Policy Exchange

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Fuelling Transition

Prioritising resources for carbon emissions reduction

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Executive Summary

A key argument made against allowing the market to invest in gas generation, even subject to the ETS carbon cap, is high future costs of retrofitting gas generation with carbon capture and storage or prematurely retiring plants in order to meet required future emissions reductions. This research note makes no assumption that retrofit CCS will be an economic option for retrofitting gas generation built in the next decade or so. Instead, we analysed the costs of building and then retiring gas generation ahead of its natural lifetime, and compared these to the marginal alternative new generation investment.

This research note concludes that, to achieve maximum overall emissions reduction and low carbon innovation, the electricity market needs to be allowed to invest in gas as a transition fuel, subject to a long-term EU emissions cap. The cap will ensure that EU emissions will be no higher as a result. Even if the emissions cap meant that such generation needed to retire early, it would still be likely to be far cheaper than the alternatives.

For example, if the market decided to bring forward gas generation instead of 4 GW of the government's planned 2020 deployment of Round 3 offshore wind *and retired that gas generation early*, we may be able to save around £700-900m a year (based on cost assumptions from reports for DECC). A huge investment in 9 GW of offshore wind by 2020 would still remain. With these savings we could instead:

- buy and retire sufficient carbon permits each year to reduce emissions by *six times* as much as the 4GW of offshore wind; and
- *double* public funding for research, development and demonstration in the key low carbon technology sectors identified by the Committee on Climate Change; as well as
- insulate 360,000 more lofts each year.

The opportunity costs of subsidies for UK Round 3 offshore wind are therefore huge, and we need a proper debate about the right levels of deployment of such very expensive technologies, limiting and allocating our scarce resources accordingly.

The Netherlands has already (without renegotiating its ambitious contribution to the EU Renewable Energy Target) capped its subsidies for renewable energy, allocating resources to deployment of the most cost-effective technologies.

Recommendations

To achieve maximum overall emissions reduction and low carbon innovation, the electricity market needs to be allowed to invest in gas as a transition fuel, subject to a long-term EU emissions cap.

To facilitate this, the government needs to scale back plans for 2020 deployment of the most expensive generation technologies, and the associated subsidies through the Renewable Obligation and proposed new Feed-in Tariff Contracts for Difference.

The opportunity costs of subsidies for Round 3 offshore wind are huge, and we need a proper debate about the right levels and rate of deployment of such very expensive technologies.

Introduction

Decarbonisation

This is a research note about prioritising the resources available in order to maximise the likelihood of securing the carbon emissions reductions that the scientific consensus says are required to mitigate the risk of dangerous climate change. A key focus of this note is on decarbonising the UK electricity sector.

There is a wide range of, existing and potential, technologies that could contribute to emissions reduction. We cannot know which technologies will make the most significant contributions to emission reduction in 2050, nor what the relative mix of technologies should be along the way.[1] *How* we decarbonise – the processes and trajectory we follow – are critically important. Decarbonisation has the potential to be expensive. Processes for identifying and selecting low carbon technologies, and for determining the order in which they are deployed, will have a big effect on these costs. The lower we can make the costs of the decarbonisation process, the more likely it is that the effort can politically be sustained (both in the UK and other countries), to deliver the challenging long-term emissions reductions required. Minimising the costs of emissions reduction will depend on continually stimulating and exploiting new *information* about technology options and costs, and the technologies themselves.

[1] Policy Exchange, 2011, *2020 Hindsight: Does the renewable energy target help the UK decarbonise?*

Electricity decarbonisation

The electricity sector provides opportunities for relatively cost-effective emissions reductions in the early stages of the economy's decarbonisation, and current knowledge strongly suggests that, in time, the supply of electricity in the UK will need to be virtually zero carbon. But there are substantial unknowns about the best route for getting there.

Under current knowledge, there is considerable uncertainty about the optimal mix of UK generation technologies, and about the optimal trajectory of UK electricity's overall contribution to UK, EU and global emissions reduction. Any attempt to identify the optimal approach must include the concept of opportunity cost. In other words, resources spent on reducing UK electricity emissions now cannot also be spent stimulating other, or longer term, low carbon innovations.

Moreover, the optimal path of the UK electricity sector will only be revealed over time. It will depend on emerging information about:

- the relative future costs of different electricity emissions reduction *technologies*;
- the relative future costs of emissions reduction between different *countries*' electricity sectors, in particular EU countries' sectors which are all subject to the same EU Emissions Trading System (ETS) carbon cap;
- the relative future costs of emissions reduction between electricity and other *sectors*, such as heating and transport; and
- the relative future costs of emissions reduction between the *short and longer terms*.

