US figures suggest that the average cost in real terms of both wind and solar power installations stabilised and/or has been increasing since the middle part of the decade 2000-09 – see Figures 3 & 4. It is unlikely that there is some large reduction in the costs of renewable energy which can be achieved without a major shift in technology.

FIG 3

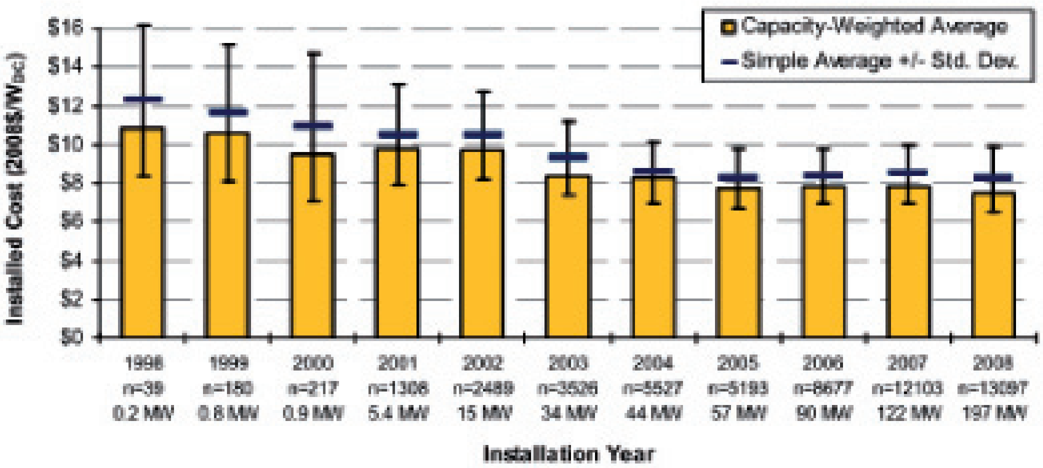
Wages & salaries generated by capital investment in power generation (£ million per £1 billion of capital investment)



Source: Figure 27 in Wiser & Bolinger (2010).

FIG 4

Average real cost per W of photovoltaic installations in US, 1998-2008



Source: Figure 4 in Wiser et al (2009).

The argument that an opportunity exists to acquire country-specific comparative advantage, leading to substantial job creation, is even weaker. The US provides the clearest example.

A. *Wind turbines.* In terms of total installed capacity, the largest global manufacturers of wind turbines have been based in Denmark, Germany, Spain and the US. In the US, the market for new capacity is dominated by American firms, followed by firms based in Denmark, Germany and Spain. The rapid growth of new capacity in China propelled three Chinese companies into the top 10 manufacturers in 2009. These characteristics indicate that wind turbine manufacturing operates in a manner similar to the markets for other power generation equipment. Small countries – Denmark for wind turbines, Sweden and Switzerland for conventional turbines and generators – can establish and retain comparative advantage in specific niches, but larger economic factors determine the broad structure of the industry. Large markets such as the US, China or Europe tend to be served by domestic suppliers, while components may be purchased either from low cost manufacturing centres or from suppliers with specialised skills that are often not specific to any one industry.

- Total employment in manufacturing wind turbines in the US was reported as 20,000 at the end of 2008, corresponding to new capacity of 8,400 MW installed in 2008 and 10,000 MW in 2009. The size of the domestic market and transport costs mean that US wind farms are more likely to buy from domestic manufacturers than would be the case in Europe, so this figure sets an upper limit on the plausible level of employment in the UK. Currently, the UK has about 2,300 MW of capacity under construction and it is reasonable to expect that the installation could increase to 5,000 MW per year on a sustained basis. The highest projection of employment in manufacturing wind turbines would be 10,000. To put this number into context, total UK employment in the manufacturing sectors covering thermal power plant equipment was about 46,000 in 2007. Growth in the manufacturing of wind turbines would have to be large simply to make up for the loss of employment in existing activities.

B. *Solar power.* The US has always been one of the dominant producers of solar power equipment since much of the technology is based upon US electronics and related innovations. In addition, the climate in some regions of the US is favourable for solar power generation – especially in California and the South-West. Thus, this ought to provide the best conditions for the Porter hypothesis to apply, but that is not what has happened.

