THE DAVID HUME INSTITUTE

Independence and the Market for Electricity in Scotland

Grant Allan

Peter McGregor

Kim Swales

May 2013

Research Paper No. 8/2013

The David Hume Institute
26 Forth Street
Edinburgh EH1 3LH

Independence and the Market for Electricity in Scotland*

Grant Allan

Peter McGregor

Kim Swales

May 2013

*The authors are grateful to all of the participants in the Roundtable discussions of an earlier version of this paper, especially David Cameron, Andy Kerr, Jeremy Peat and David Wilson. The paper draws liberally on research undertaken for ClimateXChange, the Scottish Government funded Centre of Expertise in Climate Change, and EPSRC's Highly Distributed Energy Futures Consortium. However, the views expressed are the sole responsibility of the authors.

Foreword

We at the David Hume Institute were delighted to be awarded funds, in conjunction with Professor Charlie Jeffery of the University of Edinburgh, by the Economic and Social Research Council to organise four 'conversations' on issues related to constitutional change in Scotland. Previously we have published a number of research papers related to the first two conversations; (i) macro-economic policy issues and financial sector oversight and regulation and (ii) social security and welfare under alternative constitutional settlements. We are now very pleased to be able to publish the papers for our third conversation – on a range of energy-related issues. On this topic we have also benefitted much from co-operation with the Scottish Council for Development and Industry (SCDI). The fourth will be on competition policy and regulation, for which we have the full support of the Scottish Government. All four will be completed by end May 2013.

In each of these conversations we have sought papers from a range of informed and interested parties, drafts of which were discussed at a 'Chatham House Rule' seminar before being finalised and published in advance of a full and open seminar. For the energy conversation the round table was held at the Royal Society of Edinburgh on 18th March and the seminar will take place, also at the RSE, on 7th May. We are delighted now to make these papers available.

For the round table we initially commissioned three papers. One, by Professor Mark Schaffer and colleagues at Heriot Watt University covered the evolving global; energy landscape; one by Professor Peter McGregor and colleagues at Strathclyde covered primarily energy topics; and the third by Professor John Paterson and Greg Gordon from Aberdeen University covered oil and gas issues.

However, we determined at the round table that it would be most valuable to have a separate paper on consumer matters, and we were delighted that Patricia McAuley of Consumer Focus Scotland agreed to produce such a paper, in liaison with interested parties at Which?

There is also a fifth paper of significant interest and definite relevance, produced by and separately published by SCDI. This is available at
http://www.scdi.org.uk/pi/2013/SCDIFutureScotlandApr13_Energy_web.pdf

All of the papers' authors will be with us at the seminar, where we will also benefit from an introduction from Dr Andy Kerr of the University of Edinburgh. As always with our seminars, there will also be a full question and answer session, with the authors involved.

We at DHI very much hope that these papers, along with the debate at the seminar and other elements of the conversation, will assist to inform the policy debate on an evidence-based, objective and sceptical manner. However, while commending the papers to your attention, it is as customary necessary for me to stress that the Institute itself has no views on any of the matters discussed.

Jeremy Peat
Director
David Hume Institute

Independence and the Market for Electricity in Scotland

Grant Allan,Peter McGregor and Kim Swales

1. Introduction and Background

In liberalised electricity markets the impact of further constitutional change depends on the reaction of all the relevant transactors involved in the supply and demand for electricity. This includes the manner in which supplies and demands are balanced and the way in which the market is structured and regulated. A comprehensive analysis would thus require a detailed study of the impact on the "supply side" of the market (generation, transmission, distribution and supply), as well as on the "demand side" (households, firms, government). Furthermore, the fact that electricity cannot easily be stored raises balancing issues, and the Government, both directly and indirectly (through its influence on the market structure and the regulatory framework), influences behaviour at all levels. In this paper we do not aspire to a comprehensive analysis, given the difficulties of delivering that at this stage. A full analysis, for example, would require further information concerning electricity market reform and greater evidence of the impact of constitutional change in these circumstances. Rather, we seek to focus on a number of key areas that we believe will govern the eventual impact of independence.

Under the status quo, many of the elements of the electricity market are outwith the control of the Scottish Government and are reserved to Westminster. The promotion of renewables, the resistance to new nuclear and the adoption of legally binding climate change targets are examples where successive Scottish administrations have used devolved powers to, in essence, pursue a distinctive Scottish energy policy (Allan *et al*, 2008). However, many of the key aspects of electricity market policy (including market regulation, taxation, etc.) are, under current constitutional arrangements, beyond the control (though not necessarily the influence) of the Scottish Government. Significant constitutional change may alter some aspects of market structure and transactor behaviour (for better or worse). But change under independence may not be dramatic if, for example, a unified GB electricity market is maintained and there is little substantive difference in regulation in practice, despite the establishment of a separate Scottish regulator, as the current Government again intends (e.g. Ewing, 2013; Scottish Government, 2013).

We organise our discussion around the likely impact of further constitutional change on the ability of the Scottish Government to achieve its energy policy goals, though we focus primarily on effects that are linked to possible developments in the electricity market.[1] In liberalised markets, energy policy involves the use of policy *instruments* to induce private transactors to behave in a way that achieves *targets* as well as the ultimate policy *objectives*, subject to *constraints*. In the Scottish and UK context the major policy objectives include: security of supply; environment protection (limiting carbon emissions to inhibit climate change); economic development (in a sustainable manner) and energy affordability. Additionally economic development potential has received rather greater emphasis in Scotland (where energy is one of the Government's key growth sectors) than in the UK as a whole.[2]

[1] The goals of electricity market policy are essentially the same as those of energy policy generally (e.g. DECC, 2012).
[2] Fuel poverty is sometimes added to this list.

2. Security of Supply

Security of electricity supply must surely remain a key objective of the Scottish Government, irrespective of constitutional arrangements. This is a fairly complex phenomenon, but the notion of “keeping the lights on” conveys its significance. Security of supply would typically require: a balanced portfolio of generation technologies of sufficient capacity; the reliability of these technologies (and of the sources of supply of any required fuels); and resilience to shocks (including shocks to supplies as well as to prices). With an electricity grid covering Great Britain, linked through interconnectors with Europe and Ireland, the spatial dimension to security of electricity supply will evolve with the size of the grid. Within a single physical electricity market covering Great Britain, for example, it would seem appropriate to consider security of supply at the whole-grid level.