Policy approaches

The ETS caps emissions, issuing carbon permits and allowing those permits to be traded. Its characteristics – being technology neutral, and covering thirty countries, a range of sectors and an extended time period – enable the market to reveal, transmit and respond to emerging information of the kind listed above. By doing so, it achieves cost-effective – and virtually guaranteed – decarbonisation.[2] Policy Exchange has argued, in *Gas Works? Shale gas and its policy implication* (2012), that the ETS could be improved by setting a much longer-term, more certain cap (out to least 2035, with effective banking and borrowing), consistent with climate science.[3]

Clearly a carbon pricing framework, whether through the ETS or another approach, is not the full answer to emissions reduction. As the Stern review argued, there are also important roles for government in stimulating technological innovation, and addressing behavioural barriers, for example, to energy

[2] There are ongoing debates about the relative practical merits of cap-and-trade versus carbon tax mechanisms as a method of enforcing credible long-term carbon pricing.
[3] Policy Exchange (2012) *Gas works? Shale gas and its policy implications*

efficiency. As part of this, there is an important place for subsidies for the early deployment of promising, but still expensive, low carbon technologies that would not be brought forward by investors incentivised only by a an effective long-term carbon pricing framework. There is an important debate to be had about how to get the best value from such subsidy policies and avoid wasting substantial resources. This includes debate about:

- the proportion of available resources, of the market, that should be devoted to such subsidised expensive generation technologies,
- how to select technologies for such subsidy, and
- how to design such subsidies so that they stimulate maximum learning.

Policy Exchange has previously discussed a number of these issues,[4] and has argued that, at present, this important debate is undermined by the arbitrary 2020 Renewable Energy Target, which distorts both technology support choices and market choices, and wastes resources, delivering little or no additional emissions reduction.

Much of Policy Exchange's work in this area is part of an important debate in climate policy between those whose focus is on developing carbon pricing to steer and exploit the power of markets, and those whose focus is on emissions reduction through administrative subsidies for technology-specific low carbon deployment. At the same time, both camps agree on the importance of support for research, development, demonstration and learning by doing in relation to promising new low carbon technologies. (Nor is acceptance of the urgency of addressing climate change a differentiating factor in this debate.)

Policy debate on gas as a transition fuel

This research note focuses on one specific element of this broader policy debate. This relates to the degree to which markets, subject to an effective emissions cap (or other emissions pricing framework), should be allowed to bring forward *lower* carbon technologies – principally gas generation – as a relatively cheap 'transition fuel' on the way to zero carbon electricity. It looks at the risks and benefits of allowing a substantial transition fuel, including how allowing a transition fuel could improve allocation of decarbonisation resources.

Gas Lock-in?

Policy Exchange argued in *Gas works? Shale gas and its policy implications* (2012) that allowing the market flexibility to exploit gas generation – the event of any relatively cheap (shale) gas future – could deliver not only economic but also environmental benefits. In the event that gas could be exploited as a

[4] Policy Exchange (2011) *Climate Change Policy – Time for Plan B*

relatively cheap transition fuel, it would free up resources that could be used to stimulate innovation in promising zero carbon technologies that will be needed to meet 2050 carbon goals. But Policy Exchange argued that, to secure this combination of economic and environmental benefits, reform of the ETS was a priority. Provided a long-term, certain emissions cap was in place (or adequate other approach to carbon pricing) then (a) gas generation would be brought forward only to the extent consistent with the carbon cap, and (b) reduction of the carbon cap or target over time would ensure that *unabated* gas was indeed a *transition* fuel. An effective cap would ensure that excess unabated gas generation would need to be retrofitted with carbon capture and storage, to be used only at times of peak demand or to back up for intermittent renewables, or to be retired early.

However a key strand of opinion argues for additional policies, over and above carbon capping, to restrict new gas generation or promote alternatives. A key argument put forward is the risk of 'lock-in' to gas if substantial additional new gas generation is built over the next decade.[5] The government's, and some EU, policy settings appear strongly influenced by this view.[6] A range of regulation and subsidy policies are in place or planned to deliver a desired overall generation mix in the UK by 2020 and 2030 (including through the EU Renewable Energy Target and the UK's Electricity Market Reform). Arguments for such policies include concerns that the market ETS outcome would:

1. not be consistent with a target for UK electricity decarbonisation in 2030 of 50g or 100g of CO_2 per KWh;[7]
2. fail if the ETS were insufficiently effective or ceased to exist;
3. be inconsistent with security of energy supply;
4. be more expensive, as a result of high future gas prices;
5. make it more likely that the emissions cap would be relaxed in future to accommodate the higher the number of gas generators' needs;
6. not allow sufficient stimulation of innovation and development of zero carbon generation technologies; and
7. lead to unacceptably expensive future needs for retrofitting carbon capture and storage or early retirement of gas generation.[8]

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[5] Green Alliance (2011) *Avoiding gas lock-in: Why a second dash for gas is not in the UK's interest*
[6] Despite the UK government's recent announcement that the proposed Emissions Performance Standard would be set at a level that would not bite on gas generation until at least 2045, other more important policies persist.
[7] DECC (2011) Electricity Market Reform White Paper: *Planning our electric future: a white paper for secure, affordable and low-carbon electricity*
[8] Green Alliance (2011) *Avoiding gas lock-in: Why a second dash for gas is not in the UK's interest*

This research note briefly addresses arguments 1-6, referring to relevant material from previous Policy Exchange research reports, then focuses on argument 7.

1. Consistency with UK electricity sector emissions reduction targets

The relevant concern is that the ETS emissions cap will not be sufficient to meet goals for decarbonisation of the *UK* electricity sector by 2030. The Committee on Climate Change (CCC) has argued for no more than 50g of CO_2 per KWh in UK electricity in 2030. DECC, in modelling of scenarios for Electricity Market Reform, has assumed a need to meet 100g of CO_2.

It may be that a combination of future carbon prices under the EU emissions cap and gas wholesale prices will lead to UK electricity generation in 2030 at less than 100g or 50g of CO_2 per KWh. But if gas prices follow a lower trajectory, and markets therefore exploit gas generation to greater extent, would that be a problem for overall emissions levels? It is very hard to see that it would be, provided an overall emissions cap remained in place.

