

CARBON CAPTURE AND STORAGE: A CONSULTATION ON BARRIERS TO COMMERCIAL DEPLOYMENT

Response by E.ON UK

SUMMARY

1. E.ON UK strongly welcomes the Treasury's interest in carbon capture and storage (CCS) and is pleased to be able to respond.
2. E.ON UK believes the UK government needs to put a framework in place to enable carbon capture and storage demonstration plants to be built today. However the demonstration of these technologies would require some form of financial support from government for such plants to operate economically in the UK electricity market. E.ON UK believes creating a suitable support mechanism to enable the first carbon capture and storage (CCS) projects should be the primary focus of this Treasury consultation.
3. The UK electricity industry requires a massive investment in capital over the coming decade to deliver reductions in carbon dioxide emissions, energy supply security and affordable prices. By 2015 we are expecting circa 5GW of nuclear and 14GW of coal and oil-fired plant will need to be replaced. Much of the new plant will need to become low or zero carbon generating plant if the UK is to make effective progress towards its 2020 and 2050 CO₂ emission reduction goals. Replacement of retiring plant by gas-fired CCGTs (Combined Cycle Gas Turbine power plant) alone would be inadequate to meet government objectives, as it would increase CO₂ emissions and increase UK dependency on natural gas.
4. A support mechanism or incentive scheme is required for CCS to overcome two specific barriers:
 - lack of sufficient confidence in the long term carbon price;
 - "first of a kind" costs, applying to this technology.
5. E.ON UK believes a support mechanism should be established to allow the first demonstration CCS projects to go ahead in the UK because they:
 - will allow a portion of new build to be low carbon, helping to meet government CO₂ objectives;
 - allow continued use of coal in a carbon constrained environment, improving security of supply and electricity price stability;

- demonstrate technology that could deliver major reductions in CO₂ emissions in the UK and globally in the longer term. The global applicability of the technology is important in persuading other countries (notably the USA, India and China) that reductions in CO₂ emissions can be affordable.
6. Significant uncertainty surrounds costs and technology options; E.ON UK therefore recommends that the incentive scheme should:
- bring a number of technologies to market, not “pick a winner”
;
 - use some level of competition to give a price-seeking element to the system;
 - be introductory in nature – to allow initial demonstration projects to come forward, without introducing a long term market distortion ahead of accurate knowledge of the costs of the technology.
7. In the long term, E.ON UK believes CO₂ emission reductions should be achieved through broad ranging market-based mechanisms such as the EU ETS; and not through technology specific subsidies, such as supplier obligations that can distort the market. The market is best placed to deliver CO₂ reductions in a cost effective way in the long term. For this reason incentives for CCS should be confined to the early projects and should not include long term supplier or generator obligations or quotas.

INTRODUCTION

8. E.ON UK strongly welcomes the Treasury's interest in the commercial barriers to deployment of carbon capture and storage (CCS) and is pleased to be able to respond.
9. E.ON UK is the second largest retailer of electricity and gas in the UK, selling to residential and small business customers as Powergen and to larger industrial and commercial customers as E.ON Energy. We are also one of the UK's largest electricity generators by output and operate Central Networks, the distribution business covering the East and West Midlands. We are also a leading developer of renewable power plant.
10. E.ON UK is part of the E.ON Group which is the world's largest privately owned energy service company. In addition to the UK, the Group has electricity and gas interests in Germany, Central and Eastern Europe, Italy, the Netherlands, Scandinavia, the United States and Russia.

CONTEXT

11. The UK electricity industry requires a massive investment of capital over the coming decade to deliver reductions in carbon dioxide emissions, energy supply security and affordable prices. By 2015 we are expecting that about 5GW of nuclear and 14GW of coal and oil-fired plant will need to be replaced
12. Much of this plant will need to be replaced with low or zero carbon generating plant if the UK is to make effective progress toward its 2020 and 2050 CO₂ emission reduction goals. While E.ON and other energy companies are already investing in renewable technologies, and are considering further CCGT construction, replacement of all closing plant by CCGTs would be inconsistent with delivery of the Government's 60% CO₂ emission cut target by 2050, given that much capacity built in the next decade is likely to be still operating in 2050. Although CCGTs plants produce significantly lower emissions than existing coal plants, they emit more CO₂ than nuclear plants and replacement of closing plant by gas-fired CCGTs would result in emissions rising from 2016 onwards, once coal-fired plant opted out of provisions of the Large Combustion Plants Directive has closed by 2015. It would also increase UK gas import dependency.
13. The future energy policy framework should allow industry to consider the widest range of options to achieve reductions in emissions and to diversify the UK portfolio of generating plant.