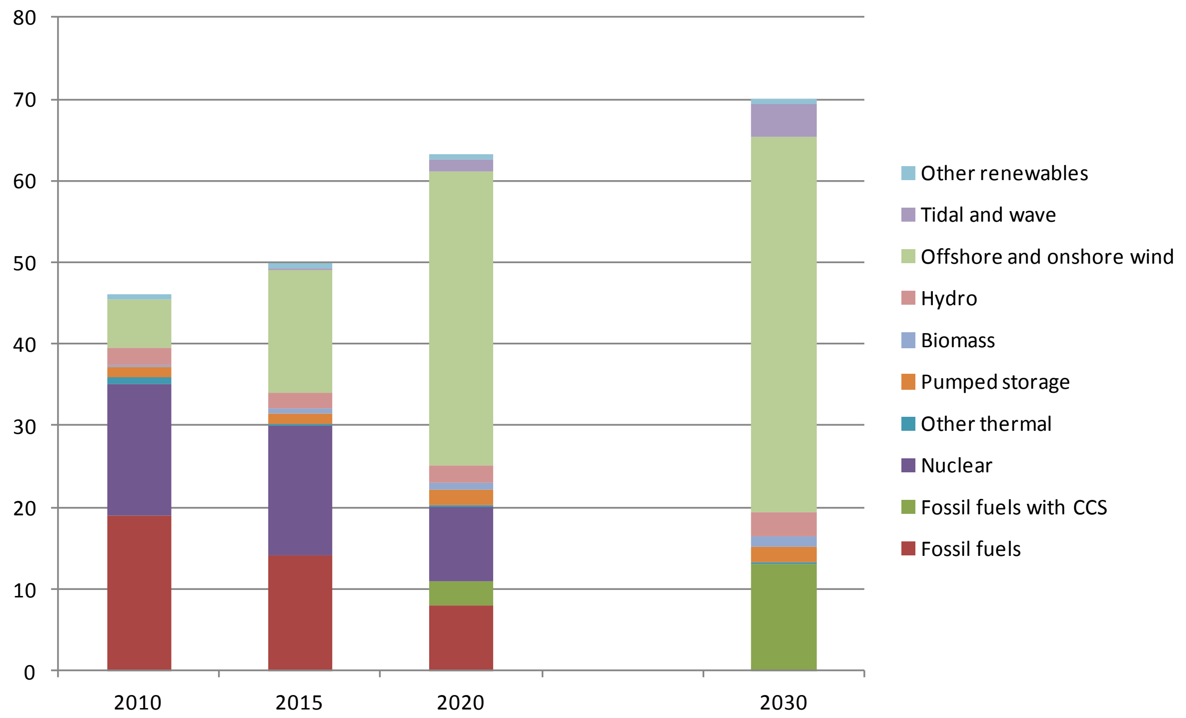
However, security of supply becomes a rather more difficult objective to achieve, other things being equal; the smaller is an economy; the more concentrated is its portfolio of electricity generators; the more insular is the market (in terms of capacity to trade electricity); the smaller is storage capacity (including fuel storage as well as pumped hydro); the more restrictive is its transmission and distribution system; and the more geographically dispersed are its residents. One, typically shorter-term, dimension of this is simply dealing with “outages” especially for generators that provide a significant percentage of Scotland’s electricity. So movement to a distinctive Scottish electricity market would pose potentially important challenges for security of supply within Scotland. It seems natural that, if we are considering the appropriate spatial scale at which to formulate and implement policies relating to security of supply, there would be major benefits from collaborating in such a way as to enhance system resilience to make domestic consumption of electricity less dependent on domestic production through links with other markets.

We consider there to be two factors affecting the value of electricity security: the balance of electricity generation technologies in the generation mix; and the resilience to supply and price shocks. We examine each of these in turn, beginning with the mix of technologies in the generation mix. Stirling (1996) raises three important dimensions of “balance” in an energy portfolio – the number of different technologies in the mix (“variety”); their contribution to the mix (“equality”); and how different each technology is (“difference”).

The current Scottish Government’s implicit targets (no new nuclear, no large scale biomass) appear to imply an electricity generation mix within Scotland that could be less diversified (in terms of technologies that are very different from one another) than is currently the case. Of course, the aspiration is to a diversified portfolio of renewables (with a particular emphasis on offshore technologies, including wave and tidal), augmented with major generating plants that incorporate CCS technology. Under scenarios between 2020 and 2030 where onshore and offshore wind, and wave and tidal, contribute a large share of the output of Scottish electricity generation facilities, by the “equality” indicator the Scottish generation mix would likely improve as the share of fossil fuels in the generation mix reduces, with a growing share from renewables. A geographic distribution of renewable technologies could go some way to mitigate the impact of intermittency from renewables (but this is limited by correlation among resources). Other things being equal, this renders security of supply a greater challenge – certainly if Scotland’s market is insular.

Figure 1 below shows one forecast for the output of Scottish grid-connected electricity generation between 2010 and 2030 (SKM, 2012). Note that between 2020 and 2030 nuclear, and fossil fuels (without CCS) cease production, with more than half of their output being replaced by fossil fuels with CCS (13 TWh). In 2010, the Scottish mix included 35 TWh of non-CCS fossil and nuclear, indicating the significant transformation of the generation mix anticipated over the next twenty years. The increase in on and offshore generation, as well as wave and tidal output, is evident from this figure.

Figure 1: Scottish generation output by plant type, 2010 to 2030, TWh



Source: Scottish Generation Scenarios and Power Flows – SKM January 2012, quoted in Scottish Government's Electricity Generation Policy Statement.

The trading of electricity therefore provides an essential element in ensuring security of supply for smaller economies. Presently, this is assured for Scotland through transmission links within an integrated GB market, and through links with Europe, which currently aspires to provide an integrated EU-wide market by 2014 (though we return to consider whether such links are likely to be unaffected by independence). The greater the transmission capacity, in particular for imports, the more secure is Scotland's supply of electricity. However, for national economies the extent of dependence on imports (usually framed in terms of fuels to be used in generation, rather than direct electricity imports) is regarded as a potential threat to security of supply. But this link is not straightforward as, for example, when miners were regarded as a threat to security of supply and imported coal the solution. However, it seems clear that an independent Scotland would likely have to depend, for periods at least, on imports of electricity or fuels from RUK and elsewhere to ensure security of supply.