While there is an EU emissions cap covering electricity emissions, actions by the UK unilaterally to meet tighter electricity emissions reductions make no difference to atmospheric emissions. Lower emissions in the UK would enable higher emissions elsewhere in the EU, with no benefits for the climate.

The CCC made its recommendation for no more than 50g of CO_2 per KWh in UK electricity in 2030 because its objective is to advise on achieving decarbonisation in the UK alone, rather than overall atmospheric emissions. The CCC has also necessarily based its advice on assumptions about the future, including future technology costs. However given the scale of unknowns about the future it makes sense to try to design policy based on fewest possible assumptions about the future that may turn out to be wrong. The ETS cap is closest to such a policy. By covering a number of countries, sectors and years into the future, it makes minimum assumptions and provides flexibility about when and where emissions reductions are made. If instead, we base policy on a narrowly focused national, sectoral, timed target in the tradable sector (based on current necessarily-limited information) we deliver no additional carbon reduction and substantially increase costs.

2. A weak or non-existent Emissions Trading System in future

Policy Exchange has argued that the ETS needs to be improved and particularly that there needs be longer term certainty about the ETS cap. But if that improvement did not happen, is there not a case for additional UK policies as 'back-up'?

While the ETS exists, even if sub-optimal, then additional UK 'back-up' policies, aimed at reducing emissions in the near-term in the tradable sector will have no effect on atmospheric emissions. These are determined by the carbon cap across the EU. Such UK policies, if more expensive than the permit price, simply raise the cost of achieving the same level of emissions reduction. They also tend to reduce the permit price, thus further weakening the ETS.

However, if the ETS actually ceased to exist, then alternative policies, whether a carbon tax, stronger Emissions Performance Standard or other approach, would have a real impact on atmospheric emissions. In developing alternative policies, the UK would need to give careful consideration to the appropriate level of ambition given the then prevailing EU ambition.

Therefore 'back-up' policies can be justified if they are contingent on the ETS ceasing to exist. But the effect of introducing such contingent policies could be to further weaken confidence in the ETS. While no decision is taken to abolish the ETS, the policy priority must be to strengthen it. Keeping it, while weakening it, for example with additional technology-specific deployment subsidies, is a very poor policy approach.

3. Consistency with energy security of supply

The relevant concern is that the UK could become over-reliant on increasingly imported gas, subject to the world wholesale gas price. Policy Exchange discussed the issues around security of UK gas supplies in *Gas works?* (2012).

In summary, the liberalised UK gas market has no difficulty attracting supplies from a diversity of sources in other parts of the world as a result of a recent massive increase in UK Liquid Natural Gas import infrastructure. In the event that one supplier proves to be unreliable, or is forced offline, others (potentially boosted by shale gas developments) can fill the gap. Indeed, exports of gas *from* the UK increasingly challenge other sources of imports into continental Europe.[9]

So the UK market has no difficulty attracting gas supplies for a price. But it is this uncertain – volatile – price, not security per se, that unnerves politicians. Are the risks from gas price volatility a reason to justify additional regulation to reorient electricity generation away from gas? It is far from clear: that any policy can avoid UK exposure to gas price movements for next couple of decades; that volatility is more economically costly than the high-cost policy alternatives; that customers prefer stable but high prices to low but more volatile ones; or that customers are unable to contract to reduce price volatility (fix their prices) more cheaply than through regulation.

4. Consistency with forecasts of high future gas prices

The relevant concern is that future world gas prices will be high, so that allowing the market to build gas generation will turn out to be expensive.

Again, this issue was discussed at length in *Gas works?* (2012). Nobody knows what future gas prices will be. Market players have incentives to respond to emerging information about possible future gas prices, and may respond on an ongoing basis by shifting the planned mix of their generation portfolios. But if instead policy settings are based on expectations of (high) prices, it is effectively gambling with bill-

[9] Pierre Noël (2011) *Gas Supply Security Policy*; Presentation to EPRG Conference; London; 23 September

payers' money. Peter Atherton of Citigroup has said the "Government is taking a massive economic bet that fossil fuel prices rise forever."[10]

Moreover, DECC's 2011 central gas price projections are for barely any rise by 2030. DECC places gas prices in 2030 at only 11% higher than 2011. (Since 2010, when DECC's 2030 projection for gas prices was 21% above 2011 prices, expected future gas prices have moderated substantially, including as a result of shale gas developments.)

5. Risk of future gas generators successfully lobbying for relaxation of the emissions cap

The concern here is that, if there were greater quantities of gas generation, there would be a more powerful future lobby for relaxing emissions targets and the ETS cap.

However, the EU has demonstrated its ability to require generation to close ahead of its natural lifetime, through the Large Combustion Plant and Industrial Emissions Directives. These Directives were of course subject to heavy coal generator lobbying and associated adjustment, but nevertheless have had impact. It seems reasonable to expect that the gas generation lobby would be weaker in relation the ETS because gas generation represents only a minority of companies affected – negatively or positively – by the ETS. Making a firm, long-term EU agreement to the ETS cap level *now* (as Policy Exchange has recommended) would help to head off future scope for lobbying.