Investment options could include coal and gas plant with carbon capture and storage, as well as nuclear plant, renewable technologies such as wave or tidal power and the increased use of biomass. Given the scale of challenge both in the UK and overseas, it is likely that most if not all of these options will be needed.

14. Carbon capture and storage (CCS) has the potential for making a significant contribution to CO₂ emissions reduction world-wide. The large geological storage capacity offshore, coupled with its potential use in Enhanced Oil Recovery, make it particularly favourable as an option for the UK. CCS technology is also an option for the developing economies such as China or India.

RESPONSE TO CONSULTATION QUESTIONS

1.31 What are the barriers to the commercial development of CCS?

15. There is currently no mechanism within the EU ETS for crediting the plant operator with the CO₂ emissions reduction that CCS would bring about. This means the operator is not able to offset the capital costs and running costs of the additional plant required for CO₂ capture. Changes to the EU ETS to correct this anomaly are being considered by the European Commission and the UK Government should continue its active support for this. Without an accepted mechanism for the inclusion of CCS-based CO₂ reductions into international carbon frameworks such as the EU ETS or the Kyoto Flexible Mechanisms, it is unlikely that CCS technologies would be deployed on a large-scale.
16. Market based mechanisms such as the EU ETS must be the primary driver for ensuring development of low carbon technologies. However the current design of the EU ETS does not allow reliable forecasting of the long term (>10 years) value of carbon, and will therefore provide insufficient incentive for CCS, even when modified to include CCS (see paragraph 15 above). Capital intensive projects such as CCS to which the cost of carbon is so crucial will not be deployed without a firm belief in the long term value of avoiding the cost of carbon emissions. Phase 2 of the EU ETS needs to be structured to provide a transition to a more sustainable scheme under Phase 3.
17. Government also needs to introduce a market based support mechanism that incentivises the demonstration of CCS plant on a commercial scale. Many of the costs associated with the first CCS projects will be "first of a kind", with subsequent projects becoming viable without subsidy. Government should establish a

mechanism which provides support for demonstration CCS projects, but does not cause long term market distortions. Incorporating CCS into the Renewables Obligation (RO) would be unwise, as it would undermine renewable investments made on the basis of the existing framework and could substantially reduce future investment in renewable generation.

18. We include a two-page "box" giving our suggestions on what form a market-based support mechanism should take.
19. Public acceptance of CCS is required, but current awareness is low. A Government led communication process is required to establish public acceptance of CCS from the environment and safety points of view.
20. There are also legal/regulatory barriers to CCS, described in paragraphs 39.

What should an incentive scheme look like?

Because of the uncertainty on costs and technology options, E.ON UK recommends that the incentive scheme for CCS should:

- attempt to bring several technologies to market, not just one;
- use some level of competition to give a price-seeking element to the system;
- be relatively short term – to allow initial projects to come forward (to overcome “first of a kind” costs) without introducing a long term market distortion ahead of accurate knowledge of the costs of the technology;
- not be prescriptive on which technology is used.

We see the incentive scheme as a short term mechanism to overcome the two barriers of “first of a kind” costs and uncertainty in the long term price of carbon. Therefore the incentive scheme should not:

- introduce an incentive that will distort the market in the long term (once the short term barriers listed above have been overcome);
- be such that future projects (which will be cheaper once the technology is demonstrated) can compete with the first projects for ongoing subsidy (this would create a first-mover disadvantage);
- interfere with the current operation of the Renewable Obligation (for example by including CCS within the RO). This risks undermining the value of RO Certificates so deterring investment in renewable energy projects.