At present Scotland is a net exporter of electricity and the Government wishes that to continue, but imports are also often required as the electricity system operates at the GB level. Even if renewables targets are met, these are likely to be predominantly from variable sources given current plans over the relevant time frame.

Therefore some back up generation capacity would be required. It is likely to be much cheaper for Scotland effectively to draw on capacity elsewhere to fill any gap. Modelling of power flows under alternative Scottish generation capacities has indicated the importance of additional transmission capacity to ensuring the security of electricity supply in Scotland. In the presence of "excess" capacity in Scotland under renewables scenarios, solutions could include: additional storage or demand side measures; additional transmission capacity to allow Scottish electricity to reach a market; or for generation to be constrained off.

RUK has a much bigger generating capacity currently, though again much of this is due to be retired. However, security of supply looks to be a pressing issue, given the projection of declining capacity margins if no action is taken. The UK intends to adopt some solutions for generation that are not being considered by the current Scottish Government, notably new nuclear and large scale biofuels. However, the former aspiration has yet to be reflected in new investment (and we consider this below). So security of supply may well be a major issue for the RUK Government too, although planned Electricity Market Reform does include payments for capacity that are intended to alleviate the problem.

Turning to the resilience of the electricity mix, one issue that arises here is whether an independent Scotland could rely upon RUK in the presence of major outages in the way that it does presently. If margins are indeed tighter in RUK, presumably that Government's first priority will be to ensure that "the lights stay on" for its own residents. Perhaps the arrangements for an integrated GB market and collaborative regulatory agreement ensure equity among customers in this respect, but this could presumably be questioned by RUK residents (and voters). If Scotland were to seek to ensure security of supply simply through Scottish capacity, the costs would be very substantial. From the perspective of the UK as a whole this would be an extraordinarily inefficient way of achieving security of supply. This would seem to be an example of provision of a quasi-public good that would more efficiently be delivered at higher levels of Government (UK and ultimately EU).

Of course, independence does not imply a neglect of interdependence. Indeed the Scottish Government's current position is that it is RUK that will need electricity from Scotland to ensure RUK's security of supply (e.g. Ewing, 2013). There are a number of issues here. If RUK does develop a security of supply problem, it will presumably choose to address this in a number of different ways, as is already apparent from the current UK Government's plans. Firstly, the RUK can seek to address this through domestic (RUK) production. Here it is constrained by legally binding EU and Climate Change targets (and EU ETS). However, for RUK nuclear and large-scale biomass are low-carbon options (though the low carbon credentials of the latter are disputed by some). Secondly, RUK can invest in further capacity to allow greater trading of electricity. While investments are planned for RUK-Scotland, they are not the only links being developed/ enhanced. If the Scottish electricity market became even slightly differentiated (from the RUK market), relative prices are going to be a major driver of RUK demand for Scottish exports. Regardless, Scotland will not be the only source of low-carbon electricity imports for RUK, given transmission links to France and elsewhere in Europe (and plans for increases in the capacity of such links and an integrated European grid), and it seems unlikely that RUK can be regarded in some sense as a "captive market", at least over the longer term. We consider the argument that RUK will in effect be rendered a captive market because of its need to satisfy legally binding EU renewable energy targets in Section 3 below.

Naturally, CCS will provide a medium term support for security of supply in both Scotland and RUK if it is demonstrated and then deployed at scale over the relevant time period, but that is by no means assured.

The generating capacity required to ensure security of supply can be moderated by actions to influence the demand side of the market, including the adoption of smart technologies for grids and metering. An enhanced ability to manage electricity demand should provide greater security of supply by providing increased opportunities for managing demand in the face of outages, for example. The efficacy of such changes in influencing both household and firm behaviour has yet to be established, however, and is complicated to a degree by the potential rebound and backfire effects associated with energy efficiency stimuli (see below).

There seems to be a presumption that an independent Scotland will not face a security of supply issue if current plans are achieved. However, it is not clear that this would be true in all possible future circumstances. An example would be if CCS is not successfully deployed but Scotland continues to rule out nuclear and large scale biomass plants. Of course, maintaining an integrated electricity market with GB and augmenting the transmission system with RUK all help to ensure security of supply in an independent Scotland (as well as facilitating net exports of electricity, which we turn to below). However, it is not entirely clear how a completely integrated market could be maintained under independence. Overall, it seems likely that security of supply will prove a greater challenge for Scotland as an independent nation than for Scotland as an integral part of the UK.

3. Climate change

Climate change and the electricity market

We have argued elsewhere that the objectives of Scottish Climate Change policy are likely to be unaffected by further constitutional change since this has been devolved since its inception (McGregor and Swales, 2013). In fact, however, climate change objectives do not impact directly on the emissions of the electricity generating sector because the latter is covered or "traded" by EU ETS, so that a reduction in this sector's actual emissions do not directly contribute to the Scottish Government's emissions targets (which include the Scottish share of EU ETS limits instead of actual emissions for traded sectors).

The Scottish Government does, however, have an additional commitment (though not a legally binding one) to decarbonise the electricity generating sector. The Scottish Government has set a non-statutory target of an emissions intensity of 50gCO2/kWh for electricity generation in Scotland by 2030. The current emissions intensity of the Scottish electricity generation is 291gCO2/kWh. The Committee on Climate Change's recent report noted that in 2010, electricity generation provided 76% of the emissions by the energy sector. Given that the energy sector is itself the biggest source of CO2 emissions Scotland, with 37% of all emissions, this is a very significant commitment. While actual emissions by the power generation sector do not contribute to the Scottish Government's emissions targets, they are nevertheless important for the ultimate objective of moderating climate change in the longer term for a number of reasons. First, EU ETS will gradually tighten as decarbonisation of the electricity generating sector proceeds. Second, the decarbonisation of the electricity sector ultimately facilitates further emission reduction in other sectors. A key example is in transport, which emitting 24% of Scotland's total CO2 in 2010, through electrification of vehicles. Decarbonisation of electricity will also allow reduced carbon heat generation.

