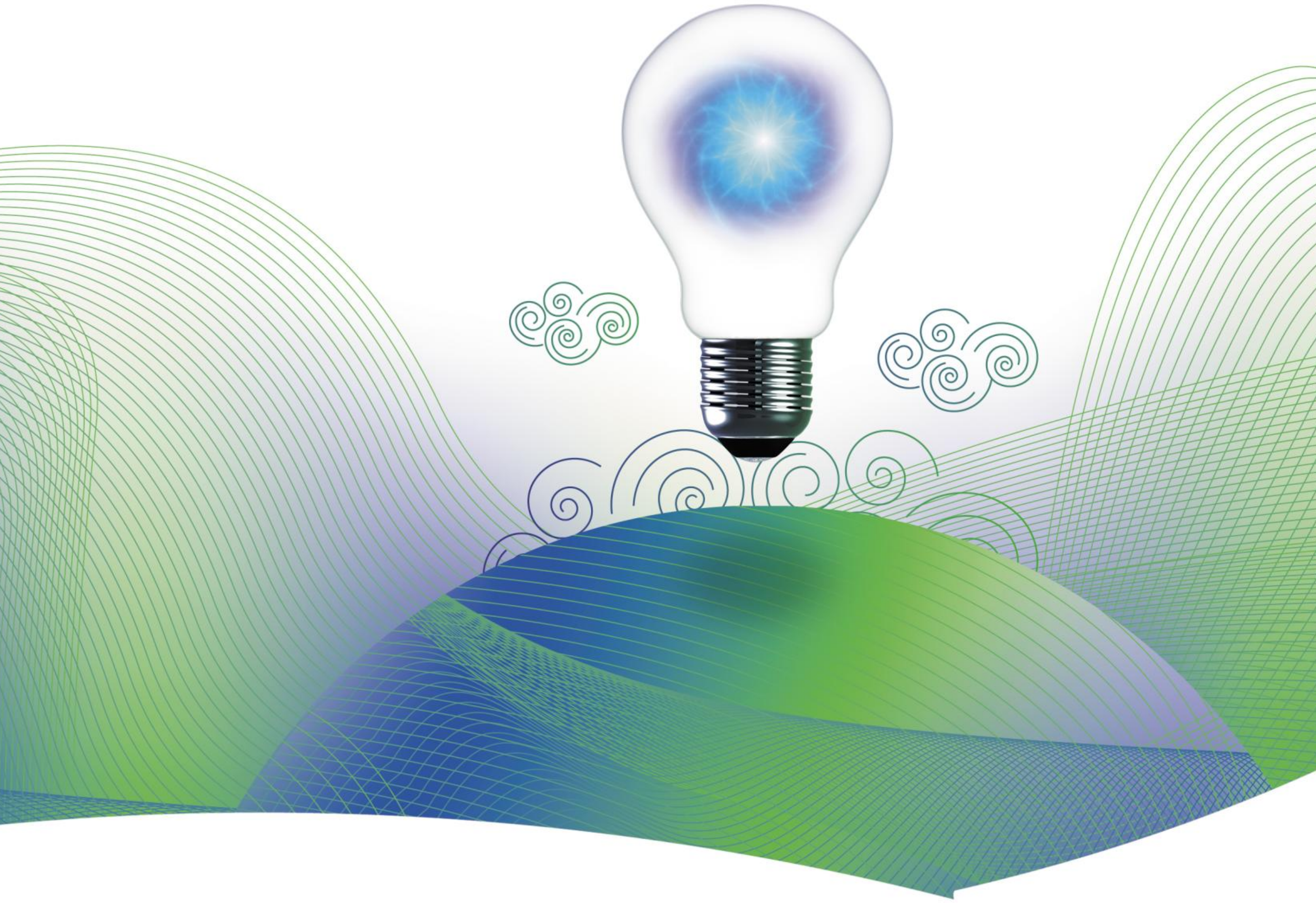
Economic Impact Assessments of the proposed Carbon Capture and Storage demonstration Projects in Scotland – a Summary report

May 2011



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1. Executive Summary

The economic impacts associated with CCS demonstration result from the construction phase as well as from the operational phase. These impacts can be direct impacts resulting from activities related directly to the construction and operation of CCS or indirect impacts related to upstream activities. In addition, induced impacts also result throughout Scotland as a result of additional income distributed throughout the broader economy. The estimated capital expenditure required, GVA and jobs will depend on the demonstration plants which will eventually take place. The textbox below summarises the results from the current study.