For all the above reasons, we do not believe a supplier obligation would be a suitable incentive mechanism for CCS.

We suggest an incentive scheme along the following lines:

1. Carbon capture and storage, together with marine, biomass and off-shore wind projects, should be defined as technologies that are currently uneconomic but have the potential to make a significant contribution to meeting the longer term energy mix. The market should be invited to tender potential development projects as part of a ‘pre-auction’ process. There would be separate tender processes for each technology type and the timing of tenders would vary depending on the level of technological development and the potential availability of commercial scale projects;

2. Projects should be short listed and invited to tender for Government support;
3. The support mechanism should involve a contractual arrangement that clearly defines the risk allocation between Government and the private sector.
4. Support could take the form of a combination of the following:
 - A carbon contract (£/t CO₂) in which the operator is paid for the CO₂ emissions avoided compared to a benchmark new build technology (most likely conventional gas-fired CCGT). This would most likely take the form of a contract for differences between the carbon price fixed in the contract, and the market price for carbon each year delivered by the EU ETS. This would transfer the carbon price risk from the operator to the Government;
 - Electricity price subsidy (£/MWh) for the low carbon electricity generated;
 - Capital grants;
 - Increased carbon permit allocation (over and above the new build allocation for conventional plant), although to be significant this would need to extend into Phase 3 of the EU ETS which is not yet well defined;
 - Tax incentives. The system of enhanced capital allowances should cover all the generation assets associated with CCS projects since project is demonstrating technology integration more than novel components. In addition, the arrangements under which exploration and appraisal costs incurred by the oil and gas industry are included within "research and development" for the purposes of the 100% capital allowances available for capital expenditure on R&D, should be extended to costs incurred at similar stages of the development for low carbon generation projects. These costs would for example be those incurred after a potential site has been identified but before the decision has been made to go ahead with the investment, where further research is needed to determine whether geological or geographical features of the site make it a suitable location;
 - Granting of climate change levy exemption certificates as currently available to CHP plants (although for this support

to have a substantial impact, the climate change levy would need to be extended beyond 2013).

For CCS projects, the funds could be raised from the hypothecation of receipts from sales of emission permits under Phase 2 of the EU ETS (either through auctioning by Government or mandating sales of a proportion of permits allocated). For renewable energy projects such as marine or off-shore wind, other sources (such as from NFFO auction receipts) are also available.

1.32 a, What CO₂ savings could be delivered by CCS, and how do these savings vary between different options for deployment, different fuels, and different kinds of technology at each stage of the CCS process?

21. CCS technologies can be applied to power generation from coal, gas and other fossil fuels. This means it could potentially be fitted to every fossil fuel power station in the UK, securing significant emissions reductions. However because CCS has a high capital cost, adoption becomes increasingly financially onerous as the load factor of a plant decreases. CCS would be most plausible for new base load plant, located near a carbon storage site.
22. Two fundamental technology options are ready for full scale demonstration; pre-combustion and post-combustion carbon capture. Both technologies can deliver circa 90% CO₂ reduction (based on new build) over conventional plant and a full scale demonstration using either technology could be built now. This could be retro-fitted to existing plant or new build. The technologies are described in more detail in response to question 1.34a.

1.32 b, Can the life-cycle CO₂ savings be estimated comparably with those of other technologies? And how do the potential CO₂ savings compare with other options for reducing carbon emissions?

23. The estimated life-cycle emissions of different technologies are dependent on fuel source not just from operation but also those used during manufacture, construction and decommissioning. The table below shows estimated ranges for different technologies based on historical studies.

| Technology (2005-2010) | gC/kWh | Equivalent to gCO ₂ /kWh |
|---------------------------|--------|-------------------------------------|
| Lignite | 228 | 836 |
| Coal (without CCS) | 206 | 755 |
| Natural Gas (without CCS) | 105 | 385 |
| Biomass | 8-17 | 29-62 |
| Wind | 3-10 | 11-37 |
| Nuclear | 3-6 | 11-22 |

