UK Renewable Energy Policy Since Privatisation

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Abstract

The aim of this paper is to look at the UK's renewable energy policy in the context of its overall decarbonisation and energy policies. This will allow us to explore the precise nature of the 'failure' of UK renewables policy and to suggest policy changes which might be appropriate in light of the UK's institutional and resource endowments. Our focus is on the electricity sector both in terms of renewable generation and to a lesser extent the facilitating role of electricity distribution and transmission networks. We will suggest that the precise nature of the failure of UK policy is rather more to do with societal preferences and the available mechanisms for encouraging social acceptability than it is to do with financial support mechanisms. Radical changes to current policy are required, but they must be careful to be institutionally appropriate to the UK. What we suggest is that current policies exhibit an unnecessarily low benefit to cost ratio, and that new policies for renewable deployment must pay close attention to cost effectiveness.

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UK Renewable Energy Policy since Privatisation

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January 2010

This paper reviews the progress with increasing renewable energy supply in the UK since 1990 with a particular focus on recent developments. The UK is regarded as a country where the considerable potential for renewable energy[2], relative to other major European countries, has failed to be realised. It is also frequently suggested that the UK needs to change its policies to renewables to look more like that in Germany or Spain (e.g. Mitchell, 2007).

The aim of this paper is to look at the UK's renewable energy policy in the context of its overall decarbonisation and energy policies. This will allow us to explore the precise nature of the 'failure' of UK renewables policy and to suggest policy changes which might be appropriate in light of the UK's institutional and resource endowments. Our focus will be on the electricity sector both in terms of renewable generation and to a lesser extent the facilitating role of electricity distribution and transmission networks. However we will highlight the interactions between the electricity, heat and transport sectors in the UK within the overall decarbonisation policy context.

We will suggest that the precise nature of the failure of UK policy is rather more to do with societal preferences and the available mechanisms for

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[1] This paper is a longer version of a chapter in *Harnessing Renewable Energy* edited by Jorge Padilla and Richard Schmalensee (to be published by RFF Press an imprint of Earthscan). The author acknowledges the financial support of Gas Natural in writing this paper (and LECG in managing the process) and ongoing intellectual support of the ESRC Electricity Policy Research Group. Bin Feng provided excellent research assistance. The comments of Boaz Mozelle, David Newbery , Jorge Padilla, Dick Schmalensee, Steve Smith, Jon Stern and an anonymous referee are acknowledged. The usual disclaimer applies.

[2] The definition of renewables used in this chapter is that in the EU Draft Renewables Directive ''energy from renewable sources' means renewable non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases' (European Commission, 2008, p.21).

encouraging social acceptability than it is to do with financial support mechanisms. Radical changes to current policy are required, but they must be careful to be institutionally appropriate to the UK. Calls to ‘just do it’ with respect to delivery of larger quantities of renewables are economically irresponsible and highly likely to backfire in terms of achievement of ultimate policy goals such as decarbonisation and energy security. What we suggest is that current policies exhibit an unnecessarily low benefit to cost ratio, and that new policies for renewable deployment must pay close attention to cost effectiveness.

UK renewable energy policy exists in a wider energy policy context. The UK’s stated energy policy can be summed up as aiming to achieve ‘secure, affordable and low-carbon energy’.[3] It therefore has three identifiable priorities: addressing climate change, providing energy security and keeping energy bills down. These policy objectives are naturally in tension. The first two are expensive, while tackling the third entails keeping prices down, if not for everyone, for a significant minority of poor consumers. Between 1990 and 2003 domestic electricity prices fell significantly in real terms in the UK (by around 30% per unit), but have risen by around 40% from 2003-2008.[4] The number of households defined as being in energy (or fuel) poverty (spending 10% or more of total expenditure on heating and power) has risen from a low of 2 million in 2003 to 3.5 million in 2006[5] out of a total of around 25 million households[6]. This has put a strain on the ability of richer consumers to simultaneously finance poor consumers (via bill payments to company support schemes)[7] and expensive policies arising from climate change and energy security objectives. EU directives have also provided significant shape to UK energy policy, providing the basis for

[3] See http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/uk_supply.aspx, Accessed 25 August 2009.
[4] Source: Table 2.2.1 (st), available at http://www.decc.gov.uk/en/content/cms/statistics/source/prices/prices.aspx. Accessed 25 August 2009.
[5] Source: http://www.berr.gov.uk/files/file48037.pdf, Accessed 25 August 2009.
[6] Source: http://www.statistics.gov.uk/cci/nugget.asp?id=1866, Accessed 25 August 2009.
[7] See http://www.ofgem.gov.uk/Media/FactSheets/Documents1/updatedhouseholdbills09.pdf Accessed 20 October 2009. This indicates that in August 2009, 8% of a typical electricity bill and 3% of a typical gas bill was being charged to support environmental schemes, of which the most expensive were targeted on lower income consumers.

targets to 2020 for CO_2 reduction and renewable electricity generation share.

The UK policy context is nicely illustrated by Scrase and Watson (2009) who discuss the conflict between a desire to take a policy lead on carbon capture and storage (CCS) and the requirement to keep the costs of a potentially very expensive policy down. Initially the government were considering picking a winner and supporting a project proposed by the oil company BP, only to realise that it would have to have an open competition to select a CCS project. Government policies will always be tempered by the reality of the need to control costs (and to obey EU rules on competition), especially when those costs are shown to be high relative to their political benefit.

The paper is organised in seven sections. Section 1 looks at the overall decarbonisation policy context. Section 2 reviews the potential for renewables in the UK. Section 3 discusses the place of renewables within the energy system out to 2050 drawing on some recent work by the UK energy regulator, Ofgem. Section 4 reviews policy towards renewables since 1990 with a particular focus on recent developments. Section 5 examines the evidence on the performance of UK policy compared with that of other countries. Section 6 uses a new institutional economics perspective to discuss what sorts of policies might be right for the UK in the light of the evidence. Section 7 returns to the issue of overall policy towards decarbonisation and the place of renewables within this.

Section 1: Overall decarbonisation policy in the UK

The passage of the Climate Change Act and the introduction of carbon budgeting represent a substantial institutional commitment on the part of the UK to keeping the government accountable for maintaining the UK on a credible pathway to long-term targets. The UK has one of the most ambitious decarbonisation policies in the world as embodied in the 2008 Climate Change Act[8].

[8] Source: http://www.opsi.gov.uk/acts/acts2008/ukpga_20080027_en_1 Accessed 28 August 2009. UK carbon targets are net of trading, and hence can include carbon credits purchased from abroad.

This policy consists of a commitment to reducing net Greenhouse Gas Emissions by 80% by 2050 (on 1990 levels) and an intermediate target reduction of 26% by 2020. This target is supported by five year carbon budgets (the first period being 2008-2012 inclusive). These budgets are formulated by civil servants within government (initially the Office of Climate Change) supported by a report from the independent Committee on Climate Change. Government ministers have a statutory duty to introduce policies which support the achievement of the targets. The first report of the Committee on Climate Change was published in December 2008 (hereafter referred to as ‘The First Report’). This gave indicative budgets for the periods 2008-12, 2013-17 and 2018-22. The budget for any period beyond this must be set at least 12 years ahead.

The report was then followed up by a significant discussion in the HM Treasury Budget for 2009 of policy measures aimed at supporting the achievement of the decarbonisation targets in the light of the First Report (see HM Treasury, 2009). The announced measures included support for green manufacturing, improvements to the renewable support for offshore wind, increased funding for combined heat and power and a support mechanism for up to 4 CCS plants. The legislation implies that if the government were to fail to enact appropriate policies to keep the UK on track to achieve its targets this could result in legal action against Ministers by third parties. It remains to be seen on what grounds any action would be likely to be successful given the less than direct link between specific government policy and impact on a national GHG target.

The First Report was notable because it gave numerical detail on the potential contribution of various sectors to decarbonisation and in doing so set indicative targets for different parts of the economy. It laid out a target of 21% for the reduction of GHGs to 2020 (31% in the event of a Global Deal in Copenhagen in December 2008) and also suggested that complete decarbonisation of the electricity sector should be envisaged by 2030 and that this implied 30-40% of electricity from renewables by 2020. The 2030 targets for the electricity sector were significantly more ambitious than had previously been envisaged.

For reference in 2008 UK GHG emissions were 623.8m tonnes of CO2e (CO2 equivalent units), which is 20% below the 1990 baseline of 779.9m tonnes.[9] This meant that the UK is the only major European country to have already met and exceeded its 2012 Kyoto target for emissions reduction target (which was 12.5%).[10] It is however worth pointing out that the UK target is the result of negotiations within the EU to share out the Kyoto negotiated EU wide target, and that the baseline date of 1990 is very favourable to the UK. This is because it coincides with the privatisation of the UK power industry which led to the 'dash for gas' which resulted in an unintended environmental windfall as dirtier coal fired plants were displaced from the system (see Newbery and Pollitt, 1997).This favourable starting place in which the UK finds itself is certainly a major factor in its relative enthusiasm for decarbonisation[11].The EU Renewables Directive (2009/28/EC) further commits the UK to a 15.4% target for renewables contribution to total final energy consumption in 2020 as part of the EU's overall 20% renewables by 2020 target. This further target is acknowledged and accepted within the Committee on Climate Change's First Report. The UK also has a specific annual target for the percentage of electricity from renewables out to 2015 as part of its Renewables Obligation Certificate (ROC) scheme (discussed in Section 4).

Two examples of the detail in the First Report are given below.

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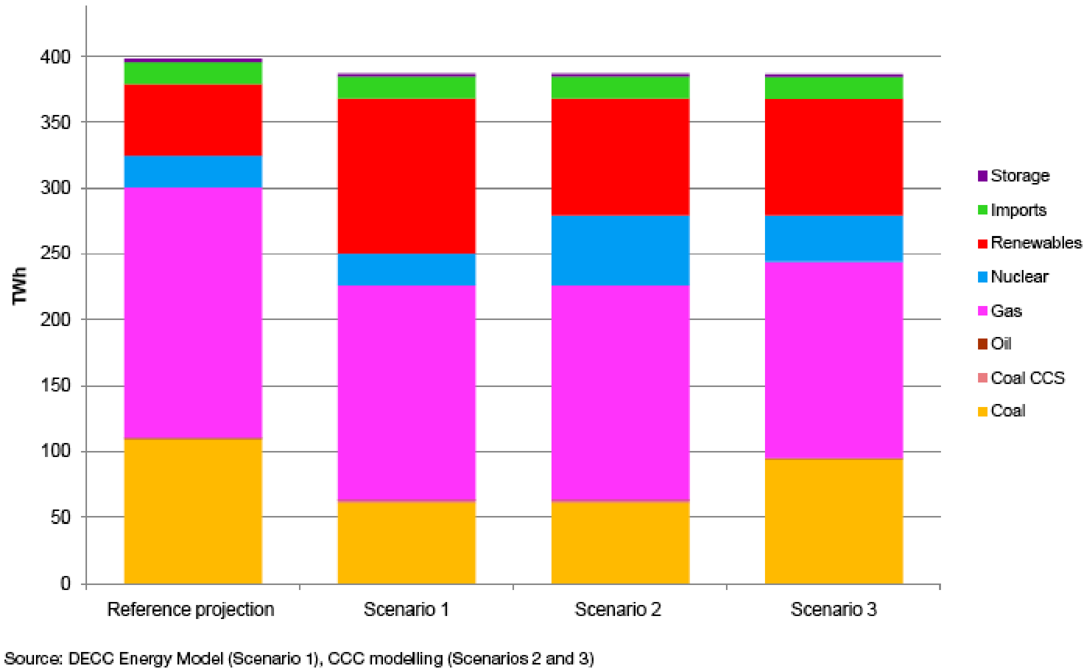
[9] Source: http://www.defra.gov.uk/environment/statistics/globatmos/download/ghg_ns_20090326.pdf Accessed 27 August 2009.

[10] See Table 1 in http://www.eea.europa.eu/pressroom/newsreleases/GHG2006-en

[11] It is worth noting that Germany also favours the 1990 baseline date, as this coincides with the collapse of the Berlin Wall and the rapid decarbonisation of the former East Germany due to industrial decline and improved environmental standards.