Accordingly, the decarbonisation of the electricity generating sector is, in fact, a key element of Scottish Government's climate change policy despite contributing nothing immediately to its emissions targets. The main types of policies that impact on emissions through their effect on electricity use do so through: the price of carbon; the promotion of renewables (notably through Renewable Obligation Certificates and Feed-in Tariffs for small scale developments); the Renewable Heat Incentive and Renewable Heat Premium Payment; and the promotion of more efficient use of electricity. We briefly consider how independence might impact on each in turn.

The price of carbon, renewables and electricity efficiency

Currently the ***price of carbon*** is set within EU ETS (for covered sectors) and therefore is outwith the Scottish Government's control. There remains scepticism about the ability of the scheme to establish a sufficiently high long-term price of carbon to signal the scale of action on emissions required (given the manner of EU ETS implementation), and it is clear that the present Scottish Government would like to see a higher carbon price established.[3]

Under independence it is conceivable that a Scottish Government, especially one outwith the EU, would choose to introduce a carbon tax. We explore the possible consequences of this in Allan et al (2012). A substantial carbon tax does indeed prove capable of exerting a significant contractionary impact on emissions, though the scale depends on the financing. If there was no recycling of the carbon tax revenues, the emissions reduction is greatest but partly because of the simultaneously adverse impact on the economy. Returning the carbon tax revenues to the economy benefits economic activity while not significantly stimulating emissions, although the specific impact depends on how the revenues are "recycled". The reduction in economic activity is mitigated if the tax revenues are used to stimulate general government expenditure, but completely offset if they are used to reduce the tax on labour income. In this final case, economic activity rises while emissions fall suggesting a "double dividend". The proposed EMR does include a proposal to establish a carbon price floor that would create similar incentives to inhibit the use of carbon-intensive technologies (DECC, 2012).

The ***promotion of renewables*** is a key feature of current Scottish Government policy, as indeed it has been of successive Scottish administrations. This reflects the scale of the resource in Scotland and the perceived opportunities for economic development (considered in Section 4 below). The Scottish Government has used a variety of instruments to encourage this. An example is the streamlining of the planning process and investments in port infrastructure to facilitate offshore developments so as to create a perception of a renewables-investor-friendly location. However, currently the main policy instrument used to directly induce this is ROCs. While the Scottish Government has influenced the policy, as reflected in the banding that favours new marine technologies, the costs are currently borne by UK consumers as a whole. However, not surprisingly some doubt has been expressed about the likelihood of this arrangement continuing after independence, and if it is not, and the Scottish Government continues to pursue its objective of generating the equivalent of Scottish consumption of electricity, prices to Scottish consumers would have to rise significantly above those charged in RUK (Citigroup, 2011) .

[3] Under ETS the price of carbon adjusts to ensure emissions targets are met. However, the manner in which ETS has been implemented leaves room for doubt about the political commitment implicitly to impose high prices in the future, once the economies of Europe pick up from the current recession.

The Scottish Government believes that, in effect, this relationship will be continued since the UK looks to be struggling to meet its legally binding EU target (which translates into 30% renewable electricity) even with Scotland's substantial contribution. So, in effect, RUK will have little option to continue to purchase "green energy" certificates from renewable electricity generation in Scotland and effectively subsidise its generation.

However, one issue is whether RUK is really a "captive market" even in these circumstances, as Toke *et al* (2013) note. Other domestic (RUK) options may be more attractive post-independence, including local offshore options and other import possibilities, as noted in our discussion of security of supply issues above. The RUK could also choose to trade in green certificates e.g. with Ireland in order to meet its EU targets.

A further issue is that, following independence, existing EU targets will presumably require to be renegotiated. If a resource criterion were employed, as Scotland has higher renewable electricity generation its target could be raised () and RUK's diminished, perhaps to the point where RUK was no longer dependent on Scottish renewable generation (Toke *et al*, 2013). In these circumstances Scotland's renewables would have to be funded by Scottish electricity consumers (or perhaps by general taxation). If this is indeed the case, there would need to be careful discussions around the likely levels of financial support for technologies, and its affordability from Scottish consumers. Additionally, the transition of generation facilities that currently receive support from these schemes may require to be honoured, but what support rules would projects at pre-operational, planning, scoping stages be entitled to? It is possible that following independence generation facilities in Scotland would be in receipt of a number of different support mechanisms. Some questions remain however: would those facilities remain on this GB-wide mechanism or be changed onto schemes funded by Scottish consumers? If the latter, by how much would bills need to rise? If the former, would this apply for new generation facilities as well?

Matters appear even more challenging for an independent Scottish Government when consideration is given to the fact that huge investment in electricity infrastructure is required to bring Scottish renewable electricity to the South. Under independence, and the circumstances envisaged above, achievement of Scotland's renewable targets would add to the pressure on Scottish consumers (and voters).

The UK's proposed EMR would substitute "contracts for difference" for ROCs as the main policy for encouraging low carbon technologies as a whole, not simply renewables (the focus of ROCs). The idea is to provide long-term assistance through establishment of a "strike price" for electricity that would mitigate price uncertainty. While intended to promote new nuclear capacity, it has yet to encourage such investment to be brought forward. The uncertainty regarding the precise implications for renewables is, at least temporarily, leading to a delay in some intended deployments.

Energy efficiency generally, including electricity efficiency, is often regarded as something of a "magic bullet" allowing "more to be done with less". Unfortunately, matters are more complex than this once it is recognised that energy efficiency improvements tend to reduce the price of an effective unit of electricity and thereby tend to stimulate demand. The resultant rebound and backfire effects can mitigate or even more than offset the benefits to energy efficiency changes (e.g. Hanley *et al*, 2009).

4. Economic development potential

Successive Scottish Governments have emphasised the economic development potential of low carbon technologies in general, but renewables in particular. The concentration of renewable resources in Scotland, both onshore and offshore, renders their exploitation particularly attractive here as they offer the opportunity simultaneously to reduce emissions and stimulate economic activity. Few instruments produce this kind of double dividend: in general emissions move directly with economic activity. So renewables are one possible way of tackling the trade-off between the environment and economic growth: sustainable economic growth. In this section we explore the likely economic development potential of renewables and then ask how this is likely to be impacted by independence.