Moreover, we should recognise that it is combined lobbying *across the EU* which impacts the ETS cap. There is no reason to expect that policies with the effect of restricting *UK* gas generation investment would affect the overall scale of EU gas generation – and thus the size of the EU gas lobby. This is because – under the ETS – lower UK tradable emissions as a result of unilateral UK policy will be offset by increased emissions elsewhere in the EU, quite likely involving gas.

Perhaps most importantly, lobbying for relaxation of emissions targets could arise in a range of ways. In fact, the more expensive it turns out to be to meet emissions targets, the more likely that energy consumers and governments will want to relax the emissions cap. So allowing the market to exploit gas as a relatively cheap transition fuel would appear likely to help sustain emissions reduction efforts.

6. Consistency with developing zero carbon generation technologies

As discussed earlier, policies to promote low carbon innovation, including subsidies for early deployment of promising technologies, are an important part of the policy mix. There should be substantial investment in a range of promising renewable and other low carbon technologies. There is an important debate to be had about the right allocation of resources to such policies.

But these policies need to be clearly distinguished from policies intended to target a planned outcome

[10] Peter Atherton (2011) *Where will the famous £200 billion come from?",* Citigroup presentation at National Grid conference, July 2011.

for the overall generation mix, such as the 2020 Renewable Energy Target (RET). This target is a poor way to prioritise resources for innovation:

- Instead of stimulating learning in a full range of diverse low carbon technologies, the RET leads to resources being disproportionately targeted on renewable energy.
- Within a diversity of supported technologies, the priority for resources should be those thought most likely at the time to become cost-competitive in future. Instead the RET ensures the priority is those technologies deployable at scale in the short term.
- Innovation support should target those technologies with most potential for *global* deployment, because the reason for climate policy is to reduce global carbon emissions. But the RET drives prioritisation of most *domestically* deployable technologies, such as offshore wind.
- Policy should maximise learning gained from the money spent. This should include ensuring a proportionate rate of deployment of still very expensive technologies (learning needs time to accumulate over successive generations of deployment). It should also mean the right balance between research, development and demonstration, on one hand, and 'learning by doing' through subsidised deployment, on the other. But the RET drives a disproportionate focus on very rapid large-scale deployment to meet the target.
- Innovation necessarily involves failures, from which we also learn. Deployment subsidies for a particular technology therefore need clear criteria for success, to identify when the subsidies should be renewed or curtailed for reprioritisation to other technologies. If a technology's costs are not falling fast enough, then it cannot be allowed to use up a disproportionate amount of the climate policy resources available. But the RET encourages the government to keep on funding a technology, almost regardless of its cost reduction progress, if it is the only way to meet the target.

The Costs of Retiring Gas Generation Early

"The more unabated gas plants are built between now and 2020, the greater the likelihood that electricity consumers will have to pay either a) to increase subsidy for existing gas plants by increasing the number of contracts to retrofit CCS, or b) to absorb the cost, through higher bills, of prematurely retiring unabated gas plants built in the 2010s. ...Current and planned gas capacity will either lock the UK into high carbon levels, or result in gas power station investments of up to £10 billion being retired early or needing costly CCS retrofit."

Green Alliance, *Avoiding gas lock-in: Why a second dash for gas is not in the UK's interest* (2011)

A key argument made against allowing the market to invest in gas generation, even subject to the ETS carbon cap, is high future costs of retrofitting gas generation with carbon capture and storage or prematurely retiring plants in order to meet required future emissions reductions.

Carbon capture and storage (CCS) may develop in future such that it can be retrofitted cost-competitively in the relevant time period. But, as in many other areas, there is considerable uncertainty about this. The Green Alliance also rightly makes the point that not all new gas plants are being built near potential carbon storage sites, therefore increasing the cost of any future retrofit.[11]

This research note makes no assumption that retrofit CCS will be an economic option for retrofitting gas generation built in the next decade or so. Instead, we analysed the costs of building and then retiring gas generation ahead of its natural lifetime, and compared these to the marginal alternative new generation investment.

Analysis of early retirement costs

Round 3 (R3) offshore wind (i.e. in deep water) is essentially the marginal generation technology, since it is the most expensive which the government plans to build at scale. This analysis asks the question: Would there be savings from switching a few Gigawatts of the planned R3 offshore wind roll-out to gas generation *if the additional gas generation had to be retired early, as a result of the EU emissions cap?*

Clearly, there could also be significant savings from switching some planned R3 offshore wind, not only to gas, but also to onshore wind or some other types of low carbon generation. However, the main reason for the government's ambitious plans for R3 offshore wind are non-financial barriers to short-term deployment of other low carbon / renewable technologies, such as planning constraints on onshore wind. If such barriers could be alleviated, then the market would have wider investment options for low carbon generation investment. Policy Exchange has discussed how such planning

[11] Green Alliance (2011) *Avoiding gas lock-in: Why a second dash for gas is not in the UK's interest*

barriers might be addressed in previous reports.[12]

We compared costs of generation using assumptions about 'levelised costs' (see Box 1). We focus in this analysis on the period 2015-2020, when a large quantity of R3 offshore wind is planned to be built to meet the 2020 renewable energy target. Table 1 sets out our assumed average levelised costs for generation built in this period.

Box 1: Levelised costs assumptions

Levelised costs combine assumed capital and operational expenditure, including fuel and carbon costs, discounted over time, and expressed as a flat per MWh cost of generation. The assumed operational lifetime of the generation plant determines the period over which costs are smeared. Levelised costs do not take into account impacts on the wider electricity system, such as additional reserve and balancing requirements, so do not reflect the full costs particularly of intermittent wind generation.