- *Photovoltaic (PV) cells and modules.* Until 2005, exports of PV cells and modules exceeded imports. However, despite rapid growth in domestic production in 2008, imports were significantly greater than exports and accounted for more than one-half of all domestic deliveries. The trend is clear: US manufacturers are gradually being displaced by low-cost producers – particularly from China, Japan and the Philippines – as production costs overtake technology as the driving factor in the market. Total employment in manufacturing PV cells and modules will increase for a period – it was about 11,000 in 2008 – as the overall market grows, but this trend will eventually reverse as market growth slows and imports continue to increase.[8]

[8] There is a common misrepresentation of the situation for PV installations. The cost of PV modules has fallen and may continue to fall due to technological change. At the same time, this is a cyclical industry, price changes are often driven by the balance of supply and demand – the same applies to gas turbines as well. Even then, PV modules do not account for the bulk of the cost of PV installations, since inverters, transformers, civil works and supports, and grid connections are more important in cost terms. These are conventional technologies used in a wide range of other generating plants. Lower costs for PV modules do not translate directly to lower costs for PV installations.

- *Solar thermal equipment.* The manufacture of solar thermal collectors in the US is a much smaller industry than PV cells and modules, with employment of about 1,100 in 2008. Exports represent 15% of total production and imports have captured about 30% of the domestic market – a share that has been increasing gradually since the early 2000s. The main source of imports is Israel, so the key factor in this case is not production costs but technology.

These examples illustrate the circumstances under which the Porter hypothesis is more or less likely to be relevant. The primary beneficiaries from the initial phases of learning by doing and economies of scale in renewable energy are small countries that gain a first mover advantage due to a combination of local conditions and innovation – e.g. Denmark for wind turbines and Israel for solar thermal equipment. Over time, however, these initial advantages are eroded as international markets expand and conventional economic factors such as transport and manufacturing costs reassert themselves.

The examples discussed – and others such as geothermal or biomass – provide no evidence that the UK can acquire a long term comparative advantage in the manufacture of renewable energy equipment by any combination of policies that are both feasible and affordable. This would be true even if other countries – whether in Europe or the rest of the world - had no interest in such an objective. In practice, many countries face lobbies for industrial support and market intervention that rely upon the Porter hypothesis to justify financial assistance today on the promise of economic benefits tomorrow. Even if the logic was correct for one country on its own, it cannot possibly be correct when extended to many countries in a open global economy. This is just a fools' competition in which taxpayers and energy consumers must lose.

7. Impact on spending and production

The previous sections focused on the immediate impact of programmes to promote renewable energy on employment, looking at sectors that may benefit directly or indirectly from such investments. The background paper demonstrates that the true cost of renewable energy – calculated on a proper like for like basis – is extraordinarily high. The UK Government has suggested that electricity prices will have to rise by 40% to recover the costs of restructuring market incentives and investments required to meet its targets for reducing CO2 emissions up to 2020. This is likely to be a substantial under-estimate when considering the impact on the economy as a whole, partly because the figures focus on retail rather than wholesale prices and partly because the analysis does not take full account of the investments required to accommodate intermittent sources of electricity generation.

Increasing the investment required to meet future electricity demand by 9-10 times relative to reliance on modern gas-fired plants will approximately triple the average cost of generation. Savings in fuel use are almost entirely offset by the higher costs of operations and maintenance (O&M). After allowing for transmission and distribution costs, the wholesale prices paid for electricity by industrial and other large users will increase by at least 100% and more likely by 150% over the next 5-8 years. Further, this assessment makes no allowance for other measures such as the cost of ETS emission permits, the Climate Change Levy, the Renewable Transport Fuels Obligation, etc – none of which will apply to a manufacturer who relocates to China or any number of other countries.