Figure 1: Scenarios for the Electricity Generation Sector for 2020

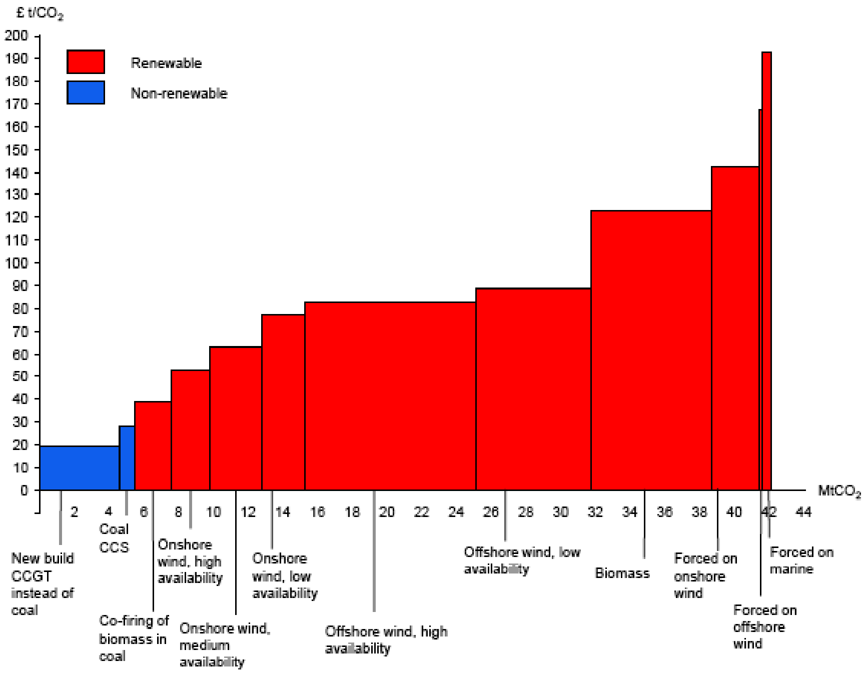


Source: CCC (2008, p.203)

Figure 1 shows the contribution of renewables projected within three scenarios for decarbonisation policy. The recommendations of the Committee suggested Scenarios 1 and 2 were the most plausible (because Scenario 3 assumes significantly more CCS). The share of renewables is 30% in total electricity generation in scenario 1, while scenario 2 gives the same level of overall emissions with 22.5% renewables and extra nuclear generation to make up the shortfall in low carbon generation capacity.

Figure 2 shows the contribution of different renewable technologies to the achievement of scenario 1. This shows that offshore wind, onshore wind and biomass (both in its own right and co-fired with coal) will make significant contributions by 2020. It also indicates a marginal role for marine power.

Figure 2: Marginal Cost of Abatement Curve (MACC) in Scenario 1 to achieve overall decarbonisation target for 2020.



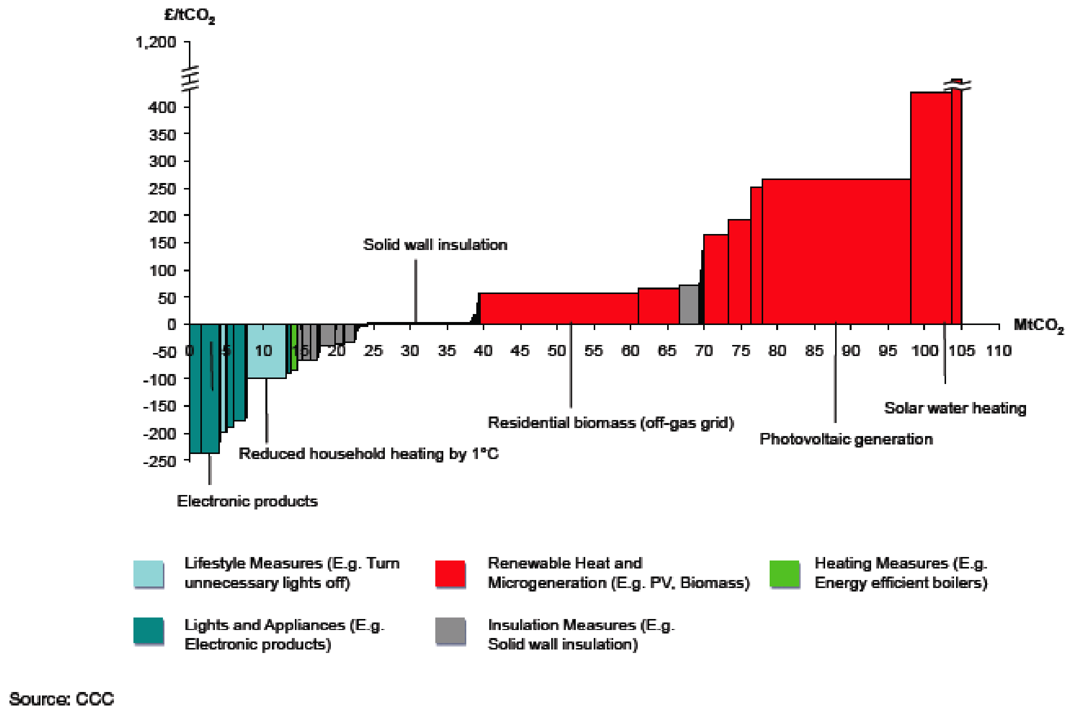
Source: CCC Modelling.
Note: 'Forced on' plant refers to plant which is built despite the existence of enough generation capacity on the system (e.g. to meet a target). It therefore displaces existing plant rather than new plant.

Source: CCC (2008, p.206)

The Committee on Climate Change modelling suggests the overall cost of the electricity decarbonisation policy will be around 0.2% of GDP p.a. to 2020 and could result in price rises of up to 25% for domestic customers relative to no policy intervention.

The First Report also discusses the potential for the direct reduction of emissions from buildings rather than larger grid connected electricity. This involves a combination of renewable heat and micro-generation. For residential buildings it identifies a potential contribution of 14% reduction in heat emissions via a combination of biomass, solar hot water, heat pumps and biogas by 2020. In addition there may be small contributions from PV and other sources for micro-generation of electricity. The potential for decarbonisation via the direct and indirect emissions from residential buildings is given in Figure 3.

Figure 3: Marginal Cost of Abatement Curve in Residential Buildings to 2020 – Technical Potential.



Source: CCC (2008, p.221)

Similar technologies are expected to deliver savings in CO2 in the non-residential and industrial sectors.

In the transport sector significant CO2 savings are expected from the uptake of hybrid and electric vehicles (saving 8m tonnes CO2 p.a. by 2020) and from the use of biofuels (saving 5m tonnes CO2 p.a.). Thus it is clear that the transport and electricity sectors may increasingly interact on CO2 abatement as low carbon electricity will be required to power electric vehicles while energy crops could either be configured for use in power stations or in vehicles.

Recently the newly created responsible government ministry - the Department for Energy and Climate Change (DECC, 2009a) - published a UK Renewable Energy Strategy. In line with the First Report, this suggested that more than 30% of electricity should be generated from renewables by 2020, as well as 12% of heat and 10% of transport energy (in order to meet EU targets).

The UK's targets are ambitious by historical standards of decarbonisation. Between 1979 and 1987 France reduced its national carbon emissions from fossil fuels by 30%[12] as its nuclear power programme increased the share of nuclear power plants in total electricity production from 20% to 70%. If one thinks that this programme was many years in the planning and initial building and was itself very ambitious AND that it only achieved the first 30% of an 80% decarbonisation target one gets an idea of how ambitious the UK's targets are.[13]

The UK's commitment to decarbonisation is likely to lead to a relatively tight domestic policy with strong pressure for the purchasing of renewable electricity and CO2 permits from abroad. In 2007 the UK was a net purchaser of CO2 permits to the tune of 26 m tonnes, or 3% of its 1990 GHG level[14]. It also purchased energy via the interconnector with France (3% of total electricity delivered) which may have displaced higher carbon energy in the UK[15] and was one of the largest net importers of internationally traded bio-energy (mainly for co-firing in coal fired power plants and for blending in petrol)[16]. All of these have some scope for expansion in terms of achieving the net decarbonisation of the UK economy.

Given the ambitious targets for decarbonisation and renewable energy in the UK, it seems highly likely that nationally these targets will be missed (certainly on renewables). In these circumstances serious consideration will be given to meeting the targets via net purchases of CO2 or green energy certificates from abroad (e.g. funding CCS in China). Indeed, if additionality could be clearly established this would seem to be a very sensible option given that at the margin such purchases would be much cheaper than the price of domestic alternatives.

[12] Source: http://cdiac.ornl.gov/ftp/trends/emissions/fra.dat.
[13] Though it could be argued that a 40 year time frame does give more scope for learning and avoids the need for premature scrapping of existing assets.
[14] Source: http://www.defra.gov.uk/environment/statistics/globatmos/download/ghg_ns_20090203.pdf Accessed on 27 August, 2009.
[15] Sources: DUKES (2009, p.122).
[16] See Perry and Rosillo-Calle (2008) and Junginger et al. (2008).

Section 2: Potential for Renewable energy in the UK

A defining feature of the UK is the considerable potential it has for renewable energy relative to its demand. The UK has some of the best wind, tidal and wave resources in Europe, as well as affording opportunities for biomass and solar. The technical potential of each of these resources is very great, but the estimated 'economic' potential of major technologies are given below. UK electricity supplied in 2008 was 380 TWh[17].

Table 1: Estimates of the potentials for different renewable technologies in UK

Technology Category	**Technology Detail**	**Annual Potential**
Wind power	Onshore	50 TWh
	Offshore	100 TWh
Bioenergy	Biomass	41 TWh
Geothermal	Ground source heat pumps	8 TWh
Hydro	Large scale	5 TWh
	Small scale	10 TWh
PV	Retro fitted and Building integrated	>1 TWh
Marine	Wave energy	33 TWh
	Tidal barrage	50 TWh
	Tidal stream	18 TWh
Total		**~316 TWh**

Source: Jamasb, Nuttall et al., 2008, p.81-82.

In addition the UK has low carbon options for carbon capture and for nuclear. The UK has up to 1000 years worth of storage capacity of CO2 in the North Sea and currently generates around 13% of its electricity from nuclear power[18]. The UK has endowments of coal and oil and gas (though all three are depleting). Thus carbon capture and storage and nuclear power are likely to compete with renewables to play a part in decarbonisation of the

[17] Source: DUKES 2009, Table 5.5.
[18] Source: DUKES (2009, p.122).

electricity sector. The UK is already committed to an auction for one demonstration CCS plant and is reviewing designs for a new generation of nuclear power plants. Electricity demand growth is growing slowly at around 1% a year (pre-economic crisis) and energy efficiency measures - such as the elimination of filament light bulbs from 2011[19] and the introduction of smart metering for all electricity customers by 2020 - seem likely to moderate demand growth.

David MacKay (2008, p.109) casts his presentation of the likely contribution of renewables to UK decarbonisation in the context of delivering the current level of energy consumption per person per day of 125 KWh/day/person. He suggests that renewables contribution is likely to be only 18.3 KWh/day/person made up of: hydro 0.3 kWh/d/p; tidal 3 kWh/d/p; offshore wind 4 kWh/d/p; biomass 4 kWh/d/p; solar PV 2 kWh/d/p (+an additional 2 kWh/d/p from solar hot water) and onshore wind 3 kWh/d/p. Thus renewable energy would contribute around 15% towards total decarbonisation. MacKay's analysis is helpful in that illustrates that a big contribution towards current electricity provision, comes in the context of electricity only being the source of around one third of current emissions of GHGs.

The exact mix of different renewable technologies, CCS fitted to coal or gas fired plants, nuclear and demand reduction in the UK energy mix will depend on the relative costs of the different technologies. Kannan (2009) shows the impact of different assumptions on the significance of CCS in UK decarbonisation and hence the implications for other sources of decarbonisation. Demand reduction technologies are the cheapest GHG abatement technology at the moment[20], though demand reduction measures suffer from well known institutional barriers to adoption (Grubb and Wilde, 2008). Nuclear is probably the next cheapest. Among the renewable technologies in the UK onshore wind, biomass and offshore wind are lowest cost at scale to 2020. Table 2 shows some cost sensitivities for 2005 in the UK.

[19] Source: DECC Low Carbon Transition Plan (DECC, 2009c, p.72). This also been recently been agreed at the EU level.

[20] See Figure 3 above for an illustration of the significance of this in residential buildings.

Table 2: Examples of estimated current costs of technologies for the UK

Technology	***Technology Detail***	*p/kWh (2005)*
Nuclear	Generation III	3.04-4.37
Gas	CCGT With CCS	3.65-6.78
Coal	IGCC with CCS	3.5-5.67
Wind	Onshore	4.68-8.89
	Offshore	5.62-13.3

Source: Jamasb, Nuttall et al., 2008, p.75.
Note: the spread of estimates reflects ranges in the discount rate, capital cost, fuel and carbon prices and other sensitivies.

The above table illustrates large uncertainty in the costs of building new plant even with established technologies. For wind this reflects the importance of exact location which determines both build costs and the available wind. The range of costs illustrates substantial overlap under favourable vs. unfavourable circumstances for any pair of technologies. However it is important to point out that this uncertainty over actual costs for current new build, does call into question projections of costs to 2020. For instance Dale et al., (2004) assume onshore and offshore new build costs of £650 per KW and £1000 per KW in scenarios with 25% energy from wind. The most recent (albeit pre-recession) wind parks are currently coming in at nearer £1000 per KW and £2500 per KW (see Blanco, 2009, and Synder and Kaiser, 2009). This is somewhat concerning (given a return to macroeconomic growth) for the likely projected costs of renewable scenarios to 2020, especially given that the costs of electricity (which will include cumulative subsidy commitments to renewables) in 2020 will still likely reflect, to some extent, the cumulative cost of all wind capacity installed since 2005.