The Scottish Government has identified "Energy (including renewables)" as one of its six "private-sector dominated Growth Sectors", alongside food and drink, creative industries, sustainable tourism, financial and business services and life sciences. The most recent Growth Sector statistics reveal that that the "Energy" sector is significant for Scottish employment and income. In 2011, the sector employed 64,800 and had the highest median weekly gross pay per full time employee job of any growth sector in 2012 at £663.10 per week. This is 33% higher than the median wage in Scotland. The sector also has international importance for Scotland with 21% of Scotland's exports to the rest of the UK and 18% of all Scotland's international (non-RUK) exports coming from this sector in 2011 (Scottish Government, 2013).

While these statistics relate to energy activities in Scotland, capturing the distinctive contribution of renewable energy is more complex. Simply put, there is no one industrial classification which captures all the activities currently undertaken in the Scottish economy – of which there are many – which can be identified with the renewable energy sector. The activities of designing, developing, testing, manufacturing, installing and operating renewable technologies are classified across a range of industrial sectors. Additional difficulties are that some firms, for example fabrication facilities, will have a portion of their work supplying the renewable sector, which may be only one of many activities to which they sell products. These issues make it difficult to quantify the impact of renewables, but this should not be a barrier to such an attempt being made. Indeed, detailed firm-level data-gathering, coupled with standard input-output modelling – as used for other sectors - could readily identify the unique contributions across the Scottish economy made by the activities which are considered part of the renewable sector. Such a repeatable exercise could make a useful contribution to understanding the mechanisms linking different levels of policy and publicly stated targets for the economic impact of renewable energy and technologies.

The Scottish Government's targets for renewable energy developments are often explicitly tied to the development impact that meeting the target may confer on the Scottish economy. The renewable energy roadmap, for instance, mentions that the Scottish Government's target of the equivalent of 100% of Scottish electricity consumption produced from renewable electricity in Scotland is: "A target that is necessary to reindustrialise Scotland through 21st century technologies and seize the opportunities to create tens of thousands of new jobs and secure billions of pounds of investment in our economy" (Ewing, 2013).

We see four direct routes between renewable electricity and economic development. These are:

- The impact of expenditures on demand
- Technology learning leading to export potential
- Retention of income locally through new facilities contributing to Scottish communities and firms near the development site
- Spillovers from innovation in renewable energy technologies to other activities of the economy

We briefly sketch each route below, before examining the possibility that independence for Scotland would change the size or nature of any economic impact on Scotland.

4.1 Stimulating demand in the host economy

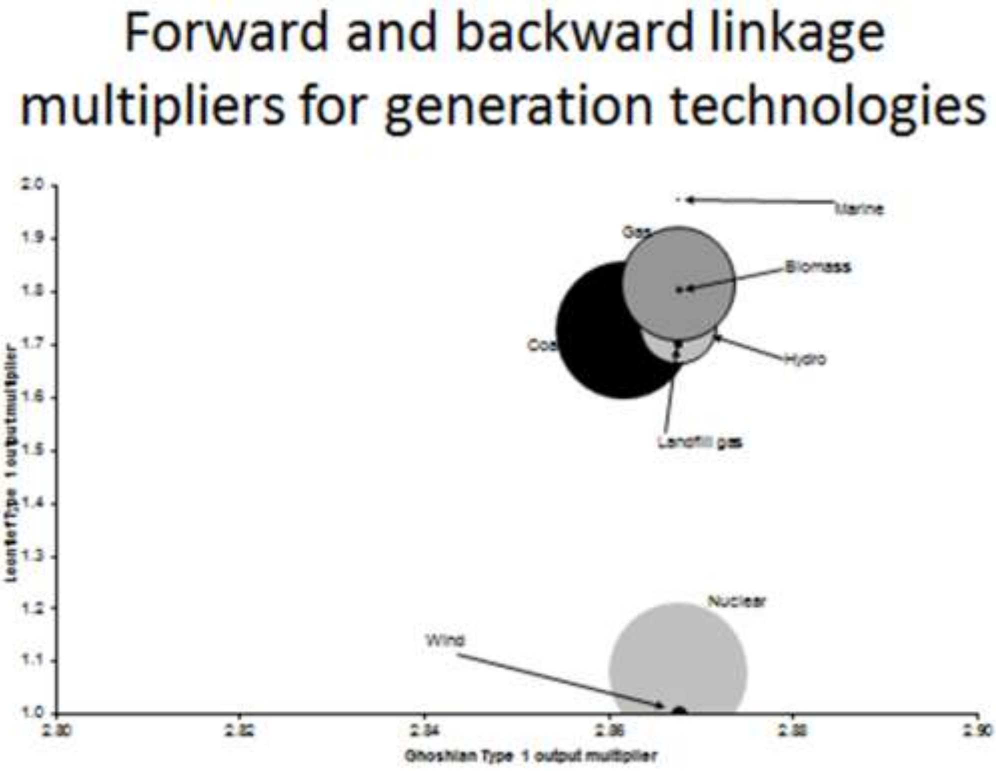
The development of any new renewables project is likely to stimulate the demand side of the host region. The extent of this stimulus will depend on: the scale of the project; the openness of the host economy; and the level of "backward linkages" – the degree to which the project is embedded in the host economy. Multipliers give a "bang per buck" indicator of the likely impact of a stimulus to demand and these are plotted for a number of Scottish generating technologies (in 2000) in Figure 2 (Allan et al, 2007).

In Figure 2 the strength of backward linkages, through the supply chain, are indicated by the scale of Leontief Type 1 multiplier, plotted on the vertical axis. This indicates the direct and indirect effects of a stimulus to the final demand for electricity from this source. The strength of forward linkages – through each technology's sales of electricity – are indicated on the horizontal axis. Since each of the generating technologies sells all of its output to the transmission, distribution and supply sectors, the extent of forward linkages is common to all the technologies. The scale of each technology (in 2000) is indicated by the size of the corresponding circle.

Figure 2 shows that onshore wind at that time had very little in the way of backward linkages to the Scottish economy: there was effectively no indigenous supply chain and so little knock on effect. Of course the Scottish Government is aware of the importance of an indigenous supply chain and has attracted international investors to locate in Scotland to manufacturing offshore wind turbines. In contrast marine had significant knock on effects. The subsequent developments in wave and tidal and the belief that Scotland is world leading in these technologies suggest there is considerable potential here.