Source: OECD Nuclear Energy Agency

We are not aware of studies assessing the life-cycle emissions of coal and CCS. However, the majority of emissions arising from fossil fired plant arise during operation. Considering emissions during lifetime operation gives a similar ranking to the above and allows inclusion of CCS technologies, providing a simplified comparison of fundamental technology options:

| Generation Type | CO₂ emissions g/kWh |
|------------------------|---------------------------------------|
| Coal (supercritical) | 710 |
| CCGT | 370 |
| Coal+ CCS | 90 |
| CCGT+ CCS | 40 |
| Wind | 0 |
| Nuclear | 0 |

24. Some carbon dioxide emissions are to be expected during operation of CCS plant because the capture process will not be 100% efficient. Its precise efficiency will be a matter for cost optimisation.

25. Carbon savings must be measured relative to an alternative. In the short term the dominant technology deployed for new generation will be CCGT. So CCS may be expected to save about 280 g/kWh fuelled on coal or about 330 g/kWh on gas.

1.34 a, What are the different technological options currently available and in development for each stage of the CCS process – and what are the costs of these options?

26. There are currently no large scale power generation projects incorporating carbon capture and storage. The technology is therefore poorly optimised and the costs are not well understood – and this is expected to remain true until a number have been built (probably greater than 10 worldwide). There are consequently quite a range of technology options, all with uncertain costs, and all of which could become the cheapest option. At this stage, it is therefore unhelpful to attempt an accurate ranking of technology options on cost grounds.

27. In broad terms, the main technology options for carbon capture are as follows:

- **Post-combustion capture – in which the CO₂ is extracted from the flue gas.** The best proven technology for this is amine scrubbing, although previous applications

have focused on high purity CO₂ (eg. for the food industry) rather than high capture performance. For coal, the existing plants are an order of magnitude smaller than would be required for full scale CCS. Nevertheless plant could be built now, though with significant "first of a kind" technical risks. Considerable effort is underway to improve amines and test them on coal-derived flue gas. The technology risk for post-combustion amine scrubbing on natural gas is lower, but the efficiency penalty is still high for natural gas. This technology is well suited to retrofit on new (supercritical) coal-fired plant, and can also be retrofitted to gas-fired CCGTs.

- **Pre-combustion capture – in which the flue is chemically converted at high pressure into a synthetic gas of hydrogen and carbon dioxide.** The carbon dioxide is captured, and the hydrogen burnt in a conventional CCGT. Carbon capture is relatively cheap and well proven in this case, but there are significant technology risks with the chemical conversion process, and with the integration of a chemical plant with a CCGT. Again, the plant could be built now but "first of a kind" technology risk would be involved. This is the technology proposed by BP and partners for Peterhead using natural gas, and is also under active consideration by E.ON UK, Progressive Energy and others for new build coal-fired plant. It is well suited to retrofit on CCGTs (a retrofit that can include conversion to coal), but cannot credibly be retrofitted to conventional coal-fired plant.
- Oxyfuel and other technologies – these are potentially promising and may become cheaper than the above options in the longer term. However, they are not yet sufficiently well proven for full-scale power plant built. A small-scale (30MW) oxyfuel demonstration is planned in Germany. A full scale demonstration plant may be operational before 2020, but not before 2015.

28. For carbon storage, E.ON UK is currently only considering deep geological storage (>800 metres below ground level), either in depleted oil and gas fields, or in saline aquifers. It is expected that the first CO₂ storage sites will be in depleted oil or gas fields in the North Sea. The technology is well understood. However the costs are highly site specific, depending on: pipeline lengths; the geology of the storage site; and the extent to which existing infrastructure can be re-used. In addition, the legal and regulatory framework is not yet developed so costs of consenting, monitoring and verification costs are all unknown.

1.34 b, What scope is there for applying these technological options to different forms of power generation (particularly gas and coal) and other large-scale sources of CO₂ emissions, and can they be installed on the basis of both new build and retrofitting?