As Jamasb, Nuttall et al. (2008) note, a key determinant of the relative attractiveness of different technologies will be the degree of learning in costs and that this depends on their current stage of development. Foxon et al. (2005) note the different stages of development that the various renewable technologies available to the UK are at. Wind costs can be expected to fall as capacity increases significantly around the world, however the prospects for learning in hydro and tidal barrages are low (limiting their ultimate scope for expansion). The additional costs of fitting CCS are difficult to estimate due to lack of information, while the scope for learning may be constrained by the maturity of the different elements of the CCS process (see Odenberger et al., 2008). This is in addition to the difficulty of reconciling all the interested parties (Drake, 2009). PV, tidal stream and other marine technologies offer the greatest potential for cost falls from their current cost given low current levels of output and the implied scope for cost reduction[21]

SKM (2008) provides estimates of the possible cost of decarbonisation of the electricity sector by 2020.

Table 3: Costs and Benefits of Electricity Sector decarbonisation by 2020 (2008 prices).

		Renewable Scenarios		
	Conventional	Lower	Middle	Higher
New Generation capacity (£ billion)				
Renewable Capacity	2.3	50.1	60.2	77.4
Non- Renewable Capacity	14.9	12.6	12.3	12.0
Total	*17.2*	*62.7*	*72.5*	*89.4*
Network (£ billion)				
Offshore wind connection	0.0	8.4	10.6	14.1
Onshore wind connection	0.1	1.0	1.2	1.4
Other reinforcement	0.8	0.8	0.8	0.8
Total	*0.9*	*10.2*	*12.6*	*16.3*
Total Grid Investment Costs (Generation+network)	**18.1**	**72.9**	**85.1**	**105.7**
Marginal Generation cost	35.9	25.0	22.6	18.9
Cost per MWh produced (£/MWh)				
Generation costs (Fixed and variable)	46.8	51.9	52.6	54.5
Balancing and intermittency	1.7	6.3	7.2	8.7
Grid expansion for renewables	0.1	3.5	4.1	5.2
Total Cost including network (£/MWh)	**48.6**	**61.7**	**63.9**	**68.4**

Source: SKM (2008, p.8)

Table 3 shows that renewables could impose significant total costs on the electricity system. The capital costs of connecting offshore wind in particular could involve up to £15bn of expenditure (more than the total cost of generation under a conventional scenario). The cost of balancing and intermittency could rise by up to £7/MWh or 10% of total system costs. The UK may have the wind resources but they will have significant cost

[21] See for instance DECC (2009d, p.92), which shows projected cost falls of PV of 70% to 2050 against only 22% for coal fired CCS.

implications for the system, raising average electricity costs by up to 40% against baseline.

It is clear that while the UK does have significant potential for renewables, there is a significant amount of uncertainty about the cost at which renewable generation can be delivered. Large quantities of renewable generation will significantly raise average electricity costs and be subject to significant cost variance. Support mechanisms will need to be carefully designed both to provide enough incentive and to ensure that delivered capacity is not excessively expensive.

Section 3: Renewables in scenarios for the 2050 electricity system

While the path to 2020 has been significantly examined in the context of the First Report of the Committee on Climate Change, there remains substantial uncertainty about the path out to 2050. The path to 2020 seems likely to be dominated by grid connected generation, with a significant role for large wind parks, both on- and increasingly off-shore. However the Great Britain electricity regulator, Ofgem, recently presented a range of scenarios (Ault et al., 2008a) for the electricity system out to 2050 which highlight the significant amount of technological and economic uncertainty out to 2050. These scenarios focussed on the range of possibilities for the development of electricity networks within the context of Ofgem's role as economic regulator of electricity transmission and distribution networks. Five scenarios were developed: Big T&D, DNOs, Energy Service Companies, Microgrids and Multi-purpose networks. The scenarios are briefly described in Table 4.

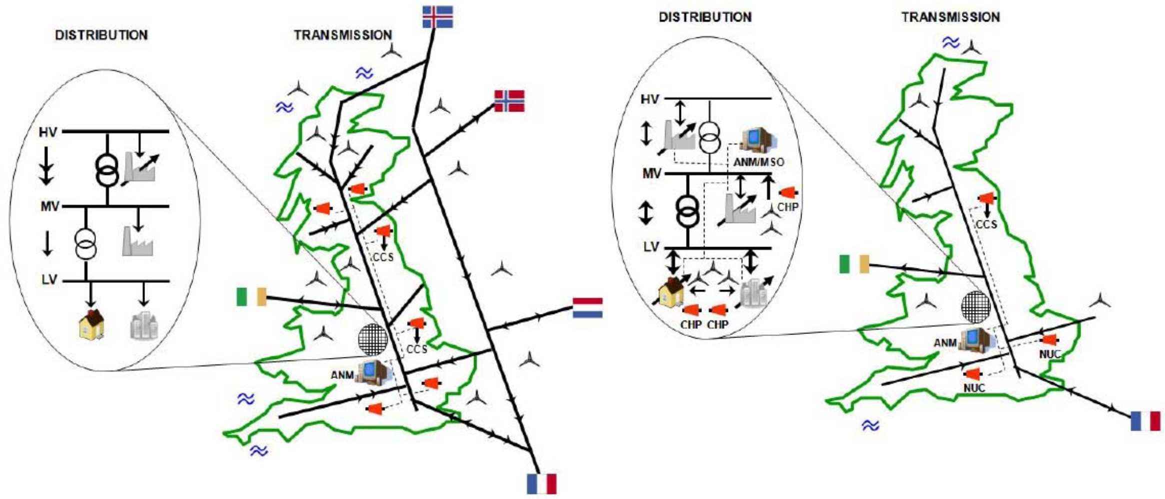
Table 4: The Five LENS Scenarios

Big Transmission and Distribution (T&D) – in which transmission system operators (TSOs) are at the centre of networks activity. Network infrastructure development and management continues as expected from today's patterns, while expanding to meet growing demand and the deployment of renewable generation.
Energy Service Companies (ESCOs) – in which energy services companies are at the centre of developments in networks, doing all the work at the customer side. Networks contract with such companies to supply network services.
Distribution System Operators (DSOs) – in which distribution system operators take on a central role in managing the electricity system. Compared to today, distribution companies take much more responsibility for system management including generation and demand management, quality and security of supply, and system reliability, with much more distributed generation.
Micro-grids – in which consumers are at the centre of activity in networks. The self-sufficiency concept has developed very strongly in power and energy supplies. Electricity consumers take much more responsibility for managing their own energy supplies and demands. As a consequence, microgrid system operators (MSOs) emerge to provide the system management capability to enable customers to achieve this with the new technologies.
Multi-purpose Networks – in which network companies at all levels respond to emerging policy and market requirements. TSOs still retain the central role in developing and managing networks but distribution companies also have a more significant role to play. The network is characterised by diversity in network development and management approaches.

Source: Ault et al., 2008, Forward by Stuart Cook.

These five scenarios give rise to very different electricity networks in 2050. For instance Figure 4 illustrates the difference between the two most different scenarios: Big T&D and Micro-grids.

Figure 4: Two LENS scenarios for 2050



Big transmission and distribution **Micro-grids**

Key to symbols:

	Electricity network components: thickness of line illustrating network capability, and size and number of arrows indicating level of network utilisation
	Residential, commercial and industrial consumers – with diagonal arrow denoting active demand management if present
	Renewable electricity generation (including wind, biomass, etc . but excluding marine)
	Renewable marine electricity generation (wave, tidal, etc.)
CCS	Thermal generation, sometimes with additional information about type, e.g. carbon capture and storage (CCS) or nuclear (NUC) – without a type indicator, this symbol refers to conventional thermal generation
ESCO	System management ,with additional information about type, e.g. energy service company (ESCO), distribution system operator (DSO), microgrid system operator (MSO), or active network management (ANM) to represent more real time and active operational management of networks
-----	Information and communications technology (ICT) infrastructure for network operational management
	Power system transformer between different voltage levels
	Power system interconnection with other countries, e.g. France, Ireland, Netherlands, Norway, or Iceland

Source: Ault et al, 2008a, p.iv,v,viii.

Under the Big transmission and distribution scenario the electricity grid is substantially reinforced to support an offshore grid and large amounts of intermittent wind generation on and offshore. By contrast the Micro-grids scenario involves large amounts of local and micro-generation and a grid not much bigger than today. The striking difference between these two scenarios is the size of the network and the scale of electricity generation capacity.

The Micro-grids scenario involves significant matching of local supply and demand via smart metering and smart grids and exploits the considerable potential for micro-grids opened up by new technology. Abu-Shaikh et al. (2006) discuss a world where a combination of domestic PV, micro-CHP and a small battery could result in a micro-grid that is potentially independent from the large scale electricity network. This would reduce the demand for and cost of centralised generation investments and integrated networks for those consumers. The degree to which this sort of scenario requires active individual, as opposed to community or company led initiative, can vary (Sauter and Watson, 2007). However the micro-potential is large: technically solar PV could already provide 51% of domestic electricity supply and solar thermal 33% of domestic hot water requirements, even though the current economic costs are prohibitive.

Clearly with technological breakthroughs leading to drastic cost reductions, uptake might be rapid and driven by individual consumers rather than traditional utilities. However there remains substantial inertia in existing electricity and heat systems, high new technology costs and a lack of government commitment to funding significant learning (Allen et al., 2008 and Watson et al., 2008). Micro-grids requiring community involvement (i.e. those where there is shared use of local generation or heat, and hence high levels of local interdependency) face significant social barriers such as the reliance on identification with the concept of community (Walker et al., 2007) and the fact that while many are positively disposed, few in the community would want to take the lead in organisation (Rogers et al., 2008). However there might be significant advantages for the likelihood of getting planning permission, willingness to pay and in achieving local development objectives from the promotion of small-scale community energy (Hain et al., 2005). There are also high transaction costs for the connection of small scale distributed and micro-generation with the distribution grid and difficulties for new energy service companies wishing to make use of a combination of existing grid assets and their own investments (Pollitt, 2009).

The supporting MARKAL modelling work for the LENS scenarios has quantified the interactions between demand for electricity, heat and transport and the significant potential impact of the arrival of electric vehicles (Ault et al., 2008b). The arrival of competitively priced private electric vehicles is associated with substantial decarbonisation of the transport sector while not significantly increasing the demand for electricity (because electric vehicles are energy efficient). Electricity and heat are connected by substantial increases in combined heat and power (from biomass) in some scenarios. Under the modelled micro-grids scenario there is 23 GW of micro-generation and 24 GW of micro-CHP capacity on the system in 2050 out 113 GW of total generation capacity (Ault et al., 2008a, p.xi).

The LENS modelling highlights that scenarios other than one based on large scale passive electricity networks and central generation envisaged in the First Report of the Committee on Climate Change are plausible. A move to smaller scale local generation and supply companies would have significant implications for technology choices, for networks and for total energy demand (Pollitt, 2009). The modelling also reveals the potential for large differences in costs between scenarios, the dependency of the future on technological innovation and the high risk that policy will not deliver on its ambitious overall targets.

Section 4: Policies towards renewables in the UK

In this section we attempt an overview of UK renewables policy since the privatisation of the UK electricity supply industry beginning in 1990. Summarising UK policy is not a straightforward task because of the large range of government initiatives towards renewable energy and the large number of policy changes that have been announced in recent years, some of which have yet to be implemented fully.[22] Discovering the exact cost of renewable energy support is not easy, as evidenced by the fact that the best sources of information are answers to parliamentary questions rather than published annual statistics. This is particularly true of the expenditure on individual technologies. We are grateful to the heroic efforts of Mitchell and Connor (2004) who reviewed UK renewable policy from 1990-2003 and provide the inspiration for some of our presentation.

In broad outline there have been two main support mechanisms for renewable electricity and heat generation since privatisation in the UK: the Non-Fossil Fuel Obligation (NFFO) which ran from 1990-2002 and the Renewables Obligation Certificate (RO or ROC) Scheme which began in

[22] NAO (2008, p.17) reports 20 government policies, strategies and reviews on energy between 1997 and 2009, with 16 of those from 2003 onwards.

2002. Both of these schemes have, during their period of operation, been the most significant form of renewable energy support in the UK and have been designed to work in parallel with liberalised electricity and gas markets.

The assessment of renewable support policies is complicated because there are two obvious metrics of success: the amount of renewables realised relative to potential (quantity) and the total cost of renewable support policy relative to the amount of generation actually supported (suitably discounted) (cost). These two trade-off, meaning that success in one is likely to be associated with less success in the other.

4.1: NFFO

NFFO was originally designed as a way financing the extra costs of nuclear power which became clear in the run up to privatisation. A Non-Fossil Fuel Levy was introduced on final electricity prices to pay for nuclear de-commissioning liabilities and electricity suppliers were forced to buy nuclear power at higher than market prices in auctions for non-fossil fuel power run by the Non Fossil Purchasing Agency (NFPA).[23] In order to avoid this being seen as a discriminatory subsidy to the nuclear industry, it was recast as a way of supporting non-fossil fuel generation more generally and a portion was allocated to support renewable energy (Mitchell and Connor, 2004). The portion was small but it provided a relatively significant amount of money to the industry at a time when government expenditure on new technologies was falling to a very low level (and the Department of Energy was closing). The money was allocated to new renewable projects via a series of bidding rounds whereby renewable energy projects bid for an RPI-indexed per KWh price for initially 8 and later 15 years. Winning bids were selected by cost within each technology category.