Levelised cost assumptions from a number of sources (Mott MacDonald (2010), Parsons Brinckerhoff (2011) and Arup (2011)) are set out in Table 1. It is assumed that plant life is 22 years for R3 offshore wind and 30 years for a Combined Cycle Gas Turbine (CCGT).[13]

The levelised costs depend on when plant is built. For example, R3 offshore wind levelised costs are assumed to fall from around £190 per MWh to £173 per MWh for projects starting in 2017 and perhaps £145 per MWh for projects starting in 2020. The government has established an industry Task Force to set out a path and action plan to reduce the costs of offshore wind (overall) to £100 per MWh by 2020. (Mott MacDonald's 2011 report,[14] gives lower estimated levelised costs for offshore wind of £169 per MWh in 2011 (and projections for £103-114 per MWh by 2020). However, this figure is for relatively shallow water offshore wind, and therefore not the marginal (highest price) R3 offshore wind generation that would be displaced by alternative new generation.)

There is considerable doubt about whether projected R3 offshore wind cost reductions will be achieved, particularly as Arup notes: "For Round 3 offshore wind there are significant challenges in deploying in often deeper water further from shore" and little learning by doing will occur until the first significant R3 deployments are completed from around 2015. The government's aspiration is particularly challenging and its recent increase in the post-2015 subsidy for offshore wind, in the Renewable Obligation banding review, did not suggest confidence in meeting it. (Of course, if the costs of Round 3 offshore did fall very significantly, and were close to the target of £100 per MWh, they would offer an option which was competitive with gas generation without the need for the large additional subsidy under current

[12] Simon Moore (2011) *2020 Hindsight – Does the renewable energy target help the Uk decarbonise?* Policy Exchange. Alex Morton (2011) *Cities for Growth,* Policy Exchange.
[13] Arup (2011), Study Report for DECC, *Review of generation costs and deployment potential of renewable electricity technologies in the UK.* With a range from £225/MWh to £168/MWh.
[14] Mott MacDonald (2011) *Costs of low-carbon generation technologies*, for the Committee on Climate Change.

government policy.)

We have used the Mott MacDonald (2010) projected cost reductions in R3 offshore wind (broadly consistent with Arup (2011)), and projected cost increases in CCGT.

Table 1: Levelised cost assumptions

	Levelised costs for full plant lifetime (£/MWh)	
Source of assumption (year of project)	**R3 offshore wind**	**Unabated gas generation CCGT**
Mott MacDonald (2009) [15]	190.5	80.3
Parsons Brinckerhoff (2011) [16]		76.6
Mott MacDonald (2013)	174.6	86.7
Arup (2015) [17]	192	
Mott MacDonald (2017) [18]	172.9	96.5
Arup (2020) [19]	145	
PX assumption for period 2015-2020	**173**	**97**

The first part of answering our question above was to estimate the additional cost of retiring a CCGT early: What would be the additional cost if a gas generation plant built in the next decade was forced by the EU emissions cap to retire early after 22 years, 15 years or 10 years? We estimated revised CCGT levelised costs very simply: by smearing the upfront capital costs over the assumed shortened lifespan of the plant. The shorter the assumed plant lifespan, the higher the levelised cost, since the capital costs are allocated to a smaller number of MWh.

Table 2 sets out estimated capital and operational costs of a CCGT, with those for R3 offshore wind set out for comparison. It should be noted that the upfront capital costs for a CCGT are a very small fraction of R3 offshore wind capital costs, both in absolute terms and as a proportion of total levelised costs.

[15] Mott MacDonald (2010) *UK Electricity Generation Costs Update*. Mott MacDonald's 2011 report *Costs of low-carbon generation technologies*, for the Committee on Climate Change, does not separately identify costs for Round 3 offshore wind.

[16] Parsons Brinckerhoff (2011) Report for DECC, *Electricity generation Cost Model – 2011 Update Revision 1.* With a range from £45/MWh to £100/MWh

[17] Arup (2011)

[18] Mott MacDonald (2010)

[19] Arup (2011). Assumes a 12% annual reduction in costs.

Table 2: Levelised costs breakdown between capital and operational costs[20]

	2017 project start (£/MWh)	
	Gas CCGT	**R3 offshore wind**
Capital costs	11	127
Fixed and variable operating costs	6	46
Fuel costs	50	0
Carbon costs	30	0
Total levelised costs	**97**	**173**

We made a number of simplifying assumptions, discussed in Box 2. These assumptions were considered acceptable for the purposes of our rough-and-ready examination of the costs of retiring gas generation early. Given the scale of the estimated cost advantage of gas compared to R3 offshore wind, even with early retirement, our general conclusions are not dependent on the precision our estimates. Indeed, the analysis is likely to be significantly biased against CCGTs in one particularly important respect. Back-up will be required for the vast majority of wind capacity (the 'capacity credit' for wind is only around 10-20% at high wind penetration)[21]. It would almost therefore be justifiable to compare CCGT operational costs *alone* with *total* costs of R3 offshore wind, because CCGT *capacity* will be needed on the system regardless of whether or not wind is built.