29. All the main technology options can be applied to new power generation on gas, coal and indeed biomass-fired units. Post-combustion capture is well-suited to retrofit on conventional combustion plant, and can also be retrofitted to CCGTs. Pre-combustion capture technologies can only really be retrofitted to CCGTs. However, pre-combustion capture would allow conversion of an existing natural gas-fired CCGT to hydrogen derived from coal, allowing some of the existing UK gas-fired power generation fleet to be converted to low carbon coal generation if the future market allows. In principle, over 90% of CO₂ emissions from power generation in the UK could be eliminated using CCS in the long term. However, it should be recognised that some power generation units are "peaking" units, that is to say they only operate infrequently during periods of high demand. Even if a market were created with sufficient incentives to allow CCS to be fitted on all baseload plant, it is unlikely that peaking plant would be fitted with CCS for many years.

1.34c At what level of market readiness are these various technological options?

30. As noted above, none of the available CCS technologies are well proven in power generation applications. Pre-combustion and post-combustion units are under active consideration and could be built now, but with some additional "first-of-a-kind risk".

31. The main factor limiting market penetration is the lack of a secure long term market incentive to reduce CO₂ emissions. Currently the main incentive is the EU ETS (which itself needs modification to include CCS), and the price of CO₂ permits in the EU ETS is impossible to predict accurately beyond 2012, as there is no certainty on the number of permits to be available or indeed the scheme rules.

1.34 d, What limitations exist when it comes to selecting from the options at each stage to form a full CCS process?

32. E.ON UK does not fully understand the intent of this question. We would welcome the opportunity to clarify the question and discuss with the Treasury.

1.35 a, What would be the costs and benefits of early adoption of this technology in the UK?

33. CCS has a number of benefits which warrant early adoption in the UK:

- **Security and diversity of energy supply** – CCS can bolster security of supply by enabling the UK to utilise a range of fuels from diverse sources and suppliers, without impairing progress towards CO₂ emissions reduction targets. Specifically it allows the UK to keep burning coal, which comes from diverse sources (available both within the UK and on a well-established international market) and can be stockpiled. Without CCS, continued coal burn may become unviable as it would hamper emissions reduction progress. The major alternative would be gas build, which would increase UK dependency on imported gas.
- **CO₂ emissions reduction** – The UK has set itself demanding CO₂ reduction targets both to enable the UK to help meet the global challenge of climate change and to support concerted international action. CCS can play a major role in helping the UK reach its emissions reduction targets by reducing emissions from conventional fossil fuel plant by 90%. CCS can deliver these reductions more rapidly than Nuclear, as new CCS build could come online early in the next decade (If new Nuclear occurs it is not expected till >2018). Early adoption of CCS would demonstrate to the international community – particularly large CO₂ emitting economies heavily dependent on coal such as the US and China - that Britain is committed to developing technologies which can contribute to combating climate change. Once the technology has been demonstrated and shown to have global application potential, global willingness for a post Kyoto emissions reduction agreement should be enhanced.
- **UK Requirement for new low carbon generating capacity** – About one third of the UK generation fleet will close over the coming decade. The type of new capacity built will have a major effect on UK CO₂ emissions for decades, given the lifetime of generation assets. It is therefore timely in a UK context to support the use of CCS for a proportion of this new plant.
- **Utilisation of North Sea oil and gas field infrastructure** – CCS could utilise the oil and gas infrastructure currently pumping fuel out of the North Sea, to pump CO₂ in. However North Sea gas production is declining and infrastructure is

starting to be decommissioned. Committing to CCS early would enable the industry to make best use of existing oil and gas assets in the North Sea.

34. The cost of early CCS adoption should be confined by using a project specific short term support mechanism. E.ON UK does not favour a long term supplier obligation, as once CCS has proven itself, subsequent projects should compete on a level playing field with other low carbon technologies. Long term subsidies could lead to market distortions, ultimately to the detriment of the UK consumer.

1.35 b, Are there skills gaps that could create barriers to CCS in the UK?

35. There is a need for substantial investment in new power generation infrastructure over the next decade in the UK, which will stretch the existing specialist engineering skills base in the UK. This looks set to coincide with other major infra-structure projects (including the 2012 Olympics in London) so there may also be a general labour shortage for large construction projects in the UK.

36. However, we do not consider that there are skills shortages of particular relevance to CCS over and above those likely to affect the power industry and the off-shore industry in general.