However, it is worth noting that there is heterogeneity among renewables, so the choice of technology to generate electricity may matter a great deal for the scale of economic "impact". While these estimates are hardly encouraging in terms of the impact of onshore wind farms, the latter can have significant effects on host local communities through community benefits and especially if there is co-ownership (which we return to in the next section). This is a fairly rigorous input-output (IO) approach, in contrast to some "green job" estimates. However, there are still sources of potential upward bias. First, there is no recognition in this approach of the possible "crowding out" of other domestic activity, e.g. the IO method assumes a "passive" supply side: this method operates "as if" only demand matters (we return to this shortly). Also there is no recognition of the opportunity cost of any subsidies provided to generators.

Figure 2.

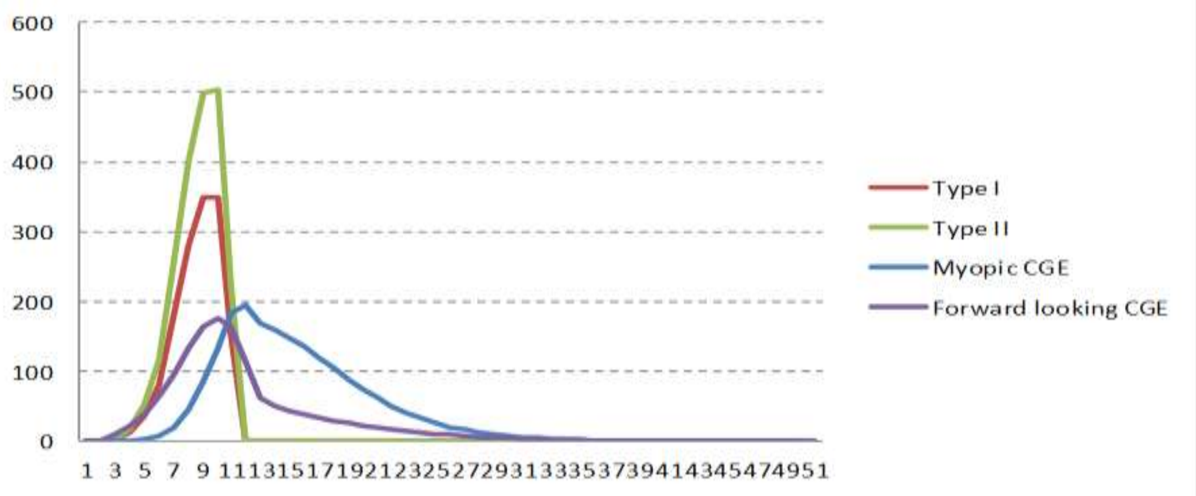


Further, what publicly available evidence there is suggests that local links between construction and installation of energy infrastructure can sometimes be mixed. For some technologies and some projects the supply chain of inputs is truly global (BVG, 2011), with the consequence that the local economic impacts from transitory expenditures can be modest.

In response to the lack of "crowding out" considered in the IO modelling of the impact of renewable energy expenditures, recent work has used computable general equilibrium models, in which the supply side of the economy is explicitly modelled. In these models, the extent of any crowding out can be quantified. These have shown that, even for temporary expenditures, there can be economic impacts that last well beyond the period of expenditures. These are the so-called "legacy" effects.

An example is given in Figure 3 where we simulate the anticipated expenditures between 2010 and 2020 that will be involved in the installation of the 1.6GW capacity marine energy devices in the Pentland Firth and Orkney waters. For this piece of work, we use our Scottish computable general equilibrium model (Allan *et al*, 2013). IO modelling approaches imply that all economic impacts occur in the same period as the expenditures – due to their assumed passive supply-side response. Under the "myopic" (i.e. backward-looking) and forward-looking CGE model configurations, however, the same expenditures give a quite different impact.

Figure 3: GDP Impacts of Pentland Firth Developments



The Type I input-output (IO) results include only direct and indirect effects of the expenditures, where the latter reflect the fact that purchases of intermediate inputs from other sectors in turn stimulate their output. In addition, the Type II input-output results include effects induced by the increase in incomes and therefore consumption expenditures. Type 1 and 2 results are shown in red and green, respectively, in Figure 3. These input-output results overstate the impacts on GDP during the period in which direct expenditures are occurring, once induced wage and price effects are taken into account as a comparison of the IO and computable general equilibrium (CGE) results confirms. These are the results over the first 10 years. However, note that the CGE results also imply the presence of legacy effects that extend well beyond the direct expenditure period. (We have only explored the impact of the installation expenditures here, but operating expenditures could also be considered).

Of course, the impact on the Scottish economy of the large expenditures anticipated in developing infrastructure and capacity in renewable energy and electricity over the next few decades could be significant. Where the impact depends upon the sourcing of inputs from activities in the Scottish economy, the major issue is that the supply chain for goods and services is likely to be a global one. Estimates of the local (i.e. Scottish) sourcing share vary, but it is likely to be higher for some products than others, and could be related to the feasibility and cost of transportation. Anecdotally, from the offshore wind sector, there could be little role for even UK-based firms in specific products.

While we have concentrated here on the economic impacts of the expenditures, it is straightforward to extend the models to allow them to track the impact on emissions.

4.2 Supply side impacts

Up to this point we have only discussed the economic consequences of the expenditures. However, part of the motivation for encouraging new renewable technologies is their potential impact on innovation through learning effects. These in turn stimulate enhance efficiency and reduced costs, further augmenting the market share of the new technology. While the scale of these effects can be substantial, we find that they depend to a significant degree on the precise specification and parameterisation of the learning functions. This can also facilitate the development of a world market in the new technology and a stimulus to Scottish exports.