The result was a significant amount of bids in each of the auction rounds and falling bid costs in each successive round.[24] Connor (2003, p.76) reports that

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[23] Initially the levy was 10.6% in England and Wales and fell to 0.9% in 1998 when payments for nuclear power ended. It was phased out in April 2002, having been 0.3%. The levy rate in Scotland – which was not used to fund nuclear liabilities - began at 0.5% in 1996 and reached a maximum of 1.2%. Source: Wikipedia entry on 'Fossil Fuel Levy'.
[24] There were five rounds of NFFO in England and Wales: NFFO-1, start date 1990; NFFO-2, -3, -4 and -5 in 1992, 1995, 1997, 1998. In Scotland there were three rounds: SRO-1, -2 and -3 in 1995, 1997 and 1999. In Northern Ireland there were two rounds: NI-

in the five rounds of NFFO in England and Wales, onshore wind costs fell from 10p/KWh in 1990 to 2.88p/KWh in 1998, with substantial falls for the other technology bands. While NFFO was successful in soliciting a large number of competitive bids and in ensuring that any funded projects were cost effective for electricity customers, it failed rather spectacularly in one key respect: delivery of actual investment by the winning bidders.

Across the UK, between 1990 and 1999, out of 302 awarded wind projects covering 2659 MW only 75 projects were built rated at 391 MW (Wong, 2005). Spectacularly, none out of NFFO-5's 33 awarded wind projects was ever contracted. By contrast out of 308 landfill gas projects awarded, 208 were operational in 2008 with 458 MW of capacity out of 660 MW contracted. For all the rounds of NFFO out of 933 awarded contracts 477 were built, representing 1202 MW out of 3639 MW. [25] The primary cause for the failure was that bidders were over-optimistic in their estimates of the actual delivery cost of the project, often because the nature of the least cost auction – with no assessment of likelihood of delivery - incentivised minimisation of expenditure on preparing realistic bids (Mitchell and Connor, 2004).

In reviewing the failure of the NFFO policy it is important to remember the context in which it operated. NFFO occurred in a context of renewables being a very low priority for UK government policy and during a period of a rapid switch from coal to gas fired power. Prices and pollution (in terms of quantities of CO2, SOX and NOX) fell substantially. The focus on market driven investments was good for energy and carbon efficient CHP investment in the industrial and commercial sectors (Marshall, 1993, Harvey, 1994 and Bonilla, 2006), which had struggled prior to privatisation (Jarvis, 1986). UK privatisation was a significant policy success in economic terms, and especially when the benefits to the environment are considered (Newbery and Pollitt, 1997).

The privatisation and market liberalisation policies ensured that the UK would easily meet its Kyoto targets for 2012 without any further action (which was not the case for other leading European countries). The mood at the time is nicely summarised by a government minister for energy in 1988

NFFO-1 and -2 in 1994 and 1995. See Wong (2005, p.131). The last NFFO contract is due to expire in 2018.

[25] Source: DUKES (2009, Table 7.1.2).

who wrote that ‘privatisation of the electricity supply industry should boost the commercial prospects for these [green] technologies as a free market is established’[26]. Indeed Friends of the Earth were optimistic that the opening up of the domestic energy market to competition in 1998-99 would give rise to demand for ‘green’ tariffs and stimulate the production of green energy (Stanford, 1998). It was only as the EU moved towards substantial targets for renewables that it became clear that the UK needed a policy which delivered large quantities of renewables.[27] However there are significant lessons to be learned from the NFFO experience.

Somewhat surprisingly there is surprisingly little quantitative analysis of the bids that were successful under NFFO and the factors in their success and failure. Elliott (1992, p.267) criticised the NFFO scheme as a ‘somewhat half-hearted hybrid market/interventionist system’ that ‘would still leave short-term price and market factors to shape important long term strategic choice concerning patterns of technological development.’ Institutional barriers emerged early on as a critical factor in successful project implementation (McGowan, 1991).

In particular, it became clear that there was a problem with the success rate of projects in gaining the necessary consents required to commence building (known as ‘planning permission’ in the UK) and that there was a lack of attention to proper environmental impact assessments (Coles and Taylor, 1993). It was noted that in the early years less than half of all councils had planning guidance for renewable energy projects and that more importantly there was a lack of learning between councils (Hull, 1995). There were calls for clearer guidelines for the planning process to facilitate wind power (Roberts and Weightman, 1994). Early industry views of the scheme were positive, recognising that it did constitute a significant increase in expenditure on previous levels (Porter and Steen, 1996). However the successive rounds of auctions were thought not to provide assurance of continuity of support for renewables generally (Elliott, 1994, Mitchell, 1995) and there were worries that while they supported near market technologies, declines in R+D expenditure were bad for less advanced technologies like marine (Elliott, 1994).

[26] Michael Spicer quoted in Elliott (1992, p.266).
[27] Under the 2001 EU Renewables Directive the UK signed up to 10% target for renewable electricity generation which is embodied within the successor scheme to NFFO (European Commission, 2001).

The final years of NFFO (1999-2001) coincided with a sharp decline in wholesale electricity prices as significant amounts of new gas fired capacity came into the market and there was increased competition within the initially duopolistic generation sector (Evans and Green, 2003). NFFO bidders had clearly been over optimistic in their bidding and their situation was exacerbated by the end of the compulsory wholesale power pool in March 2001. This had guaranteed the pool price to all generators. It was replaced with a contract market and a balancing market. Intermittent renewable generators relied on the balancing market and this market delivered much more volatile prices than the pool and was further complicated by having a system buy price and a system sell price which frequently diverged with buy prices much higher than sell prices with significant negative consequences for wind generators. This is because such buy-sell price divergence creates a penalty for imbalance between supply and demand for a generator. Over-supply or over-demand result in an imbalance payment. As wind generators have less capacity to match supply and demand (due to the exogenous effect of weather) relative to fossil fuel generators who can adjust their spinning reserve. Of course this is not necessarily inefficient, as generators should be incentivised to solve the imbalance problem. The impact of this effect seems to have subsided after one year of operation of the new arrangements, partly due to the arrival of a more generous subsidy regime when Ofgem found little evidence of negative impact from the change to the trading system on renewable generators.[28]

4.2: The ROC Scheme

The Renewables Obligation Certificate Scheme which replaced NFFO in 2002 is a form of tradeable green certificate (TGC). Under the scheme the government has set a minimum share of electricity to be acquired by electricity suppliers from specified renewable sources. This share is steadily increasing from 2002 to 2015, see Table 5. Under the ROC scheme electricity suppliers must acquire ROCs in the prescribed target share of renewable generation for each annual period. They can do this by buying or earning ROCs. ROCs are created when specified renewable generators generate electricity. Essentially this splits the market into two, a renewable

[28] See Ofgem (2002).

part and a non-renewable part, with renewable generators getting a price for the ROCs they create plus the wholesale price of power.[29]

However the UK scheme has two important features introduced at its inception. First, there is a buyout price (i.e. a penalty price) for ROCs should there not be enough ROCs created by renewable generation. This price is specified for each trading period and effectively caps the price creators of ROCs can receive. Second, there is recycling of the revenue collected from the buyout sales of ROCs. This takes the form of allocating the revenue back to the creators of ROCs in proportion to the number of ROCs they created.

The renewable energy industry was very positive about the new incentive mechanism (Hill and Hay, 2004). So they should have been, because the scheme is very generous. Thus for example in 2007-08 the buyout (penalty) price was £34.30/MWh and only 64% of the required ROCs were created by generators meaning the buyout price bound in the certificate market. The total payment by suppliers was the target quantity of renewables multiplied by £34.30 / MWh. This meant 36% of the total ROC payment made by suppliers was available to be recycled and was divided proportionally among the generators who created actual ROCs. Accordingly the renewable generators received £34.30 plus £18.65 (i.e. an additional 36/64 times £34.30) for each ROC actually presented. This sum is in addition to the wholesale cost of power. As the total cost to suppliers of the ROC scheme was £876m, this implies that consumers overpaid by the value of the buyout revenue - £316m (36% of £876m, or over 1% of total electricity expenditure of £30.7bn in 2008)[30]. Interestingly the government collects the associated ROC payments on the generation contracted under NFFO, via the NFFO fund, which creates a surplus above the payments to generators under NFFO (this surplus is estimated to be around £200m per year).[31]

It is also worth noting that renewable generators also receive the benefit of avoiding the cost of having to redeem CO2 permits in the EU Emissions Trading Scheme. The requirement that fossil fuel generators must present

[29] Continuing NFFO contracts are funded via the revenue from the auction of ROCs (by the NFPA) associated with the contracts (see Ofgem, 2004).
[30] Source: DUKES Expenditure on energy by final user to 2008 (DUKES 1.1.6), http://www.decc.gov.uk/en/content/cms/statistics/source/prices/prices.aspx. Accessed 25 August 2009.
[31] See Oliver Tickell, 'Robbing us of Renewables' *The Guardian*,6th September 2008.

such permits further increases the implicit price support for renewable generation over conventional fossil fuel generation.

Table 5: ROC targets and delivery against targets

	Target renewable share in GB[32]	**% Delivery in UK**	**Nominal Buyout Price £/MWh**	**Total Cost £m**
2002-03	3.0	59%	30.00	282.0
2003-04	4.3	56%	30.51	415.8
2004-05	4.9	69%	31.59	497.9
2005-06	5.5	76%	32.33	583.0
2006-07	6.7	68%	33.24	719.0
2007-08	7.9	64%	34.30	876.4
2008-09	9.1		35.36	1036.2
2009-10	9.7		37.19	
2010-11	10.4		+ inflation thereafter	
2011-12	11.4			
2012-13	12.4			
2013-14	13.4			
2014-15	14.4			
2015-16	15.4			Estimated: ~1753m (2008-09 prices) assuming no demand growth

Note: From 2016, the share is fixed at 15.4% until 2027.
ROC scheme cost is total cost including revenue recycling.
Source: www.opsi.gov.uk and Renewable Obligation Certificate Annual Reports from Ofgem.

The ROC scheme is curious for two reasons. First, it relies on under delivery to trigger the maximum subsidy amount. If the target number (or more) ROCs were presented then the price would drop to zero. Second, if there is any under-delivery the maximum amount of subsidy is paid to those actually

[32] Target share lower in Northern Ireland, but NI ROCs are tradable throughout UK. There is also a nominal distinction between Scottish ROCs (SROCs) and English and Welsh ROCs (ROCs) but these are tradable and both are included in the GB target share.

creating ROCs. Thus the scheme assumes failure to meet the target and ensures that a fixed total subsidy is paid, given this, regardless of how few ROCs are created.

The scheme is further complicated by the introduction of banding from 1 April 2009. This changes the exchange rate to ROCs of some renewable generation: established technologies will get less than 1 ROC per MWh, newer more. This change breaks the link between the total number of ROCs and the share of renewable energy generation and will presumably result in a reduced amount of electricity being produced from renewables if the scheme were fully successful (if the share of high exchange rate technologies were to take off, as it might with offshore wind).

The Carbon Trust (2006) recommended a move to banding to recognise the different stages of development that the technologies were at and hence the higher learning benefits associated with increased funding to earlier stage technologies. Oxera (2005) point out the cost implications of allowing NFFO plant to earn ROCs once their NFFO contracts expired (around £620m) giving those projects unexpected additional subsidy. Oxera calculated that as much as half the payment via ROCs was in excess of that required to ensure that the funded projects went ahead, and that existing landfill gas projects did not require any ROCs to be economically viable.

Table 6: Banding of ROCs from 1 April 2009

Generation type	ROCs per MegaWatt hour
Landfill Gas	0.25
Sewage gas Co-firing of biomass	0.5
Onshore wind Hydro Co-firing of energy crops Energy from waste with CHP Co-firing of biomass with CHP Geopressure Standard gasification Standard pyrolysis	1
Offshore wind Biomass Co-firing of energy crops with CHP	1.5
Wave Tidal stream Advanced gasification Advanced pyrolysis Anaerobic digestion Energy crops Biomass with CHP Energy crops with CHP Solar photovoltaic Geothermal Tidal impoundment – tidal barrage Tidal impoundment – tidal lagoon	2

Source: http://www.decc.gov.uk/en/content/cms/news/pn037/pn037.aspx Accessed 25 August 2009.

This implies that the subsidy to offshore wind could be increased by £26.47/MWh (50% of the 2007-08 ROC revenue) and to tidal by £52.95/MWh (100% of the 2007-08 ROC revenue). In the 2009 budget offshore wind was subject to an emergency re-banding provision which saw offshore wind ROC band go to 2 for 2009-10 and 1.75 for 2010-11.

4.3: Financial commitments and delivery under NFFO and the ROC

Table 7 summarises the financial commitments made under the NFFO and ROC schemes, as well as a reference amount for the amount of public R+D expenditure reported to the IEA. The increased significance of the ROC scheme is evident.