1.41 a, What scope is there to develop and use CCS within the current regulatory framework?

37. Under the current regulatory framework CCS is unlikely to be deployed. A number of barriers exist that must be removed to enable widespread uptake of CCS:

- **Inclusion of CCS in the EU ETS** –E.ON UK is concerned that no mechanism exists for crediting the operator with the CO₂ emissions reduction that CCS would bring. Without a mechanism of accreditation, an operator would be unable to offset the capital and running costs of the additional plant required for CO₂ capture. This is being addressed by the Commission, who are considering changes to include CCS within the EU ETS. The UK Government should continue its support for this change. In addition, in order for a power company to invest in CCS, the company would need confidence in the long-term value of carbon emissions. This would also be much improved if the EU ETS rules were firmly defined not just over the 2008-12 period, but also over ensuing periods.

- **Removal of legal barriers to offshore CO₂ storage** – The majority of the UK's resources for storing CO₂ in geological formations are located offshore. The London Convention and the OSPAR Convention need to be amended to allow CO₂ storage in the North Sea. Because CCS technologies are relatively new, the storage of CO₂ underground for purposes other than as the incidental result of Enhanced Oil or Gas Recovery, is not included explicitly in these conventions. The UK Government (DTI and DEFRA) are already pursuing this.
- **No clear planning or regulatory framework** – No specific planning framework is currently in place for offshore CO₂ storage. We would urge government to put in place a framework for CCS projects, in order to give guidance to planning bodies and prevent lengthy planning delays caused by ad hoc policy discussions.
- **No clear definition of long term liability** – Because of the very long timescales proposed for CO₂ storage, it is not credible for private companies to carry the long time liability for stored CO₂ indefinitely. The timing and conditions under which liability would transfer to the Government (presumably following completion of the CO₂ injection phase) need to be agreed between Government and industry.

1.41 b, What regulatory framework would need to be put in place to support the development of CCS technology while also ensuring protection of human health and the environment?

38. E.ON UK does not believe that risks from transportation, injection and storage of CO₂ are unique to CCS. These risks are sufficiently managed by current legislation.

1.41 c, What additional costs and considerations are created by the long-term liability implications attached to CCS, and how can these be best managed?

39. It is not clear at present what entity would be legally responsible for the management of the stored CO₂. During the lifetime of the CO₂ injection, this might be expected to be a company. However over the long-term, this responsibility and liability would be best placed with the Government as companies are unlikely to exist over the timescales in which the CO₂ will be stored for. The regulatory framework to govern this needs to be

put in place. Until that is done, long-term liability will form an additional project risk that is difficult to quantify.

1.41 d, What issues arise concerning (short-term) liability for CO₂ at particular points in the CCS process? Are there costs attached to these and what are they?

40. E.ON UK accepts that the short term liability for CO₂ leakage (during the lifetime of the CO₂ injection) might have to rest with business. Practically, the CCS process is likely to be handled by more than one company and regulation governing liabilities throughout the CCS process could prove helpful. However E.ON UK does not believe regulation is essential, as liabilities could be handled contractually between businesses. Long-term liability for stored CO₂ would be best placed with government as industry could not financially or physically cover the liability over CO₂ storage timescales.

1.41 e, What might be the likely public reaction to concerns about CCS, and how could concerns be addressed?

41. We do not believe there will be a significant adverse public reaction, but the Government and industry together will need to ensure that information is actively communicated to the public on the purpose of the technology and its role in tackling the threat of climate change while maintaining secure and diverse energy supplies. In particular, we believe the Government needs to lead a communication process to establish public acceptance from environmental and safety perspectives. Acceptance under international protocols will help this process as will the existence of an appropriate onshore regulatory regime.

1.48 a, What are the costs currently associated with the development of different potential CCS technologies and forms of development?

42. We have given our view of generic costs of CCS in answer to questions 1.32a and 1.32b.

1.48 b, How might these costs change over time and what is the evidence for any estimates of this?