Box 2: Simplifying assumptions

In practice, the effect of the emissions cap biting would be likely to drive gas generation from 'mid-merit' to 'back-up' in the electricity market, in a process of steps towards retirement, rather than an abrupt closure. With increasing intermittent generation in future, gas generation may be able to run profitably on relatively few hours a year backing up low wind periods. Our analysis is therefore a considerable simplification from the real world.

Our analytical approach also makes a number of other simplifying assumptions, including:

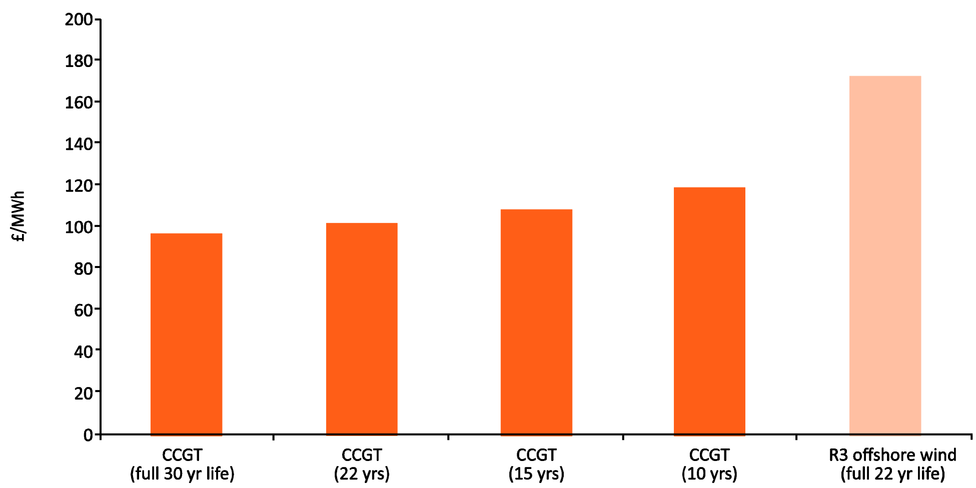
- the trajectory of operational, fuel and carbon costs a shortened lifespan CCGT is the same (pro rata) as for a 30-year full life CCGT;
- the trajectory of annual operational hours for a shortened lifespan CCGT is the same (pro rata) as for a 30-year full life CCGT; and
- the CCGT discounted operational cost per MWh does not vary significantly between a plant's early and late life.

[20] Mott MacDonald (2010)
[21] House of Lords Economic Affairs Committee (2008) *Fourth Report: The economics of renewable energy.*

These assumptions are unlikely to be precisely correct. For example, if a plant retired when still relatively young, then its average operational costs per MWh, would be likely to be lower than full lifetime average operational costs. Operating hours of a plant will tend to decline towards the end of its life, as it becomes relatively less efficient and as the proportion of intermittent generation increased.

Chart 1 sets out our (rough-and-ready) results for the increased levelised costs of a CCGT under different assumptions about shortened plant life. These were calculated simply by recovering upfront capital costs over a shorter number of years than the full 30-year lifetime. The levelised cost of a CCGT with an expected 22 year lifespan is £101/MWh; with 15 year lifespan £108/MWh; and with 10 year lifespan £119/MWh.

Chart 1: Estimated 2015-20 levelised costs of CCGT with a range of assumed lifetimes



This analysis suggests that the additional levelised costs of early retirement of gas generation are modest, because of low upfront capital costs are compared to other types of generation. It is likely to be much cheaper in the next decade to build gas generation *and retire it well ahead of its full lifetime* than to build R3 offshore wind.

A Policy Proposal

The Department for Energy and Climate Change (DECC) plans the deployment of between 13 GW and 18 GW of offshore wind by 2020, as part of its plan for meeting the EU 2020 Renewable Energy Target.[22] That would be likely to include between around 8 GW and 13 GW of R3 offshore wind. The Committee

[22] DECC (2011) *UK Renewable Energy Roadmap*

on Climate Change (CCC) recommended that, unless there was clear evidence of cost reduction, the UK's ambition for offshore wind should be limited to 13 GW by 2020. They also said that, given high costs, there could be a case for slight moderation below that level, but fell short of recommending reduction of the 2020 ambition for offshore wind at this point.[23]

Given the findings of this research note, there appears to be a strong case for moderating the government's plans for R3 offshore wind. There is certainly a case for continuing to build some R3 offshore wind, in order to promote learning about deployment in deep water, and to identify whether and how fast costs might approach cost-competitiveness with other technologies. This research note has not undertaken the analysis needed to determine precisely the right level of R3 offshore wind investment. It simply tries to inform debate about that, by exploring the opportunity cost of subsidising large-scale R3 offshore wind deployment this decade.

We model an example of halving the 2020 ambition for R3 offshore wind, substituting gas generation for around 4 GW of planned wind (assuming that investors saw returns on such gas generation investment as consistent with the evolving ETS emissions cap).[24] This example would alter plans relating to less than 4% of the expected total UK generation capacity in 2020.[25] There would still be a substantial 9 GW of offshore wind installed, including 4 GW of R3 offshore wind, by 2020.

Furthermore, we assume that the additional gas generation would need to be retired early. If we assume that the gas generation retired at the same 22 year lifespan as the planned offshore wind it replaces, then our rough-and-ready estimate is that over £8.5 billion (NPV at project start[26]) would be saved compared with current plans.[27] If the gas plant was retired after only 15 years, we estimate savings of around £6.5 billion over the 15 years; for 10-year gas plant the saving would be around £4.5 billion over 10 years. These are broadly equivalent to savings of £700-900 million a year (using a 10% discount rate).