Table 7: Financial support for renewables in the UK (nominal)

£m	**R&D	RO	NFFO
1990-1991	14.7		6.1
1991-1992	17.1		11.7
1992-1993	16.1		28.9
1993-1994	15.2		68.1
1994-1995	9.1		96.4
1995-1996	9.1		94.5
1996-1997	6.2		112.8
1997-1998	4.3		126.5
1998-1999	3.3		127.0
1999-2000	4.6		56.4
2000-2001	4.4		64.9
2001-2002	6.1		54.7
2002-2003	10.5	282.0	-
2003-2004	11.6	415.8	-
2004-2005	19.7	497.9	-
2005-2007	36.6	583.0	-
2006-2007	49.5	719.0	-
2007-2008	41.6	876.4	-

Sources:
** UK government renewable R&D budget data from IEA renewable R&D database, http://wds.iea.org/WDS/ReportFolders/ReportFolders.aspx; Mitchell and Connor (2004, p.1943).
Note: RO does include revenue recycling.

While the ROC scheme is the most significant element of the UK's expenditure on renewables it is not the only element. Table 8 is a summary offered in a ministerial answer to a Parliamentary Select Committee question. It is noteworthy that there are still significant additional amounts being spent by the taxpayer on supporting earlier stage technologies outside the CO2 price and RO support mechanisms. However the order of magnitude of energy customer support for renewables is of the order of £1.8bn in 2008, in addition to £400m by the taxpayer. This level of support is up 47% in real terms from the figure estimated by Wordsworth and Grubb

(2003) of £1.3bn in 2002-03[33]. Table A1, at the end of the paper, gives a more detailed breakdown of renewable funding over the 2005-2008 period. Some of the expenditure reported here may overlap since it is collected from a number of sources: but it indicates significant direct funding for PV, marine, offshore wind and biomass outside the main ROC scheme.

As will be clear from the above discussion of the progress with the RO scheme, the development of electricity from renewables has been disappointing in terms of overall cost relative to delivery given the UK's resource potential and its ambitious targets. Table 9 gives the figures in terms of total electricity generation. A number of features stand out. First of all, electricity from biomass is currently larger than that from wind. Hydro remains significant within the UK renewable portfolio. Connor (2003) reported estimates from 2002, which suggested that UK would only meet 2/3 of its target level by 2010. This still seems likely. However the striking thing about the 2002 estimates is that for biomass, offshore wind and hydro they seem likely to be met or exceeded, while being let down by onshore wind. The UK is failing to meet its projections for renewables as predicted but this is largely due to the failure to deliver the long expected increase in generation from onshore wind.

Both NFFO and RO have stimulated electricity from landfill gas and co-firing of biomass and municipal waste (with fossil fuels). These technologies were near market in the early 1990s and had good prospects at that time. Brown and Maunder (1994) discussed the UK's potential for exploiting landfill gas and Jamasb, Kaimal et al. (2008) discuss the prospects for waste to energy, noting there is significant further potential, especially if CHP is involved. The use of biomass for co-firing in coal fired plants continues to be one of the most sensible uses of biomass, as it is well proven that mixes of up to 10% biomass require little adjustment to existing plant (Thornley, 2006). Small hydro projects have also had some success with a steady increase in hydro generation from these schemes. These projects use established technology and have benefited from market based support mechanisms. Paish (2002) highlights around 400 MW of further potential for small scale hydro in the UK.

[33] UK inflation between September 2002 and September 2008 was 15%. Source: ONS, CPI series. www.ons.gov.uk, Accessed 27 August, 2009. The National Audit Office only reported a figure of £700m p.a. for annual costs 2003-2006 (NAO, 2005, p.35).

Table 8: Support for renewable energy in 2007-09

Scheme	Description	Cost	Paid by
Renewables Obligation	Electricity suppliers must buy a proportion of their sales from renewable generators, or pay a buy-out charge	£874 million in 2007/8 [a]	Electricity consumers
EU Emissions Trading Scheme	Renewable generators indirectly benefit from the increase in electricity prices as other companies pass the cost of emissions permits into the price of power	Perhaps £300 million in 2008, given current permit prices [b]	Electricity consumers
Carbon Emissions Reduction Target	Energy companies must install low-carbon items in homes, which could include microgeneration from 2008	Total cost will be £1.5 billion over 3 years—most spent on energy efficiency	Gas and electricity consumers
Renewable Transport Fuel Obligation	Fuel suppliers must supply a proportion of biofuels or pay a buy-out charge	No more than £200 million in 2008/9 [c]	Consumers
Climate Change Levy	Electricity suppliers need not pay this tax (passed on to non-domestic consumers) on electricity from renewable generators	£68 million to UK generators; £30 million to generators abroad in 2007/8	Taxpayers, via reduced revenues
Lower fuel duty for biofuels	The rate of fuel duty is 20 pence per litre below that for petrol and diesel	£100 million in 2007	Taxpayers, via reduced revenues
Environmental Transformation Fund	Grants for technology development and deployment, including subsidies for installing renewable generation, planting energy crops and developing biomass infrastructure.	£400 million over three years from 2008/9	Taxpayers
Research Councils	Grants for basic science research	£30 million in 2007/8	Taxpayers
Energy Technologies Institute	Grants to accelerate development (after the basic science is known) of renewables and other energy technologies	Allocation (and eventual size) of budget not yet announced.	Taxpayers and sponsoring companies

Source:http://www.publications.parliament.uk/pa/ld200708/ldselect/ldeconaf/195/19509.htm#a53 Accessed 28 August, 2009.

It is also the case that there are promising developments with offshore wind in the UK (assuming the actual delivered costs can be kept down). As of August 2009, offshore wind capacity is currently 598 MW, but 1246 MW is under construction, and a further 3613 MW has been consented. This contrasts with 3730 MW of onshore wind capacity, with only 930 MW under construction, and 3275MW consented.[34] It seems likely given the continuance of high levels of support via banded ROCs that offshore wind will overtake onshore wind generation, albeit on the back of very disappointing delivery of onshore wind projects.

Looking at the success of the NFFO and RO schemes. NFFO did well on cost of the policy, but less well on quantity of renewables delivered. RO did better on quantity delivered but much less well on cost of the policy.

4.4: Other Renewables Policies

While the main support mechanisms have favoured wind and biomass, direct government funding, as detailed in Table A1, has also helped the marine industry. A resurgence in research and demonstration funding in the last 10 years has resulted in some positive developments (see Mueller and Wallace, 2008). The first 1.2 MW is tidal stream plant was installed in 2008 (Riddell, 2008) and the industry well placed internationally to exploit this and related marine technologies (Elliot, 2009). The UK government is currently conducting another feasibility study of the 8.5GW Severn Barrage (which could generate 5% of the UK's current electricity demand). This is the biggest of the UK's potential tidal projects (Conway, 1986), but cost and environmental issues remain to be addressed (see DECC, 2009a). However it would seem sensible to trial a smaller scheme first (such as a barrage across the Mersey), in order for learning that might benefit the much larger Severn scheme. A large barrage project could almost certainly not be accommodated within the existing ROC scheme.

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[34] Source: www.bwea.com. Accessed 17th December, 2009.

Table 9: Renewable Electricity Generation in the UK 1990-2008 (Source: DUKES, various issues)

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Generation(GWh)												
Wind												
	Onshore wind	9	391	945	960	1251	1276	1736	2501	3574	4491	5792
	Offshore wind	0	0	1	5	5	10	199	403	651	783	1305
Solar photovolatics		0	0	1	2	3	3	4	8	11	14	17
Hydro:												
	Small scale	91	166	214	210	204	150	283	444	478	534	568
	Large scale	5080	4672	4871	3845	4584	2987	4561	4478	4115	4554	4600
Biofuels:												
	Landfill gas	139	560	2188	2507	2679	3276	4004	4290	4424	4677	4757
	Sewage sludge digestion	316	367	367	363	368	394	440	470	456	496	564
	Municipal solid waste combustion	221	747	840	880	907	965	971	964	1083	1177	1226
	Co-firing with fossil fuels					286	602	1022	2533	2528	1956	1613
	Biomass	0	334	410	743	807	947	927	850	797	964	1155
Total Biofules and wastes		676	2008	3796	4493	5047	6174	7364	9107	9288	9270	9315
Total Renewables		5857	7237	9828	9516	11093	10600	14147	16940	18136	19646	21597
Total Generation		319701	334042	377069	384778	387506	398209	393867	398313	398823	397044	389649
%												
Total Renewables		1.83%	2.17%	2.61%	2.47%	2.86%	2.66%	3.59%	4.25%	4.55%	4.95%	5.54%
of which	Wind	0.00%	0.12%	0.25%	0.25%	0.32%	0.32%	0.49%	0.73%	1.06%	1.33%	1.82%
	Hydro	1.62%	1.45%	1.35%	1.05%	1.24%	0.79%	1.23%	1.24%	1.15%	1.28%	1.33%
	Biofuels	0.21%	0.60%	1.01%	1.17%	1.30%	1.55%	1.87%	2.29%	2.33%	2.33%	2.39%

PV has relied on direct government support for installation programmes which have only involved a small number of installations, mainly funded via the DTI/BERR, under the Low Carbon Buildings Fund. This funding has only installed a few hundred PV systems. The degree of satisfaction with the technology among the recipients of funding has been positive (Faiers and Neame, 2006), but a lack of significant sums of money and proper assessment of the learning from the policy has been noted (Keirstead, 2007). This is in spite of a well regarded R&D plan for solar being put in place in the 1990s (Stainforth et al., 1996) and work showing that significant community installations of solar would not pose any local grid problems (Thomson and Infield, 2007).

The government has made two announcements of changes to its renewables policy, which are due to be implemented in the future, which are relevant to any assessment of the need for reform of the current arrangements. Both of these policies are allowed for in primary legislation (Energy Act, 2008)[35] and are currently being consulted on as to their exact form.

First, there is due to be a Feed-in-Tariff (FIT) for small scale low carbon generation.[36] FITs guarantee fixed per kWh prices for renewable generation and can be differentiated by technology type. This will be for renewable electricity generation up to 5 MW and fossil fuel CHP up to 50 kW. This is to encourage PV, small scale wind (including micro wind), micro-hydro and micro-CHP. It aims to 'remove uncertainty for investors, reduce payback periods and increase returns on investment'. It specifically aims to 'engage communities, businesses and domestic households in the fight against climate change'. This policy is due to be in place in April 2010. This policy responds to industry concerns about the lack of ambition in micro-generation policy (Lupton, 2008).

Second, there is due to be a Renewable Heat Incentive (RHI).[37] This has the potential to be a significant policy covering all scales of production: household, community and industrial. It is intended to drive the share of renewable heat to 14% (though this is not a firm target) up from 0.6%. It

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[35] See http://www.opsi.gov.uk/acts/acts2008/ukpga_20080032_en_1 Accessed 28 August 2009.
[36] See BIS website on Feed-in-Tariffs. www.bis.gov.uk Accessed 20 August 2009.
[37] See BIS website on Renewable Heat Incentive. www.bis.gov.uk Accessed 20 August 2009.

could cover 'biomass, solar hot water, air and ground source heat pumps, biomass CHP, biogas from anaerobic digestion and bio-methane injected into the gas grid'. It may also involve support payments to households. It will be funded by a levy on fossil fuel suppliers of heat, certainly gas suppliers, but potentially suppliers of coal and heating oil and LPG. This policy could address a major imbalance in the current energy tax regime the under-taxation of gas for heating.

4.5: An Assessment of Renewables Policies

A 20 year view of UK renewables policy suggests a failure to translate a country's early resource based promise into actual delivery of renewable energy. However it would be wrong to suggest widespread policy failure. The UK is making progress on decarbonisation and has strong and increasingly comprehensive policies in place, covering electricity, heat and transport (via policies towards electric vehicles and biofuels).

Two points are worth making at this stage. First, renewable energy policy remains an expensive gamble for all countries. Second, it is unclear what part particular renewable technologies should play in decarbonisation to 2050.

As Helm (2002) has pointed out a sensibly high and stable price of carbon is the starting point for all economically literate decarbonisation policies. In the absence of this it is virtually impossible to establish proper signals for mature technologies and near market technologies whose response to the proper price signal determines how fast we need to accelerate less developed technologies. This is particularly true for nuclear, CCS and demand reduction investments, many of which are being delayed by low, volatile and uncertain prices for carbon. The UK with its diversified energy system, exposure to world energy markets and openness to both nuclear and CCS has keenly felt the lack of a proper carbon price signal. Without a proper carbon price it is unclear how much renewables are actually required and at what point it is sensible to stop directly subsidising their deployment (i.e. we won't know when they have become mature technologies).

As Nelson (2008) discusses, the failure to set a sufficiently tight cap on CO2 at the EU level makes a nonsense of UK renewables policy as a policy for decarbonisation. More renewable electricity generation within the EUETS simply causes fuel switching in the fossil plant from gas to coal, not to mention delaying non-renewable low carbon investments in CCS and nuclear. In this context UK renewables policy has been somewhat conservative with respect to funding levels under NFFO and with respect to renewable energy targets under the RO and, until recently, unwilling to pick winners.