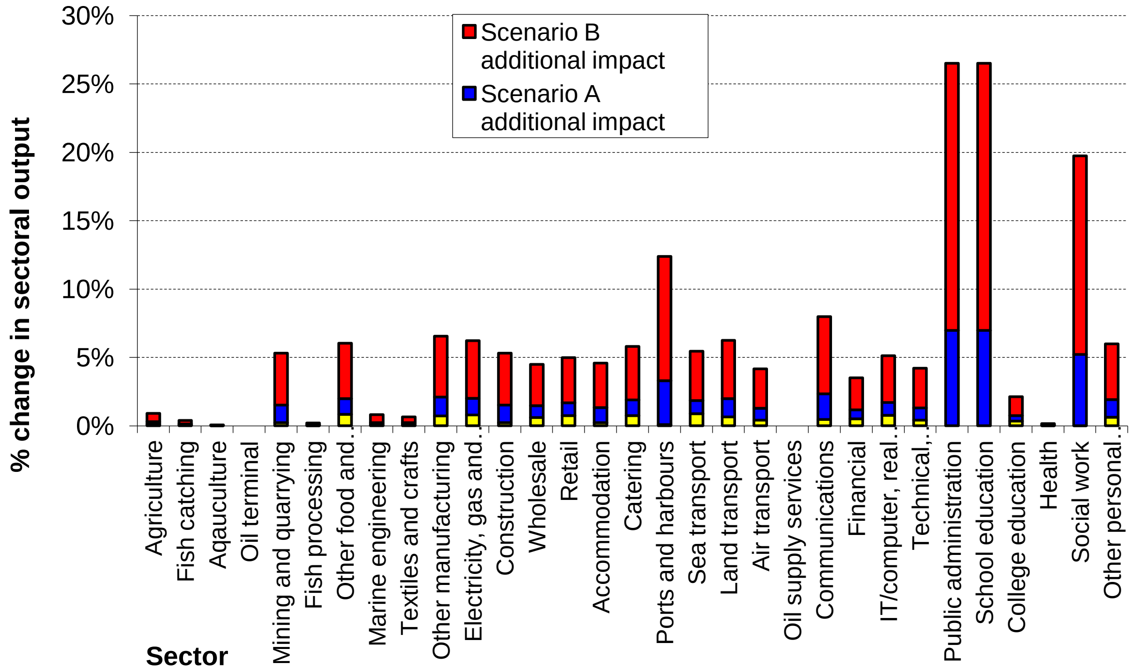
While capturing innovation properly is therefore more of a challenge we have explored the impact of: endogenous learning embedded in new technologies; the impact of developing an export market for marine technologies; and the scale of the subsidy required to achieve various emissions targets (and these are very substantial). While past patterns of the development of renewable technologies (most notably onshore wind) can be instructive, the heterogeneity of these technologies mitigates against mechanical extrapolation. There is undoubtedly considerable potential here, but also uncertainty about Scotland’s ability to realise this potential.

4.3 Local income retention

An additional route from renewable energy development to economic impact is through projects having a financial link into the community or local area in which they are sited. This could take a number of forms. One form involves local residents or community groups (which may have any of a variety of legal underpinnings, including local authorities, community councils, shareholder/investor communities) making investments in local renewable energy projects or facilities and so receiving an income from the project.

There are a large number of onshore renewable sites across Scotland linked in these ways with communities, perhaps through the distribution of “Community Benefit” payments which can then be used to invest in local infrastructure, to expand public assets, or in other ways. The example of the Viking wind farm (Allan et al, 2011) illustrates how conventional community benefits (captured by Scenario A, coloured blue in Figure 4) and co-ownership (Scenario B, red) can augment the impact of renewable energy projects on local industries that arise through conventional backward linkage effects (yellow).

Figure 4: Impact of Viking wind farm on the Shetland economy



Displacement effects can be accommodated in principle even in this (IO/Social Accounting Matrix) framework. For example, if renewables replace fossil fuel generation the latter can (and should) be treated as a contraction in demand and the net impact effect could be identified and it may not be positive. It is also possible to adjust for the opportunity cost of public financial support or subsidy, at least in principle. See e.g. Hermannsson et al, 2013a,b)

4.4 Innovation leading to technology spillovers to other activities, e.g. high-value manufacturing

In principle technology innovation could, as well as developing skills in individuals and companies, confer benefits on other areas of the economy in which manufacturing of related products or services takes place. A simple example from marine energy could be mooring technologies having applications in sea transportation or other uses in the offshore environment. While such spillovers may be difficult to identify *ex ante*, they could be significant *ex post*.

One major issue with such a mechanism contributing to growth of Scottish firms could be the extent to which innovation in manufacturing and other activities are truly local in a globalised world of cross-border information exchange. If the specific mechanism operates through Scottish firms accessing information created in Scotland through developing energy capabilities, then surely non-Scottish firms would also be able to access such information. In a global world, any developments in knowledge might only deliver marginal and transitory gains to Scottish firms. However, first-mover advantage can be significant here, as is apparent from the history of the development of onshore wind.

4.5 The impact of independence on the development potential of renewables

Assessing the economic development impact of new renewable technologies in a rigorous way is in itself challenging; assessing the potential impact of independence here is even more so. What seems fairly clear is that there are likely to be costs, as well as benefits. The benefits include the potential, at least, of more policy instruments to encourage renewables/ discourage fossil fuel generation (such as a carbon tax), and to encourage inward investment. However, it seems likely that, in the long-run, there will be costs in the form of higher electricity charges for Scottish consumers relative to those in RUK. While the net effect may depend, at least to some extent, on the negotiating skills of an independent Scottish Government in the short to medium terms, over the long-run the RUK government’s options extend and substitution possibilities are likely to be enhanced.

5. Affordability

While the aspiration to make energy in general, and electricity in particular, “affordable” may be laudable, the Government of a small, open Scottish economy may have limited control over this to the extent that it relies on imported fuels and indeed the same is true of the UK Government. Of course, the move to decarbonisation reduces that reliance (though will not eliminate it if CCS is employed on coal and gas generation.

5.1 Levelised costs of electricity

Inspection of the levelised costs of various generating technologies gives an idea of their current competitiveness. It is clear that renewable technologies are more expensive than conventional, fossil-fuel technologies and could not currently compete with them on a level playing field.

Furthermore, there are major differences in costs among renewable technologies. In particular, onshore wind is closest to being competitive, with offshore wind considerably more expensive and the new marine technologies more expensive still (though wave substantially more so than tidal). There are typically two key issues about the deployment of renewable technologies: the carbon price and technical improvements through learning by doing.

New technologies typically are more expensive than established ones, but the rationale for subsidy is that they are expected to reduce costs through time, in part through learning and possible returns to scale, ultimately becoming competitive. However, a movement now towards a portfolio of more renewable technologies does imply an increase in costs. The competitiveness of renewables as against fossil fuel technologies also improves as the price of carbon increases, since their costs decline relatively. However, again the implication is an increase in the cost of generating electricity.