To understand the potential impact of these changes I have estimated how much employment income by sector would have to fall to offset the impact of (a) an increase of 150% in wholesale electricity prices, and (b) an increase of 100% in total energy costs. The analysis focuses on sectors which produce traded goods, competing with imports or selling in export markets. Inevitably, different assumptions can be made, but my estimates reflect a situation in which producers cannot pass on higher energy costs via higher prices but their input costs, other than for electricity or energy, are similarly fixed. If firms compete for investment funds in the international market, higher energy prices which reduce total value-added must ultimately be translated into lower wages and salaries because investors do not and will not have to accept lower returns.

Table 3 shows the traded sectors which are worst affected by potential increases in electricity and other energy prices. The criterion for inclusion was that the increase in electricity prices is equivalent to 10% or more of current employee compensation. A few sectors may be partly protected by relatively high transport costs – e.g. building materials including structural clay products and cement, lime & plaster or animal feed. Total employee compensation in the sectors identified in the table amounted to about £39 billion in 2008. This is only 5% of the total employee compensation for all sectors, but it is nearly 40% of employee compensation for traded sectors that compete in international markets.

The figures highlight a crucial issue. Suppose we take the commitment to reduce emissions of greenhouse gases as given. Does the UK government wish to achieve this by contracting the traded sectors of the economy? Total employment in the sectors that will be severely affected by the higher costs of electricity and energy is about 1.3 million full-time equivalent jobs. The prospective increase in electricity costs is 17.4% of employee compensation in all of the sectors listed in Table 3, while the increase in total energy costs is 31.5%.[9] A part of that burden may be translated into lower wages and/or higher prices in the UK market, but it is inevitable that many businesses will simply contract or close down their operations – transferring activities to more attractive locations. The consequences for manufacturing employment in the medium and longer term will far exceed any temporary boost due to investments in renewable energy.

[9] These are weighted averages of percentages in colums 2 and 3 of Table 3 with employee compensation in column 4 used as weights.

TABLE 3

Impact of higher energy prices on employee compensation by sector

	Reduction in employee compensation due to:		Employee compensation, 2008
	150% increase in electricity cost	100% increase in energy cost	£ mln
Fishing	55.0%	203.7%	109
Metallurgy	48.4%	73.3%	2,415
Building materials	44.0%	90.9%	504
Inorganic & organic chemicals	43.8%	125.0%	877
Pulp, paper and paperboard	41.3%	59.7%	650
Industrial gases and dyes	32.7%	49.1%	637
Glass and glass products	22.9%	41.9%	840
Animal feed	18.9%	29.6%	365
Shipbuilding and repair	17.9%	17.0%	1,292
Articles of concrete, stone etc	17.7%	29.0%	1,747
Mining & quarrying	15.4%	23.9%	1,504
Fertilisers, plastics & pesticides	15.2%	55.0%	905
Weapons and ammunition	14.7%	13.7%	662
Paper and paperboard products	14.7%	20.9%	2,058
Rubber products	14.1%	18.1%	849
Structural metal products	14.1%	14.5%	2,457
Agriculture	12.9%	50.4%	4,178
Soft drinks and mineral waters	12.8%	20.0%	411
Dairy products	12.4%	25.4%	822
Plastic products	12.3%	15.6%	4,871
Other chemical products	11.9%	32.1%	1,201
Machine tools	11.8%	10.1%	406
Other transport equipment	11.5%	11.5%	702
Oils and fats	11.1%	58.9%	190
Ceramic goods	10.5%	18.6%	570
Special purpose machinery	10.3%	11.5%	1,977
Alcoholic beverages	10.2%	23.1%	1,546
Metal forging, pressing, etc	10.0%	11.8%	4,280

It is easy to characterise such arguments as special pleading and that the sectors affected should come to terms with the reality of higher energy costs by improving efficiency, etc. Undoubtedly, there are cases in which the rhetoric of economic damage due to policy changes is overstated, but policymakers should beware of making that assumption in this case. I can illustrate the point by a very important example based upon personal knowledge.