Box 3 briefly discusses the relationship between these cost-based estimates for savings, on the one hand, and investment decisions and prices.

Box 3: Real-world market investment decisions and prices

The analysis in this research note is based on the relative costs of generation technologies, not on a market analysis.

In the real-world, investors make decisions to invest based on expectations about returns on their

[23] Committee on Climate Change (2011) *The Renewable Energy Review*
[24] Assuming the lower end of the government's overall ambition for total offshore wind of 13 GW
[25] Assuming electricity consumption of 335 TWh 2015-2010
[26] At 10% discount rate, as used in Mott MacDonald (2010).
[27] Assumes average availability of R3 offshore wind of 95%, load factor of 39%, and operational hours and costs profiles pro rated from full 30-year lifetime assumptions (Mott MacDonald, 2010). This is a discounted figure, since levelised costs themselves are discounted.

investment, arising from expected usage levels and prices earned for that usage. One simple way that investment options are assessed is to ensure that the projected pay-back period of the capital investment is acceptable. In generation investments these are much shorter than the full lifetime of generation plant. A typical payback period might be 10-15 years. [28,29]

If investors' expectation was that gas generation would need to retire early, then, all other things being equal, either positive returns to investors following payback would be reduced, or the market would respond by delivering slightly higher prices (through slightly increased scarcity) – to compensate for the modest increases in levelised costs.

In practice, electricity prices and returns to gas generation over the coming decades will be heavily bound up with the wholesale gas price and with government decisions on regulated renewable energy deployment and other low carbon technologies, the shape of any new capacity mechanism, the evolution of the ETS carbon permit price and the carbon price floor.

The key point is that pursuing a less costly generation mix would reduce overall costs on the overall economy.

Box 4 briefly addresses some of the key challenges to the notion of building more gas generation (subject to the ETS), instead of some of the planned deployment of R3 offshore wind.

Box 4: Key challenges to the notion of building more gas generation (subject to the ETS)

If the market were allowed to choose gas generation rather than some of the R3 offshore wind would there not be higher emissions?

The choice this decade between R3 offshore wind and gas generation will not affect emissions levels after their (say, 22 year) lifetime. Emissions then, and in 2050, will depend on what replaces them. Nevertheless, gas generation results in more carbon emissions than offshore wind *during* its lifetime. Therefore substituting at the margin gas for offshore wind would lead to UK emissions over the period being higher than they would otherwise have been. However, overall emissions into the atmosphere would be no higher. This is because it is the EU emissions cap that determines overall EU tradable emissions. If the UK subsidised less R3 offshore wind, the ETS would identify the cheapest alternative emissions reductions across the EU's countries and tradable sectors. In addition, we need to take into account the opportunity cost of additional subsidies for R3 offshore wind – could the resources be used

[28] James Bushnell (2010) *Building Blocks: Investment in Renewable and Non-renewable Technologies,* in Harnessing Renewable Energy in Electric Power Systems, Ed. Boaz Moselle et al

[29] Giorgio Locatelli and Mauro Mancini (2010) *Small–medium sized nuclear coal and gas power plant: A probabilistic analysis of their financial performances and influence of CO2 cost*, in Energy Policy 38

to make bigger emissions reductions in some other way (see later)?

If we need to retire the gas generation early, will we not have the additional expense of replacing it with something new and low carbon – why not simply build that now?

Whether we choose to build R3 offshore wind or CCGT, we will need to replace it when it closes. For gas, it will depend when it retires. If, for example, gas generation was to retire early after 22 years, the same as the expected lifetime of R3 offshore wind, then the replacement timescale for each would be identical. We cannot know what the best replacement low carbon generation technology will be in 20-30 years time. But we would expect that the cost of building low carbon generation is likely to have fallen significantly. In any case, our levelised cost estimates attempt to capture the full costs of early retirement.

If the market were allowed to choose gas generation rather than some of the planned R3 offshore wind this decade, would that not reduce rates of learning and cost reduction in low carbon technologies?

As already discussed, rapid domestic renewable energy deployment to meet the renewable energy target is unlikely to be the best way to stimulate low carbon innovation. For R3 offshore wind in particular, it is far from clear that the costs of deepwater offshore wind can fall far and fast enough, nor that offshore wind has sufficient global potential, to justify all of the planned spending on expensive short-term roll-out. The potential for additional learning about R3 offshore wind from each additional, heavily-subsidised Gigawatt needs to be compared with alternative uses for the resources to stimulate low carbon innovation. It is not good enough simply to secure benefits: those benefits must be greater than the expected benefits of using the resources in some other way (see later).

Would building gas generation instead of some of the planned R3 offshore wind reduce the likelihood of the UK meeting the EU Renewable Energy Target?

Yes, it would reduce the likelihood. But the Renewable Energy Target is a hugely unnecessarily expensive approach to emissions reduction, damaging the prospects for sustained emissions reduction. Policy Exchange has argued for the UK government to renegotiate this target.[30] But the Netherlands has already, even without renegotiating its equally ambitious contribution to the EU target, capped its subsidies for renewable energy, allocating resources to deployment of the most cost-effective technologies.[31]

[30] Policy Exchange (2011) *2020 Hindsight: Does the Renewable Energy Target help the UK decarbonise?*
[31] Ronald Roosdorp (2011) *Renewable Energy in the Netherlands,* presentation at EPRG Spring Seminar, 13 May, Cambridge.