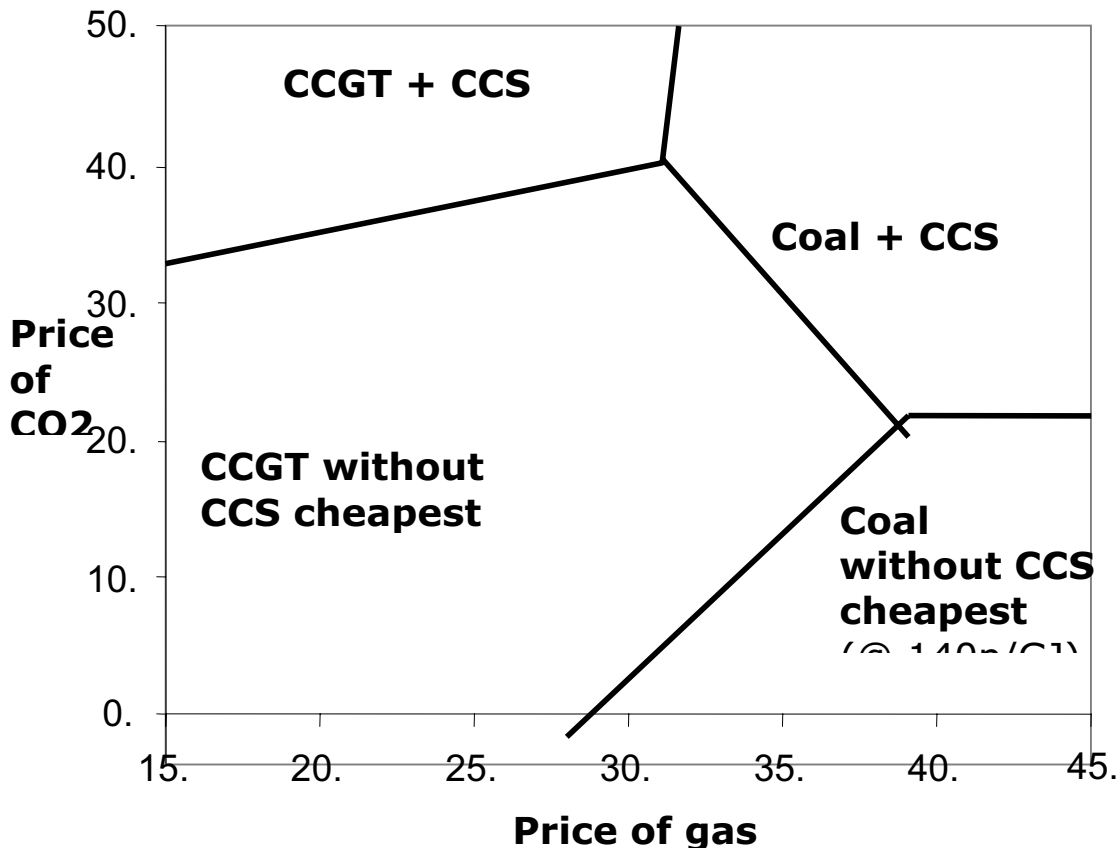
43. It is always difficult to predict future cost reductions, and E.ON does not propose to speculate. However, there is a considerable body of academic literature on the subject which may guide the

Treasury. A good analogue for post-combustion capture technologies may be post-combustion capture technologies for sulphur dioxide and nitrogen oxide removal, namely FGD and SCR technologies. Various public reports cover this subject, an example being a paper by Rubin et al. (Int J Energy Technology and Policy, Vol 2, Nos 1/2 , 2004). An overall capital cost reduction (taking into account materials, labour rates and other cost changes) of 40% over 13 years was observed for FGD, a slighter faster reduction for SCR. Caution is needed in applying these figures simplistically to CCS, since some parts of the CCS process (conventional power island components, CO₂ pipelines etc) are already well established, however they do show the scope of cost reductions achievable.

1.48 c, How might changes in the relative prices of coal and gas in the framework governing emissions of CO₂ and other pollutants affect the costs and profitability of CCS?