The UK's willingness to back particular technologies may be increasing for other reasons, however. As Eikeland and Saeverud (2007) point out the ending of the UK's status as an energy exporter in 2003 and the associated rapid decline in oil and gas reserves has been associated with a reawakening of energy security concern as a major driver of UK energy policy. It is likely to explain substantially increased interest in delivering more domestic renewable capacity.

Failure to deliver large quantities of renewables *so far* is not a particular issue in terms of decarbonisation or in terms of minimising the long-term costs of renewable deployment. This is because delay will probably mean lower costs of exploitation when they are finally exploited (due to learning by doing elsewhere and learning by research). The really unfortunate aspect of the ROC system is its failure to cost effectively deliver the renewables that it has delivered. This has been a serious design flaw and the inability of the UK government to learn and correct the flaw does not bode well for any other long-term mechanism put in place to support renewables. However given the targets for delivery that exist within the scheme it is clearly important to consider why the scheme has not delivered the quantity of renewables intended. The failure of the scheme to deliver overall lies squarely with one particular technology: the failure to deliver sufficient quantities on onshore wind. We now examine this issue.

4.6: Onshore Wind and the Planning Problem

The standard reason given for the delivery failure is difficulties in getting new wind farms through local planning processes. While conventional power plants can easily be built on existing sites and require national level planning consents, wind farms are often small in terms of MW capacity and require local planning permission if less than 50 MW (this covers most onshore installations)[38]. There has been consistent evidence that gaining

[38] There were only 8 operational schemes in May 2009 with capacity of 50 MW or more onshore (DUKES, 2009, pp.145-151).

planning permission is a serious obstacle to the development of wind farms or more precisely that the costs of obtaining permission are often prohibitive in terms of imposed delays, negotiation costs and planning restrictions on the precise nature of the final investment.

In the UK local planning decisions typically involve an applicant, such as a wind project developer, making a planning application. This would involve the submission of detailed plans and an impact assessment to the relevant local government authority. This application would initially be assessed by a local planning officer. The officer would make recommendations on the plans to the relevant group of elected local councillors for the area, who would vote on the proposal. Plans would be available for public consultation and objections could be raised during the review period. Planning applications can be granted subject to conditions and obligations. This process might result in a number of iterations in the plans. Should permission be refused the applicant can appeal the decision in which case there would be a costly public enquiry. The relevant central government department also has the right to disallow a locally approved planning application (so objectors can appeal to the relevant government minister). At the national level plans need to be submitted to the relevant government department for referral to the Secretary of State for final decision. Objections can be raised to these plans according to the planning guidelines. This national level process is being streamlined, as below.[39]

The average time for local and national planning decisions on onshore wind in 2007 was 24 months, with approval rates of 62%.[40] For large projects the Ministry of Defence, National Air Traffic Control and civil airports were major objectors. Attempts have been made since 2007 to place obligations on local councils to set target levels of energy from renewables for new developments. The 2008 Planning Act[41] allows for the setting up of an Infrastructure Planning Commission to decide on large onshore wind farms

[39] For more detail on the planning process in England, see http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/planning/plan_policy/england/england.aspx Accessed 20 October 2009.
[40] Source: BWEA (April-June 2008), Real Power, p.21, http://www.bwea.com/pdf/realpower/realpower_12.pdf. Accessed 28th August 2009.
[41] See http://www.opsi.gov.uk/acts/acts2008/ukpga_20080029_en_1 Accessed 28 August 2009.

(greater than 50 MW) as well as large offshore projects (greater than 100 MW).[42]

The literature has dug more deeply into the ‘planning problem’. Hedger (1995) highlights that wind power development involves a clash of planning cultures: land use vs. energy supply. The first is fundamentally local, participatory and concerned with preserving rural landscapes and the second fundamentally national, top-down and concerned with delivering technological solutions to national energy supply requirements. These cultures were bound to clash in onshore wind power development.

Mitchell and Connor (2004) emphasise that the emphasis on cost minimisation, combined with the tying of subsidy to particular locations and plans meant that many successful NFFO bids failed to get through the planning process. This was because they were not able to invest in local engagement or indeed to respond to the outcome of the engagement process by modifying their proposals. Indeed the competitive nature of NFFO meant that often the bidders had to keep prospective locations secret and did not engage in local consultations prior to bidding. Toke (2005a) found that for the NFFO rounds 3, 4 and 5 projects that he examined: 47 schemes were granted planning permission, 47 refused planning permission and 96 did not make or complete an application.[43]

The major reasons given for planning objections were visual amenity impairment and worries about noise (Eltham et al., 2008). These gave rise to concerns about economic effects on house prices and on tourism. The UK is a densely populated island, with many areas of lower population and high ground being located in national parks or areas attracting tourists and increasingly having large percentages of residents or second-home buyers moving there for visual amenity rather than employment reasons (see Strachan and Lal, 2004 for a discussion of the debate around tourism). The decline of employment in farming and rural industry has reduced the scope for arguments based on the small number of permanent jobs that might be created in the energy sector. This is because increasing percentages of

[42] See NAO, 2008, pp.40-41 for a discussion.
[43] In this vein, Upreti and van der Horst (2004) have an enlightening discussion of one NFFO biomass project which because it could not be modified, as suggested by the local consultation process eventually had to be abandoned.

people living in the countryside work in nearby conurbations and are not looking for employment in local industry.

Rural environmental protection charities and local community action groups thus had strong incentives to organise opposition to individual wind farm projects. This is in spite of the fact that in some cases tourism actually increased after wind turbines were installed and that the noise from a modern turbine that is 500 metres away is no more than in a quiet bedroom (Strachan and Lal, 2004, p.563). A number of studies have shown that attitudes to wind farms consistently improve after construction with many people's fears not being realised (e.g.Warren et al., 2005 and Eltham et al., 2008). It is also true that in general there is majority support for new wind farms but that there are a significant number of local and non-local objectors to given schemes (Warren et al., 2005). This suggests that there is a 'social gap' or 'democratic deficit' at the local level which needs to be overcome (Bell et al., 2005) to connect national policy delivery with legitimate local concerns.

Rather surprisingly, there has been little systematic study of success rates in individual local authority areas or by individual developers or indeed by ownership type. Only Toke (2005a) attempts a regression analysis, looking at planning permission acceptance and refusal for wind projects based on a sample of 51 proposals. He finds among other things that if local planning officers (who process applications and make recommendations to the local councillors who vote on the application) object then projects are almost always refused, while if they accept it is likely to go through on appeal and he also finds that if the Campaign to Protect Rural England which campaigns 'for the beauty, tranquillity and diversity of the countryside'[44] objects, it is likely to be opposed by the local parish council. One developer, Wind Prospect[45] (which has a joint venture with EDF to develop onshore wind farms in the UK) has invested heavily in local consultation and does seem to have been more successful in gaining planning permission (see Toke, 2005a). There have also been examples of active community involvement leading to successful development, particularly where the community owns shares in the wind farm, but these are small in capacity

[44] See http://www.cpre.org.uk/ Accessed 28th August, 2009.
[45] See http://www.windprospect.com/ Accessed 28th August, 2009.

terms.[46] However both under NFFO and RO there has been an unwillingness to actively involve communities in co-ownership of onshore wind developments, possibly because of the dominance of large power companies in the UK within the wind power sector and the high transaction costs of such engagement.

Overall, it is difficult to tell whether the full cost of developing wind power onshore is actually much higher than it would appear, given the social value of the countryside in the UK, or whether a feasible redistribution of the current benefits towards potential local objectors would be enough to solve the planning problem. Put another way, societal preferences have mattered for onshore wind and there has been a failure to encourage societal acceptance of new onshore wind investments.

Bergmann et al. (2008) use willingness to pay modelling of a sample of rural and urban dwellers in Scotland. While both groups value reduced environmental impact from power generation highly, they find that urban dwellers are willing to pay more for an offshore wind farm than for an equivalent large onshore wind farm and value the rural employment opportunities less than rural people (suggesting that even those in urban areas are willing to pay extra for offshoring). The actual construction costs of wind farms in the UK are difficult to come by but the information that is available suggests that simulations of the likely penetration of new schemes are still based on optimistic assumptions that wind costs will be much cheaper than they currently are.[47] High actual costs may therefore be a factor delaying investment. It is also the case that the achieved load factors for the whole UK wind portfolio in 2008 were 27.0% for onshore and 30.4% for offshore[48], in contrast to higher assumptions in some calculations (Dale et al., 2004, assume 35% for both onshore and offshore wind).

No doubt smaller, more local developments would facilitate reduced planning objections but they would come with their own higher costs. The move to FITs for such smaller developments should help increase the number of these types of project. However in examining scenario rankings

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[46] One of the few examples of significant capital raising from the local community was the Baywind project in Cumbria, who first raised £1.2m to form a cooperative to develop wind power. See www.baywind.co.uk

[47] Compare actual costs in Synder and Kaiser 2009 and Blanco, 2009, with cost simulation assumptions in Dale et al., 2004 and Strbac, 2007.

[48] See: DUKES Table 7.4. at www.berr.gov.uk. Accessed 27 August 2009.

from different wind actors in Northwest England, Mander (2008) found that expansion of offshore wind was the only part of a wind strategy that both pro-wind and pro-countryside lobbies could agree on, even if onshore wind became more community driven. Attempts to streamline the planning process have been made with significant reforms to the Appeals process in 2003 (Toke, 2003), giving more power at the national level, however there is clearly still an issue of getting permission. Attempts in 2005 to streamline the planning process in Wales (under a devolved administration) have had mixed success (Cowell, 2007). The Welsh Assembly designated 'strategic search areas' which were assessed to be more suitable for large wind farm developments (and hence more likely to be approved on appeal). These proved controversial with both pro and anti wind lobbies, with wind developers unhappy that many proposed schemes lay outside the 'areas' and anti-wind groups unhappy with where some of the boundaries of the acceptable 'areas' were drawn.

4.7: Comments on biomass

Biomass is likely to be the second largest renewable energy source out to 2020 in the UK. Biomass is frequently cited as a significant but finite contribution to UK decarbonisation (of the order of up to 5%) (see Taylor, 2008, for a review). Biomass policy towards waste has been largely successful due to the near market nature of the technology and its responsiveness to both NFFO and RO subsidies. The direct burning of bio-crops has also been successful given the emerging global market in tradable biomass from countries such as Brazil, Canada and the US (Junginger et al., 2008).

However government support for local bio-crop plants has proved problematic given the technological, planning and economic constraints. A high profile project involving local biomass and new technology failed due to financing concerns (Piterou et al., 2008) and it is difficult to justify the use of local bio-crops for anything other than direct burning in existing power coal fired power stations in direct competition with internationally traded biomass, which is usually produced more efficiently abroad. However some focus group studies have suggested that there is public support for the use of local biomass in small CHP plants and scepticism about the overall GHG impact of the use of internationally traded biomass (see Upham et al., 2007).

It is not environmentally sensible to use local bio-crops to produce bio-fuel in the UK. Local bio-crops produce more GHG impact when directly burnt to produce power and heat (Hammond et al., 2008). Indeed in the longer run the current use of bio-fuels to blend with petrol and diesel may be phased out as the vehicle fleet is electrified (for current use see Bomb et al., 2007). The difficulty of making a sensible industrial policy argument for a local crop-dedicated biomass power plant within a sensible long run decarbonisation strategy is helpfully discussed by van der Horst (2005). Indeed Slade et al. (2009) criticise UK bio-energy policy as being characterised by lots of initiatives but with a lack of clarity as to precise objectives to be delivered. If the UK were to rely on internationally traded biomass as its key input this would require better certification as to the source of the biomass (van Dam et al., 2008).

What we can say is that bio-energy, with its complicated supply chain, displacement impacts and total production cycle sustainability impacts, requires proper pricing of all its environmental effects (including GHGs and local pollutants) in order to calculate whether it is worthwhile (Elghali et al., 2007). The life cycle GHG impact of bio-crops is further complicated by the carbon storage impacts of increasing the area set aside for growing bio-crops (Cannell, 2003) (i.e. the impact on the amount of carbon stored in the stock of growing crops).

Section 5: Comparing the Performance of the UK with that of other countries

Our discussion so far indicates that comparative assessment of the UK's policy on renewable energy would not be straightforward. It is clear that the UK has pursued a successful decarbonisation strategy to date and that there have been several areas of relative success in responding to both price signals and in developing new technologies for deployment in the UK. The one area of failure is in deployment of onshore wind at least cost. The net environmental impact of this failure on CO2, relative to the counterfactual of achieving its renewables target, is currently zero, given that the UK is on course to meet its GHG reduction targets. However this environmental performance could have been delivered at lower cost. The excess costs of the current set of policies is hard to estimate given the diversity of support instruments however a lower end estimate would be the amount of revenue recycling within the RO mechanism. This is because this overpayment was clearly unnecessary to deliver the observed quantity of renewables on the system. This excess cost is significant and rising. However it remains small given the high cost of some other countries' renewable deployment strategies which have not allowed them to meet their GHG reduction targets (e.g. Germany and Spain).