5.2 Affordability

While some renewable technologies are not competitive with fossil fuel based technologies, in the longer term that position would be expected to improve. First, the price of finite fossil fuels seems likely to increase, though the shale gas phenomenon may limit this influence over the short and medium runs. Secondly, the cost of new renewables, in particular, should decrease through learning effects (and technology spillovers) and potential economies of scale. Where technologies learning is occurring in a global market – such as onshore wind – then the pace of development in Scotland will not likely affect the speed of cost reduction. For some other technologies, such as marine, for example, Scotland has ambitions to be a global leader. In such circumstances, the speed of cost reductions is likely to be more closely matched to the expansion of a marine energy capacity in Scotland. Where this is tied to (Scottish) funding of R&D, it is therefore plausible that the cost for Scottish funders of attaining marine energy targets could be greater than in technologies where Scotland is not a global player. This downside could be offset by the export potential conferred on firms working in the Scottish market, and the commensurate economic impact for Scotland.

From a policy perspective, an increase in the price of carbon would help to provide incentives to shift away from fossil fuels, but subsidies to renewables – especially if the newer technologies are to be encouraged – are likely to be present for some time, though the scale of subsidy to the more mature technologies should gradually be eliminated. However, neither the increase in the price of carbon, nor the reducing costs of renewables seem likely to eliminate the need for subsidies to renewable technologies in the foreseeable future. It is difficult to envisage anything other than a challenging outlook for affordability. Furthermore, independence seems likely, if anything, to make that outlook even more challenging for Scotland, since it will probably result in a greater concentration of the costs of renewables on the Scots themselves.

6. Conclusions

Our analysis suggests that, on balance, independence would render security of supply more difficult to achieve, although maintenance of a single GB market, if that can be achieved, would limit the difficulty. Independence would also furnish the Scottish Government with more policy instruments to achieve emissions reductions, but probably increase the cost of doing so if it is to be achieved through the promotion of renewables, and provision of the associated infrastructure. Similarly, independence would likely allow a wider range of policies to stimulate economic development, and encourage renewables, but increase the costs of pursuing such policies for Scots. It also seems likely that independence would have an adverse effect on affordability, although an independent Scottish Government would have significantly enhanced powers to influence distribution (though these would not be costless). However, we would emphasise that there is considerable uncertainty surrounding each of these conclusions, since this will be affected, for example, by the policy stance that the Scottish Government chooses to adopt.

It should, of course, be acknowledged that our focus on the impact of independence on the electricity market is rather restrictive. A comprehensive analysis would need to consider interdependence with other sources of energy, including gas, particularly given the potentially radical changes that this market is currently subject to. Furthermore, our analysis does not amount to anything approaching a full cost benefit analysis of the likely impact of independence on the electricity sector.

REFERENCES

Allan, G, McGregor, PG, Swales, JK and K Turner (2007) "The Impact of Alternative Electricity

Generation Technologies on the Scottish Economy: An Illustrative Input-Output Analysis", Journal of Power and Energy (Part A of the Proceedings of the Institution of Mechanical Engineers), Vol. 221, pp243- 254.

Allan, G., McDonald, J., McGregor, P and K. Swales (2008). "A distinctive energy policy for Scotland?" Fraser of Allander Economic Commentary, Vol. 32 (1), pp 46-61.

Allan, G.J., McGregor, P. G. and Swales J.K. (2011) "The Importance of Revenue Sharing for the Local Economic Impacts of a Renewable Energy Project: A Social Accounting Matrix Approach", Regional Studies, Vol.45, No. 9, pp 1171-1186.

Allan, G., Lecca, P., McGregor, P. G., Swales, K., Tamba, M. and M. Winning (2012). "The Impact of the introduction of a carbon tax for Scotland." Fraser of Allander Economic Commentary, Special Issue pp 13-18.

Allan G, Lecca P, McGregor, P and Swales, J K (2013), "The economic impacts of marine energy developments: A case study from Scotland", mimeo.

BVG Associates (2011), "UK content analysis of Robin Rigg offshore wind farm", A report commissioned by E.ON Climate and Renewables, September 2011.

Citigroup (2011) "Independent Scotland" report.

Department of Energy and Climate Change (2012) *Electricity Market Reform: Policy Overview* (DECC, May)

Ewing, F. (2013) speech delivered to the Scotsman *Energy Policy in an Independent Scotland* seminar.

Hanley, D., McGregor, P.G., Swales, J.K. and Turner, K. (2009), "Do increases in resource productivity improve environmental quality and sustainability?", Ecological Economics, 68 (3), pp. 692-709.

Hermannsson, K, Lisenkova, K, McGregor, P G and J K Swales (2013) "'Policy Scepticism' and the Impact of Scottish Higher Education Institutions (HEIs) on their Host Region: Accounting for a Regional Budget Constraint under Devolution", Regional Studies, forthcoming.

Hermannsson, K, Lisenkova, K, McGregor, P G and J K Swales (2013) "The Expenditure Impacts of Individual HEIs and their Students on the Scottish Economy under Devolution: Homogeneity or Heterogeneity?" Environment and Planning A, forthcoming.

McGregor and Swales (2013), "The Impact of Greater Autonomy on Scottish Climate Change Policy" in Scotland's Future, Goudie, A., (ed). Dundee University Press, Dundee.

Scottish Government (2012). The Scottish Greenhouse Gas Emissions Target 2010 (Scottish Government: Edinburgh). http://www.scotland.gov.uk/resource/0040/00405463.pdf

Scottish Government (2013) Growth sector statistics database, online at http://www.scotland.gov.uk/Topics/Statistics/Browse/Business/Publications/GrowthSectors/Database

SKM (2011), "Scottish generation scenarios and power flows: An analysis", November 2011, online at http://www.scotland.gov.uk/Resource/0039/00393483.pdf

Stirling, A. (1994), "Diversity and ignorance in electricity supply investment: Addressing the solution rather than the problem", *Energy Policy,* 22 (3), p. 195-216.

Toke, D., Cowell, R., Ellis, G., Sherry-Brennan,F. and Strachan, P.A. (2013), "Scotland, renewable energy and the independence debate. Will head or heart rule the roost", *Political Quarterly*, 84 (1), pp. 61-70

THE DAVID HUME INSTITUTE

REGISTERED OFFICE (Registered in Scotland No. 91239)
26 Forth Street, Edinburgh,
EH1 3LH
Tel (0131) 550 3746
Scottish Charity Number SC009579
Email: enquiries@davidhumeinstitute.com
Website www.davidhumeinstitute.com