During the transition from socialism in Central Europe and the break-up of the former Soviet Union from 1989 to 1992, I carried out a series of studies of industrial competitiveness in all of the countries affected using the methods underpinning the analysis presented here – Senik-Leygonie & Hughes (1992), Hare & Hughes (1994). A crucial issue was the potential effect of moving to market prices for energy and other natural resources on a wide range of industries. The studies highlighted the fact that a significant portion of industrial activity in all countries (more than 50% in some cases) was operating at negative or very low value-added – i.e. the cost of their inputs at world prices exceeded or was close to the value of their outputs at world prices. The inevitable consequence was that the industries concerned would collapse once they were required to pay international prices for their inputs and were exposed to competition in international markets. That is exactly what happened: industrial output and employment fell by amounts varying from 20% at the low end to 60% at the high end over a period of 3-4 years and our work correctly identified the sectors that were at most risk.

The adjustment that occurred in the transition economies was unavoidable, even though it had a massive human cost, because the industries affected were very inefficient and relied upon extravagant use of under-priced oil, gas, and other resources. The same considerations do not apply in the UK today. Electricity, energy and other natural resources are not under-priced in the UK today, even when external environment costs are properly taken into account. The Government's proposals will impose substantial costs on energy users for environmental benefits that are absolutely minimal in relation to trends in the world economy and total emissions of greenhouse gases. It is hard to understand why a Government which claims to believe that the UK cannot continue to thrive solely by selling financial and other services to the rest of the world should adopt policies that will substantial damage or close down sectors that account for nearly 40% of employment income from traded goods.

8. Macroeconomic arguments

In this section I will consider two consequences of green energy policies for macroeconomic management. They imply that the assumption that the effects of such policies should be assessed within a static macroeconomic framework has to be modified for a dynamic approach. The first element is a consequence of the reallocation of investment funds from other sectors to finance the additional costs of renewable generation. The diversion is far from marginal, amounting to about 10% of business investment over a period of 8 years. This means that the productive capacity of the economy will be lower than it would have been without the policies. Under any macroeconomic policy regime this must reduce the level of GDP in the longer term.

The reduction in non-energy investment will amount to £105-110 billion, at 2009 prices, up to 2020. Using a marginal capital-GDP ratio of 3, which is typical for developed countries, this will translate to a reduction of about 2% in potential output in 2020. Provided that the labour market remains relatively flexible, this will not affect the overall level of employment but it will be reflected in lower value-added per worker and thus lower incomes. It is roughly equivalent to the loss of one year's growth in total factor productivity. This may not seem a lot but the aggregate impact is 40% of the total reduction in the planned level of public spending announced by the Chancellor in October 2010.

The second element concerns monetary policy. The Bank of England is required to set its monetary instruments to achieve a target rate of inflation of 2% per year in terms of the CPI. The effect of the Government's policies will be to increase the trend rate of inflation between now and 2020 because of their impact on (a) the electricity and other energy prices paid by consumers, and (b) non-energy prices, as the effects of high energy costs are passed on by non-traded sectors. The combined effect of these factors will be an increase in the CPI of about 6.5% up to 2020. Again, this may not seem too serious until the implications for monetary policy are examined. If Bank of England maintains its inflation target, the effect of the renewable policy implies that the general rate of inflation can be no more than 1.3% per year up to 2020 in order to accommodate the policy-driven increase in energy and energy-related prices.

Macroeconomists use a concept called the "sacrifice ratio" to measure the reduction in capacity utilisation – i.e. the permanent loss in GDP - required to reduce core rate of price inflation by 1 percentage point. Most current estimates suggest that the sacrifice ratio is at least 2 and may be substantially higher. At the lower end of the scale this means that the Bank of England would need to operate monetary policy to reduce the level of economic activity by 1.5% relative to what it would have been. Cumulatively, this translates to a loss of GDP over the period up to 2020 amounting to about £250 billion.

Adding these two elements, the macroeconomic impact of the policies to promote renewable energy will be to reduce GDP by 2-3% for at least 10 years. The loss of income from this reduction will greatly outweigh any possible non-environmental benefits from the promotion of green technologies. To put it in context, it is equivalent to sacrificing all net investment in the public sector – i.e. the part not funded out of depreciation – or about 60% of total spending on education for the UK as a whole. These are not small sums and illustrate the costs of implementing a misguided and poorly designed set of policies.