It is fashionable to suggest that the root cause of the 'problem' of under delivery of onshore wind is the use of a TGC scheme rather than a FIT as used in Germany and Spain.[49] However a more balanced assessment by the International Energy Agency (2006) of the UK's renewable energy policy points out that TGCs have worked well in a number of jurisdictions, e.g. Texas, Sweden, Australia and New Zealand. It is only in the UK where they seem to have manifestly failed to deliver the intended capacity.

There are two common theoretical arguments for the superiority of FITs over TGCs. First, that by offering a fixed price per kWh to developers this allows new renewables to be financed more easily. Second, that FITs attract large quantities of renewables because renewables are not limited to the most attractive sites.

The first argument is well put by Mitchell et al. (2006) who argue that the UK ROC scheme exposes renewables to price, volume and balancing risks, rather than just volume risks as under a FIT. While this clearly does impose costs, it is not clear that it is suboptimal or that it explains non-delivery against the UK's renewables targets. Higher risk is relevant to non-delivery where development is small scale and the developers have little or no credit history, here there may well be a significant market failure in the market for external finance. However it is rather a weak argument when the ultimate developers are mostly large multinational companies making portfolio investments (and when most ROC credits are bought by the 6 multinational supply companies who dominate the UK market, each with generation interests and the option invest directly in renewable capacity).

The second argument makes less theoretical sense because it is not clear why developing the most attractive sites first is not desirable in any case. The quantity of renewable forthcoming is clearly accelerated by offering initially high returns, but offering a margin for renewables to attract

[49] See for example: Jacobsson et al., 2009, Toke and Lauber, 2007, Meyer, 2003, Lipp, 2007, Toke, 2005b, Butler and Neuhoff, 2008.

investors is not a function of whether the subsidy regime is a FIT or TGC but of how big a quantity of renewables is required under either scheme. TGCs can set ambitious targets as in the UK and can deliver attractive prices.[50] Low prices for renewables are not a problem with the UK's ambitious ROC targets[51].

In the end the question becomes would the UK have delivered more onshore wind capacity had there been a FIT for wind energy? For community schemes the answer is quite possibly, because the uncertainty of individual project cash flows may well have been an issue for funders. However, for larger schemes largely owned by multinational energy companies, it is hard to say. The problem has clearly been related to planning permission and it is not obvious how changing the funding regime improves the prospects for gaining planning permission unless it is more generous and offers scope for offering attractive payments to the local community.

The literature seems to suggest two more fundamental dimensions are of interest to explaining the difference in delivery of onshore wind between the UK, Germany, Spain and Denmark: land use constraints and local involvement in ownership (e.g. via local co-operatives or farmers) .

[50] See for example the performance of the Swedish scheme (Swedish Energy Agency, 2008).

[51] UK renewable generators currently (December, 2009) receive around 9.7p/KWh (ROC price + wholesale price). The German FIT for wind is 9.2 Euro cent per KWh in the first year, declining over time. Thus UK renewable generators receive more than in Germany. However adjusting for the quality of wind resource in the UK - which would increase the return on capital in the UK relative to Germany for a given unit energy price - the profitability gap is even larger than it appears (Butler and Neuhoff, 2008).

Table 10: Differences between leading wind countries in Europe

	1000 sq miles Land /per million population 2008/9	**% Onshore Wind owned by utilities/ corporates**	**% Owned by Farmers**	**% Owned by Cooperatives**	**Wind capacity MW end 2008**
UK	1.5	98	1	0.5	3288
Germany	1.7	55	35	10	23903
Spain	4.3	99+	<0.5	0	16740
Denmark	2.9	12	63	25	3160

Sources: Wikipedia for land densities; www.thewindpower.net/23-countries-capacities,php; Toke (2005b).

In Denmark local ownership is very high and it is also notable in Germany as a determinant of successful strategic deployment in these countries (Toke, 2007, Szarka and Bluhdorn, 2006). This is important because these two countries face similar if not identical land use constraints to the UK. The development in Spain however has occurred with similar ownership of wind assets (i.e. multinational companies) but in context of very little land use constraint (Toke and Strachan, 2006) relative to the UK. Thus it seems clear that none of these 'comparator' countries has similar institutional and physical starting points *to the UK*.

Econometric modelling by Soderholm and Klassen (2007) of diffusion rates of wind power across Europe confirms that the UK has lower diffusion (penetration) relative to other countries and that FITs do tend to be more successful in encouraging diffusion, but that a given FIT would likely have less of an impact in the UK than in Germany (e.g. due to lower levels of supporting public R&D expenditure).

What is clear is that the financial cost of wind power delivered on shore is unnecessarily high in the UK. Butler and Neuhoff (2008, p.1856) show that while the NFFO schemes did result in much lower support prices for wind than in the UK, they were not that much lower once adjusted for the quality of underlying wind resource. Under the RO renewable support costs are estimated to be twice as high in 2006 as they would be under a German support tariff applied to the UK's wind resource (which would be lower than the actual tariff in Germany). While Toke (2005b) shows that the ROC scheme with revenue recycling was more expensive per kWh than the Germany FIT following reductions in the size of the FIT in Germany.

Looking at Spain where large utilities have dominated in ownership of wind generation in a similar way to the UK, Stenzel and Frenzel (2008) highlight the positive reaction of incumbent Spanish companies to wind power development in Spain in contrast with that in Germany. They highlight the importance of corporate self-interest in promoting wind power development. Wind power in Germany developed in spite of opposition from Germany utilities who were forced to accommodate renewables and bear the costs of connection to the grid. In Spain this has led the corporate generators to support investment in better prediction of wind speeds at individual wind farm sites in order to better manage the grid. However in Germany there have been significant costs imposed on the transmission system, which are not reflected in the connection incentives of wind developers. This has led to grid management issues in Germany, which will become more costly to deal with as wind capacity increases (Klessman et al., 2008). It is even possible to suggest that the continuation of the grip of incumbents on the German power market is in significant part down to the unwillingness of the German government to liberalise the market fully for fear of undermining the ability of the incumbents to finance the significant reinforcement costs associated with renewables expansion.

In the UK, there were around 13.2 GW, in 195 projects in 2008, which are in the 'GB queue'[52]. These are projects which wish to connect to the power grid, but for whom currently no firm connection right can be offered (unlike under the German FIT, where renewables capacity must be connected and paid for generated power)[53]. It is suggested by the UK government that this is one of the barriers to the roll out of renewables (DECC, 2009c). This may explain some of the slow delivery of renewable wind connection in the UK, but it certainly does not explain the most significant part of it. It is impossible to tell how economically viable much of the Queue is, and Ofgem has identified only around 450 MW of wind capacity that needs to be

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[52] See http://www.ofgem.gov.uk/Networks/Trans/PriceControls/TPCR4/ConsultantsReports/Documents1/16962-The%20GB%20Queue%20-%20%20Reasons%20and%20remedies.ppt Accessed 28 August 2009.

[53] See Swider et al. (2008).

prioritised via accelerating transmission investment.[54] It is also the case that new renewable connection should face the true costs of connection to the grid and capacity and should come on stream when it is at least system cost, rather than only least generation cost. Nodal pricing would seem to be a more appropriate way of signalling this, rather than the 'connect and manage' approach under FITs in Germany (see Pollitt and Bialek, 2008).

The correct pricing for transmission capacity also points to the need for the UK to look closely at the efficiency of utilisation of transmission assets and their operational criteria. The GB transmission system in general operates an N-2 safety standard (the system must be operated in such a way that if a major link fails it must be capable of handling another similar sized failure) and has much less automatic voltage control equipment connected to the grid. This suggests that there is scope for operating the assets much more smartly in the presence of large scale renewables. For instance the nominal rating of Scotland-England interconnectors is around 7 GW, whereas the declared capacity is 2.2 GW, this suggests that transmission constraints could be made to be less in practice than they might be on paper.

Looking to other countries with TGC schemes it is quite clear that Sweden, Australia and New Zealand have avoided the problems of over-payment which characterise the ROC scheme in the UK. Clearly these jurisdictions have significantly less land use constraints than the UK. Kelly (2007) discusses the UK in contrast to Australia and New Zealand. The Australian scheme, complemented by an Office of the Renewable Energy Regulator[55], has much less ambitious targets than the UK scheme, but does not have any revenue recycling. The New Zealand scheme has higher targets than Australia but is voluntary. The Swedish scheme also does not have revenue recycling and is combined with carbon taxes throughout the economy.[56] The UK would do well to examine the overall carbon reduction incentives in Sweden.

Szarka (2006) raises an important issue about policy comparison across countries in the case of renewables, suggesting that what policy should be aimed at is 'paradigm change' not just installed capacity. Clearly what

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[54] See http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/tar/Documents1/20090508%20derogations%20interim.pdf Accessed 28 August, 2009.
[55] See www.orer.gov.au Accessed 28 August, 2009.
[56] See www.swedishenergyagency.se Accessed 28 August, 2009.

matters is where we end up in terms of decarbonisation and what is required is radical change to the UK's energy system. He suggests the real success of German policy has been to engage large numbers of individuals in taking action on climate change (as investors in local wind farms). This is an important perspective, because it suggests that the real failure of UK policy is to gain practical support for the sort of changes to the energy system that are required. Failure to focus on this aspect of the problem has led to an ineffective policy on renewables deployment, which will be more expensive than it need have been (due to a combination of under delivery and overpayment).

There is also the issue of the stability of policy through time. A concern of UK policy makers in setting up the RO scheme was to introduce stability in the subsidy regime over a long period, in contrast to the stop-start nature of NFFO. However while stability is a desirable goal in itself, this has been an excuse for not facing up to the serious deficiencies of the RO scheme. There is also little evidence that the UK has had a less stable policy towards renewables than countries with high penetration rates of renewables, such as Denmark, Germany and Spain, where response to incentives was rapid and where there have been significant changes to support policy over time.

Section 6: Explaining what might be right for the UK

If there is a problem with the delivery of onshore renewable capacity in the UK – what is to be done about it? Answering this question requires attention to the institutional context of the UK (following Rodrik, 2008). The UK's policy context is a liberalised market for a relatively small island with concerns about fuel poverty, global warming and energy security. It is clear that what is needed is a policy consistent with a liberalised energy market and with environmental targets. By contrast Germany is a country which is much less committed to liberalised energy markets. It has also much more of a focus on a green industrial policy aimed at promoting the manufacturing of wind turbines for export. While the UK has paid lip service to this sort of objective, the reality is that only 4000 jobs in the UK depend on the wind production industry, even in Germany the figure is only 38,000[57]. It is quite clear that for an industry requiring around £1bn of subsidy per year, this is not a cost effective job creation scheme.

[57] http://www.wind-energy-the-facts.org/en/part-3-economics-of-wind-power/chapter-7-employment/ Accessed 27 August 2009.

The focus should rather be on least cost achievement of environmental targets which will be much more important for the competitiveness of the UK economy and for incomes and employment. The current ROC scheme is clearly far too generous to existing onshore wind and it does not guarantee cost effectiveness for offshore wind and marine energy. It is also important that the aim of long run cost reduction for technologies that are currently not cost effective is maintained and that these technologies must compete with nuclear and CCS projects in a reasonable time frame. An important starting point for this is the creation of a single high and stable carbon price throughout the economy. This would immediately give clear signals to nuclear and CCS and provide the backstop technologies against which continuing subsidies can be measured. They would also provide the right incentives to biomass both in terms of co-firing, landfill gas and waste.

The principle of differing levels of support for technologies at different stages of development is also well established and recent moves in UK policy to recognise this are sensible and important. What is needed is the right mix of RD+D support, competitions and general support mechanisms such as an FIT or GTC.

It seems clear that for small schemes a FIT for small scale wind and small hydro does offer an attractive mechanism at the low levels of development that the UK is currently at and hence current moves in this direction are sensible, given high transaction costs in setting up such schemes and arranging finance.

For offshore wind it would seem that a NFFO style set of annual auctions would offer the best way of keeping prices down. NFFO arrangements could be amended to ensure actual delivery, with penalties for non-delivery. Indeed given the scale of offshore wind’s potential and the problem of finding a suitable level of support initially relative to other sources of renewables this would seem to be a good way forward. Bids could take form of contracts for differences (as suggested by Ofgem, 2007, for the reform of the ROC scheme), whereby bids were for a fixed price for the electricity generated, which would be paid at that price minus a reference wholesale price, with the payments being levied across licensed suppliers in proportion to their supply. This would incentivise efficient location decisions, as connection and use of system charges would still be borne by the generators and they would be incentivised to maximise the actual wholesale price they received in the market. It would also tie in with successful experience for the use of competitions for infrastructure delivery under the private finance initiative (Pollitt, 2002). As with any procurement process, which is repeated with (potentially) a smallish number of bidders over time, the auctions would have to be monitored for collusion between the bidders but given the standard nature of the investments and transparency of the bidding strategies employed by the players actual or tacit collusion would be easy to spot. Annual bid rounds would offer the chance to adjust quantities required and other details of the auction easily over time to reflect learning.