44. Changes in fuel input cost will significantly effect the economics of CCS build. Chart 1 shows the relative economics of unabated coal, unabated gas, Gas+CCS and Coal+CCS under different gas and carbon prices. (Please note that we have used a fixed coal price in producing Chart 1, as coal prices have historically been more stable than gas and carbon. We have also assumed single technology costs where in reality costs are very uncertain and site specific).
45. Chart 1 shows the sort of carbon price needed to make CCS build viable without a support mechanism (for the assumed technology and coal costs), however first of a kind demonstration plants are likely to be more expensive. The required carbon price is clearly dependent on the gas price. We would expect the cost of carbon to be higher in a world where gas was expensive, than one in which gas was cheap.
46. In the future, it is possible that the cost of carbon will be sufficient in making CCS economic, however the current methodology behind the EU ETS, and the current lack of long term global commitments on climate change abatement, make long term carbon price forecasting hazardous.

Chart 1, Which fossil fuel option gives the lowest cost of electricity



The costs assumed are intended to be representative of future technology, once first-of-a-kind costs are

1.48 d, To what extent does EOR reduce costs and increase the commercial viability of CCS?

1.48 e, How does EOR using CO₂ compare in cost terms to EOR using other means?

1.48f Is the use of CO₂ for EOR appropriate on the UK continental shelf and at what stage in the life of a specific field is it appropriate to use EOR?

47. We do not wish to comment on EOR as it is outside our current operational experience.

1.48g What are the costs of building capture-ready plant and how do they differ from the cost of constructing fully operational CCS facilities? To what extent can any additional costs be mitigated by decisions on design, location etc?

48. "Capture-ready" is a poorly defined concept. We have taken part in DTI-supported studies looking at retrofitting coal-fired pre-combustion capture to an existing CCGT (Connah's Quay) and an existing coal-fired unit (Ratcliffe). In both cases, it was

technically possible to fit carbon capture, the only real constraint being the need to acquire some additional land. Could one therefore argue that these plants are capture-ready by default? That said, these plants were not designed with CCS in mind, so there would be additional costs and inefficiencies in the new capture plant as neither the plant layout nor the thermodynamic cycle would be fully optimised. The main requirements for “capture-ready” new build plant seems to be:

- having sufficient land available
- designing the plant layout with CCS in mind
- having an export route and storage sites available for the CO₂

The cost impact of these requirements are modest.

49. Even these requirements do not really apply to CCGTs, since these can be retrofitted to fire hydrogen that is generated at a remote site. The hydrogen can be produced from coal or gas with pre-combustion carbon capture. In the case of CCGTs, most can be retrofitted with this technology as they stand.

50. It should be noted that, while the additional costs of “capture-ready” are very modest, there are significant costs associated with the conversion from operation without capture to operation with capture. These include modifications to the steam turbine to accommodate changes in steam flows, additional cooling requirements, and possibly significant outage time. It is therefore significantly cheaper to build the capture plant at the same time as the main power station, if it is known that capture will soon be required.

1.48h Is the use of CCS currently a profitable option for businesses in the electricity supply sector and other sectors and, if not, what is the shortfall? Under what conditions might it be profitable?

51. The economics of CCS has been covered in paragraphs 46-48. We do not believe that CCS is currently profitable. It would become profitable if the market delivers long term high gas and carbon prices, although the very first projects may still require support due to additional “first-of-a-kind” costs. However, in order to deliver the large scale investment decisions to build CCS, confidence in the long term price of carbon needs to be significantly greater than it is at present and operators would need to be credited with abating CO₂. (Portfolio generators such as E.ON would expect to manage the long term risks associated with fuel price uncertainty.) The current shortfall depends on the

perceived commodity price forecasts, the chosen technology for power generation and the site for carbon storage. As such, it is not well defined and is likely to be both project and company specific. For this reason, it is recommended that the Government use a form of incentive that includes a price-seeking element to allow the most cost effective demonstration units to go forward.

1.54 What is the impact of the current policy framework on the development of CCS? And are there any particular issues that need to be taken into account with regard to CCS when considering the use of policy mechanisms to reduce CO₂ emissions in the UK economy?

52. Please refer to earlier answers.

E.ON UK
11 May 2006