9. Conclusion

The UK Government has set a target which implies that by 2020 more than 30% of the country's electricity will come from renewable sources of energy, in practice mostly from onshore and offshore wind farms. Because of the technical characteristics of wind generation the capital cost of building the generation capacity required is 9-10 times the capital cost of meeting the same demand from modern gas-fired power plants. In money terms the extra capital cost is roughly £105 billion at 2009 prices and will be equivalent to nearly 10% of total business investment up to 2020. There will be some saving in fuel costs from reliance on wind power, but this gain will be largely offset by the much higher costs of operation and maintenance for wind farms.

The justification for promoting the use of renewable energy is that it will contribute to meeting the UK's goal of reducing CO2 and other greenhouse gas emissions by 34% relative to 1990 in 2020. However, once the effects of economic growth are taken into account, the reduction in CO2 emissions as a consequence of the programme to promote renewable electricity generation will be just 8% of the reduction that has to be made between 2010 and 2020. The average cost of CO2 saved will be about £270 per metric ton, nearly 20 times the average price of CO2 traded under the European Union's Emissions Trading System.

Whatever one's view of the urgency of reducing emissions of CO_2, it is clear that the public and its political representatives have never signed up to the proposition that the UK should sacrifice a minimum of 4-5% of GDP annually in order to meet climate change targets that will have a minimal effect on global warming, even if all other EU countries adopt the same targets. Goals that may be acceptable if the cost of reducing CO2 emissions is £20 or even £50 per metric ton have an entirely different complexion if the best available policy, according to the Government, will cost a minimum of 5 or 10 times more per unit of reduction.

It is possible that the true costs of relying heavily upon renewable electricity generation were not recognised when the current targets for CO2 reductions and renewable energy were originally considered. This is unfortunate, but it reflects the fact that it is quite easy to accommodate small amounts of wind generation in a system with a substantial margin of mid-merit coal and gas power plants. Analysis of the actual performance of wind farms and the difficulties of managing large amounts of intermittent generation ought to prompt a reconsideration of the targets rather than an even more vigorous digging of policy black holes.

As the potential costs of the UK's policy commitments have become clearer, the political rhetoric has shifted to emphasising the alleged economic benefits of greater reliance on renewable energy. The argument is that the promotion of renewable energy will "create" jobs in manufacturing or maintaining wind turbines and similar equipment. Of course, the fact that practically every other developed country in the world makes the same claim is studiously ignored.

In this paper I have explained that there are two broad objections to these arguments. The first is that real incomes levels, not employment, provide the criterion by which to judge economic policies. If the level of aggregate real income is held constant, then higher employment is, usually, worse rather than better because of the loss of leisure and other job-related costs. Claims about green job creation seem to rely upon a casual assumption that higher employment is necessarily associated with a higher level of aggregate real income or welfare. Not only is this not true as a general proposition, there are strong macroeconomic grounds for believing that green energy policies will not affect the long run levels of aggregate employment. Instead, the non-environmental impact of such policies will fall on the real level of employment income. In as far as they have short term, transient, effects on the labour market, the same impacts can be met at much lower cost by other interventions.[10]

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[10] The conclusion that green energy policies will not increase – and could decrease – total employment is supported by a substantial number of studies. Examples include a recent paper that the programs act as a form of macroeconomic stimulus whose effects could be mimicked in a number of different ways, eg by Gulen (2011), an analysis of the impact of policies with respect to renewable energy in Germany by Frondel *et al* (2009) and in Spain by Alvarez *et al* (2009), and a review of arguments about the US fiscal stimulus and green jobs for a general audience by Levi (2009). The consistent theme is that claims for green job creation (a) fail to take account of adjustments outside the sectors directly or indirectly affected, and (b) do not standardise macroeconomic activity and thus assume that the programs act as a form of macroeconomic stimulus whose effects could be mimicked in a number of different ways.

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Acknowledgements

I am grateful to Ian Byatt, David Henderson, Nigel Lawson and Alan Peacock for comments on earlier drafts of this paper. The views expressed in this paper are strictly my own and do not represent the position of any organisation with which I am affiliated.

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Published by the Global Warming Policy Foundation
ISBN: 978-0-9566875-3-1

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