For large scale onshore wind the RO mechanism could be made to work, if the revenue recycling were removed and the targets adjusted according to the expected amount of capacity from offshore wind. This would essentially reward onshore renewable generation with a fixed revenue supplement equal to the buyout price (assuming the target was not met or exceeded). However it remains the case that all renewable capacity should be expected to face the full cost of transmission and distribution costs imposed on the system. This would encourage optimal siting, local generation more generally, and proper competition between renewable supply and demand reduction measures. Barthelmie et al. (2008) show that there would be benefits to learning from Spain in terms of improving the short term forecasting of wind power availability. Improved forecasting might have increased the price of wind power received by generators by the order of 14% in 2003.[58]

In sum the current revenue recycling within the RO mechanism is unnecessary and should be stopped. This is line with an early National Office Report on the RO mechanism which warned the government that it needed 'to keep a firm grip of the Obligation's cost relative to other instruments for reducing carbon dioxide' (NAO, 2005, p.4). The system needs to be altered with respect to offshore renewables in order to ensure least cost delivery of an initially very expensive renewable energy source. Large one-off projects like the Severn Barrage or the Thames Barrage (associated with a new London airport), if deemed necessary after appropriate cost benefit analysis, must be auctioned rather than financed within the RO mechanism.[59] The RO scheme could further be amended to

[58] It might be considered odd that UK wind generators have not done this already given the financial incentive to do so, but this may be due to the currently low level of wind capacity, relative to some of the fixed costs in setting up such a system.
[59] See Sustainable Development Commission (2007) on potential tidal projects in the UK.

remove its all or nothing property by ensuring that in the unlikely event that targets were met or exceeded the total amount of subsidy is divided proportionately between all those presenting ROCs. This would remove the cliff-edge effect on the renewable subsidy of meeting the target.

What the history of UK renewables since 1990 really tells us is that there are important institutional barriers to expansion of renewables onshore. These are to do with the lack of local benefit from renewable projects that employ a small number of people and have a significant perceived amenity impact. The key learning from Denmark and Germany is that local populations must perceive such projects as of positive benefit to them rather than satisfying some distant national policy objective, which they may otherwise support. The UK must develop local energy companies that are owned by local investors and / or local customers or councils if the potential exploitation of local energy resources both wind, biomass, hydro and other technologies is to be realised. This is because virtually all renewable electricity and heat technologies involve significant local impacts in terms of siting of 'industrial' facilities close to residential areas.

For offshore renewables getting costs down will be the challenge. Costs need to come down significantly if energy customers are going to support large quantities of them. The current combination of capital grants and arbitrary ROC banding is not a satisfactory or sustainable way forward. Auctions for new capacity would be institutionally compatible with the UK's liberalised electricity market and offer the prospects of falling prices over time. They would also tie in with the auctions to build, own and operate offshore transmission lines to the new wind farms that Ofgem is currently implementing[60]. Under Ofgem's offshore transmission auctions once an offshore wind farm has a firm contract for connection to the onshore transmission grid an auction will be triggered to build the interconnection between the shore and the wind farm.

In the end success, in UK policy towards renewable deployment, must be measured relative to other countries in terms of the NPV of the amount of renewable electricity generated scaled by the amount of subsidy. While this success metric will be difficult to measure at any point along the pathway, in the interim success should be measured in terms of the extent to which the

[60] See http://www.ofgem.gov.uk/Networks/offtrans/Pages/Offshoretransmission.aspx Accessed 28 August 2009.

maximum amount of renewable generation (adjusted for technological maturity) is being supported for the current level of subsidy. UK policy is clearly not being successful given the large amount of relatively cheap unexploited wind resources in the UK, in the face of overpayment to existing renewable generators. A set of policies consistent with the UK's institutional context should clearly aim for consistency with the principles of liberalised markets and emphasise the use of competitive mechanisms such as appropriately designed capacity auctions for certain types of renewable generation.

Section 7: Conclusions

The UK is struggling to develop a coherent set of policies for decarbonisation following on from its successful liberalisation of energy markets experience. Various authors have suggested that the decarbonisation policy is so ambitious that it demands radical institutional changes (Pollitt, 2008, and Mitchell, 2007). However there is little consensus on what form those institutional changes should take.

What is clear is that solutions must target least cost or else the whole policy is likely to fail due to the actual cost becoming prohibitive. On the path to this sort of ultimate policy failure, large amounts of resources are likely to be wasted, to little overall effect and for no benefit to the UK economy or the global climate. The UK has had a long history of failed government intervention in the energy market and in industrial policy in general (Pollitt, 2008). It must not continue with this sort of tradition. It has however good experience with the role of markets, undertaking basic R+D and the use of market mechanisms to deliver public goods. The UK has also particular concerns about fuel poverty. This argues for a focus on keeping the costs of renewables policy down.

The UK clearly agreed to an ambitious renewable generation target which was unnecessarily tough – in terms of the required speed of increase in the share - in the face of its EU CO2 targets which could have been met much more straightforwardly by a combination of demand reduction and switch for coal to gas fired generation (see Grubb et al., 2008). Why the UK got itself into this position is unclear, but it clearly hoped that the EU ETS would have been much more effective than it has been in supporting decarbonisation and that the EU Renewables Directive would be less significant than it has become.

The UK must also resist calls to see national renewables policy as anything other than a policy for delivering learning benefits on the path to cost parity with established technologies. An industrial policy based around renewables is not a sensible use of national economic resources. No doubt there will be some wider industrial benefit to the UK from exploiting its domestic renewables potential, however this will arise naturally and should not be an objective of policy. The British Wind Energy Association reports that the UK is a net exporter of small-scale wind turbines, the part of the market least affected by government subsidy.[61] What is needed is to move to a more competitive energy market where smaller firms compete with large incumbents to supply power and to deliver national targets and where the capacity to rapidly adopt new lower cost innovations exists. This is essential if incumbent costs are to be kept down and oligopoly pricing and excessive subsidy regimes are to be avoided. The 40 years from 2010-2050 are very likely to see huge technological and lifestyle changes which will substantially change the potential picture of the power, heat and transport sectors (see Ault et al., 2008a). We must have institutional arrangements incentivise potentially drastic innovation within the renewables sector.

The UK must learn from both its NFFO and its RO experience and incorporate the learning from both into future subsidy regimes. The evidence is that a reformed NFFO type auction could be a sensible way to deliver offshore large wind parks mostly built by large multinational utility companies. Onshore it is clear that there are legitimate land use issues with renewables which can only be addressed by smaller scale projects for local public benefit. This policy is in line with some of the more decentralised scenarios of the future development of electricity networks and would have the added co-benefit of substantially reinforcing the need for paradigm change at the individual level and aid behavioural changes which would support the optimal use of technologies which would promote energy efficiency. Auctions for offshore wind capacity might be useful in setting support prices for onshore wind capacity and in giving more certainty in the capacity likely to appear on the system.

[61] See http://www.bwea.com/pdf/small/BWEA%20SWS%20UK%20Market%20Report%202009.pdf Accessed 27 August 2009.

It is also clear that the UK needs to significantly improve the quality of the information on which policy decisions are being made. There is a severe lack of analysis of the drivers of past policy outcomes, partly as a result of the lack of information on the financial characteristics of individual projects which have been in receipt of subsidy. We could find no study on the actual performance of renewable projects in the UK. Foxon and Pearson (2007) highlight the need for improvements to the process of energy policy making whereby analysis is properly used to evaluate policy and policy is revised in the light of analysis. One particular area for improvement is in the consistency of energy policy between heat, power and transport fuel in terms of value of subsidies for carbon reduction, entry barrier reduction and to promote learning.

It is also true that the information available to potential (often small scale) developers could also be improved with significantly more use of geographic information system (GIS) mapping of potential renewable energy sites and guidance on acceptable designs and siting rules. This would focus developer efforts on sites much more likely to secure local public support and get planning permission. This sort of pro-active approach to preparing the ground for projects would seem to address some of the calls for more joined-up government (e.g. Keirstead, 2007) towards energy policy in the UK. This would seem to be important in resolving resource conflicts between local community, leisure, defence, air traffic and energy interests.

Finally, a focus on renewables must not detract from the over-riding policy aim of decarbonisation of the economy. This requires sensible carbon prices and the workings of the price mechanism. In the end it is only against sensible time and place varying prices and proper pricing of the carbon externality that any given renewables project, with its particular characteristics, can be evaluated among the myriad alternatives. While the UK’s policies towards renewables may currently be failing to deliver new capacity in sufficient quantity to hit long term renewables targets, it is by no means clear that those countries that are doing better in this regard are any nearer to achieving long term decarbonisation.

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Table A1: Detailed Government support for renewables 05-08 (incomplete)

DTI/BERR [1]	New and Renewables Barriers Busting	2005-08	52.6m	
	Sustainable Energy Capital Grant	2005-08	96.4m	
	Photovoltaic Grant Scheme	2005-08	19.8m	
	New and Renewable capital grant	2005-07	27.1m	
BERR	Total Renewable R&D and capital grants[2]	2002-2008	500m	
	capital grant funding[3]	2009-2010	50m	
	Marine Renewables Deployment Fund[4]	Since 2004	50m	
ETF Fund[2][18] [3][7]	BERR& DECC	HFCCAT Demonstration Programme	N/A	2008/09 - 2010/11 400m
		Marine Renewables Deployment Fund [4]	50 m	
		Low Carbon Buildings Programme [5][6]	131m	
		Offshore Wind Capital Grants Scheme	N/A	
	Defra	Bio-energy Capital Grants Scheme	N/A	
		Bio-energy Infrastructure Scheme [3]	10-15m	
	Carbon Trust	Innovation programme, including applied research scheme, research accelerators, technology accelerators, and incubators [3][8]	62.4 m	
		Funding for new low carbon technology enterprises, including Partnership for Renewables [3]	2007-2008 1.6m	
		Investments in clean energy technology businesses [3]	2007-2008 7.3m	
		Energy efficiency loans scheme for small and medium sized enterprises [3]	2007 - 2008 >21.5m	
		Salix Finance public sector invest-to-save loan schemes [3]	N/A	

<table>
<tr><td rowspan="2">Carbon trust</td><td rowspan="2">granted by Defra [3]</td><td>2007-2008</td><td>89 m</td></tr>
<tr><td>2009-2011</td><td>250 m</td></tr>
<tr><td>Research Council [3]</td><td>Energy Program</td><td colspan="2">90m</td></tr>
<tr><td>ESRC [9]</td><td>Sussex Energy Group</td><td>April 2005 - March 2010</td><td>2.8m</td></tr>
<tr><td></td><td>UKERC</td><td>April 2004 - April2009</td><td>3.2m</td></tr>
<tr><td></td><td>UKERC(TSEC)</td><td>Since 2004</td><td>28m</td></tr>
<tr><td></td><td>Tyndall</td><td>October 2000 - April2009</td><td>0.8m</td></tr>
<tr><td>Technology Strategy Board(TSB) [3]</td><td></td><td>since 2004</td><td>90m</td></tr>
<tr><td>Energy Technology Institute(ETI) [3]</td><td></td><td colspan="2">600 m over next 10 years and 1.1 billion potential, since 2008</td></tr>
<tr><td>Environment Technology Fund [3]</td><td></td><td colspan="2">125 m pa</td></tr>
<tr><td rowspan="5">Devolved Admin</td><td>SCHRI(took over by CARES) [10]</td><td colspan="2">3m extra</td></tr>
<tr><td>Renewable Hydrogen & Fuel Cell Support Scheme [11]</td><td colspan="2">1.5m</td></tr>
<tr><td>Scottish Biomass Heat Scheme [12]</td><td>April 2009- March2011</td><td>3.3m</td></tr>
<tr><td>Scottish Ministers' Wave and Tidal Energy Support Scheme [13]</td><td colspan="2">13m</td></tr>
<tr><td>England Regions Regional Development Agencys (RDAs) [3]</td><td>2004-2007</td><td>59m</td></tr>
<tr><td>Big Lottery Fund</td><td>Community Sustainable Energy Programm [14]</td><td></td><td>9m</td></tr>
<tr><td rowspan="3">ROC expenditure [15]</td><td rowspan="3"></td><td>2005-2006</td><td>583.00 m</td></tr>
<tr><td>2006-2007</td><td>718.97 m</td></tr>
<tr><td>2007-2008</td><td>876.41 m</td></tr>
<tr><td>EU FP [16]</td><td>For 7 years (2007-2013)</td><td colspan="2">At least 2.4 billion Euros</td></tr>
</table>

Sources:

[1] DTI Department report 2006-2007, http://www.berr.gov.uk/files/file40578.pdf
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[4]http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk//energy/sources/renewables/business-investment/funding/marine/page19419.html
[5] http://www.lowcarbonbuildingsphase2.org.uk/page.jsp?id=33
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[12] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/19185/20805/BioSupport/BioSupportIntro
[13] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/19185/20805/WTSupportScheme/WTSupportSchemeIntro
[14] http://www.communitysustainable.org.uk/
[15] This is the buy-out price multiplied by the size of the obligation. Source: Ofgem
[16]http://www.berr.gov.uk/energy/sources/renewables/policy/european/funding/page23713.html