Alternative uses for the resources saved

If, as in the example above of allowing the market to substitute gas generation (retired early) for around 4 GW of planned R3 offshore wind, what could the average annual £700-900 million cost saving be used for instead?

It could simply be used to mitigate expected rises in energy bills. But we focus here on how it could be used to promote emissions reduction.

There are clearly a wide range of options for using the resources to stimulate low carbon innovation and to reduce emissions. These include:

a) *Increasing public sector funding of research, development and demonstration (RD&D) in relation to low carbon technologies*

The Committee on Climate Change (CCC) identified around £280 million of UK public RD&D spending in 2009/10 on technologies identified by them as relevant to emissions reduction.[32] They also showed that UK energy RD&D was low by international standards, at 0.01% of GDP in 2007 (around £150 million), compared to almost 0.02% in Germany, around 0.025% in the US and almost 0.05% in France.

So £280 million a year would be sufficient to double RD&D in the key technology areas identified by the CCC, helping to address under-resourcing of UK public sector funding of low carbon RD&D.

b) *Accelerating the roll-out of home loft and cavity wall insulation*

Under the government's current proposal for the Green Deal and Energy Company Obligation (ECO),[33] rates of take-up of loft insulation and cavity wall insulation would fall rapidly from the levels of recent years. This would leave a substantial volume of cost effective energy efficiency measures unexploited. It is estimated that there are still 6-9 million homes without full loft insulation, and 1.4-3.6 million homes with easy-to-treat cavity walls yet to be insulated. Under the government's proposals, only 0.4 million houses are expected to take up loft insulation under the Green Deal over the next 10 years (a 95% fall from the 2010-11 rate), and the rate of cavity wall insulation is set to drop by 60-70%.[34]

Europe Economics, in a report for Knauf Insulation,[35] has modelled an alternative scenario delivering an additional 3.6 million loft insulations and accelerated achievement of 2.5 million cavity wall insulations. Overall, they estimate up to 1.6 million more homes could benefits from some type of insulation (loft, solid wall or cavity) than under DECC's proposals. To achieve this, their model offers additional financial incentives under ECO, with a £1250 million cost over 10 years (with an additional estimated £6 billion in

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[32] Committee on Climate Change (2010) *Building a low carbon economy – the UK's innovation challenge: Supporting analysis and review of evidence.*
[33] DECC (2011) *The Green Deal and Energy Company Obligation consultation*
[34] Europe Economics (2012) *The Green Deal and Energy Company Obligation – Scenario Modelling of Insulation Installation: A report for Knauf Insulation*
[35] Europe Economics (2012)

benefits).

So with additional resources averaging £125 million a year we could deliver an average 360,000 more loft insulations a year, including 160,000 extra homes a year insulated in some way.

c) Retiring ETS carbon permits

Let us assume that current discussions in the EU lead to the set aside of 7-800 million permits, and this more than doubles the current permit price to 15 euros on average to 2020.[36] Even at that higher permit price, we would have sufficient left from our savings to buy and retire around 30 million carbon permits each year. This alone would be more than *six times* the annual carbon emissions saving that would have been achieved from building 4 GW of R3 offshore wind instead of gas generation.[37] And retiring permits from the ETS guarantees reduced emissions to the atmosphere, unlike UK policies to subsidies offshore wind.

In summary, with the resources saved from substituting gas generation (retiring that gas generation early) for 4 GW of planned deployment of expensive R3 offshore wind (still achieving 9 GW of offshore wind in 2020), we could:

- buy and retire sufficient carbon permits each year to reduce emissions by *six times* as much as the 4GW of offshore wind; and
- *double* public funding for research, development and demonstration in the key low carbon technology sectors identified by the Committee on Climate Change; as well as
- insulate 360,000 more lofts each year.

The focus of this research note is on exploring opportunity costs. There is a question of how, in practical terms, a saving on the planned policy levy on energy bills to fund offshore wind subsidies could be redirected to alternative uses.[38].

Recommendations

To achieve maximum overall emissions reduction and low carbon innovation, the electricity market needs to be allowed to invest in gas as a transition fuel, subject to a long-term EU emissions cap.

To facilitate this, the government needs to scale back plans for 2020 deployment of the most

[36] Reuters (2012) *Set-aside could send EU CO2 to 20 eur/t-Pt Carbon,* citing Thomson Reuters Point Carbon analysis.
[37] Assuming average availability of R3 offshore wind of 95%, load factor of 39%, and new CCGT emissions of 360g per KWh, 4GW of R3 offshore wind saves around 4.7 million tCO_2 a year compared to the alternative of new CCGT.
[38] It would be relatively straightforward to redirect policy levy resources to ECO in order for energy companies to support additional home insulations. The other options would be likely to require direct government departmental spending. If the government wished to continue to raise the funds from energy bills rather than from general taxation, then it would need to establish an energy bill levy for the purpose (or for the purpose of funding equivalent other spending such as the Renewable Heat Incentive or carbon capture and storage, as was originally planned).

expensive generation technologies, and the associated subsidies through the Renewable Obligation and proposed new Feed-in Tariff Contracts for Difference.

The opportunity costs of subsidies for Round 3 offshore wind are huge, and we need a proper debate about the right levels and rate of deployment of such very expensive technologies.

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