It is noted that the Longannet demonstration is the most advanced in terms of planning, not only in Scotland but throughout the UK and so the lower end of the figures reported below assumes that only the Longannet demonstration will go ahead while the higher end assumes that all three demonstrations will be undertaken. It should be mentioned that providing support for the development of CCS on Longannet is an important cornerstone in Scotland's plans to become a leader in CCS and to effectively harvest the long-term benefits associated with the creation of a CCS industry in the North Sea.

Required expenditure: £1.2 – 3.5Bn

Total GVA from construction activities (2014 – 2020): £0.89– 2.75 Bn
Direct GVA: £0.45 – 1.40 Bn
Indirect GVA: £0.21 – 0.63 Bn
Induced GVA: £0.23– 0.72 Bn

Total jobs from construction activities (2014 – 2020): 1,546 – 4,600
Direct jobs: 966 – 3,040
Indirect jobs: 450 – 1,150
Induced jobs: 130 – 410

Total GVA from the operational phase: £0.28 – 0.53 Bn
Direct GVA: £0.12 – 0.23 Bn
Indirect GVA: £0.12 – 0.24 Bn
Induced GVA: £0.04 – 0.06 Bn

Total jobs from the operational phase: 196 - 454
Direct jobs: 51 - 120
Indirect jobs: 102 - 236
Induced jobs: 43 - 99

Note:
The lower end of the range of each of the figures above assumes only the Longannet CCS demonstration will take place while the higher end assumes that all three CCS demonstrations will take place

During the construction phase, the demonstration of CCS in Scotland has the potential to create more than 4,500 jobs between 2014 and 2020 (about 3,000 of which are direct jobs). In addition about 450 full time jobs (120 of which are direct jobs across the CCS chain) can be maintained throughout the operational phase.

Hunterston has higher overall economic impacts in comparison to Longannet because of the higher costs of constructing the transport pipeline. In addition, the study assumes that Scottish-based companies will capture a higher share in the construction of the Hunterston CCS demonstration leading to higher economic impacts. It should also be noted that wider economic impacts will result from the construction of the Hunterston multi-fuel power plant as a whole and not only from the CCS demonstration.

When considering the GVA and job creation, the need to demonstrate different CCS technologies and on different types of power plants should be taken into account. The current study recognises the importance of demonstrating CCS on gas power plants as well as on coal power plants. While CCS on Peterhead is associated with lower capital expenditure and consequently lower GVA and job creation potential, the long-term benefits from demonstrating CCS on gas power plants should not be overseen. The demonstration of amine capture on gas power plants will definitely create challenges of its own which need to be understood and so the Peterhead demonstration provides an opportunity for Scotland and the UK to broaden their future CO_2 capture market to include gas power generation as well as coal.

2. Introduction

This study looks at the potential economic impacts of the three proposed Carbon Capture and Storage (CCS) demonstrations in Scotland. This will also provide Scottish Enterprise with information and data to help develop, in the longer term, a supply chain programme for CCS. The analysis covered the three proposed CCS demonstrations in Scotland (Longannet by Scottish Power, Peterhead by Scottish and Southern Energy and Hunterston by Ayrshire Power Limited) which submitted NER300 applications to UK Government Department of Energy & Climate Change (DECC) on Feb. 9th, 2011. Individual reports which examine in detail the impacts from each of the CCS demonstrations were produced. This report provides a summary of the total economic impacts which could result from each of the three projects.

The study considers the economic impacts of demonstrating the full CCS chain (capture, transport and storage) and covers both the construction and operational phases. Direct, indirect and induced impacts are considered in the local regions where the demonstration will take place and also throughout Scotland. The activity areas covered in this study encompass engineering, project management, procurement, manufacturing, construction and commissioning.

The methodology followed consists of a combination of expert and stakeholder consultation, literature review and CCS cost modelling. The work undertaken made use of recent published literature on the potential impacts of CCS in Scotland and in the UK. The economic impacts which can potentially be achieved in Scotland depend on the expenditure required and also on the share of equipment and plant supply that Scottish industry can capture in each of the demonstrations. Since CCS is in the early stages of development, there is some uncertainty associated with estimating the required expenditure and the share of equipment and plant supply which can be attained by Scottish industry. As a result, it should be noted there will be some degree of uncertainty associated with the resulting economic impacts reported here. However, the information given in this report provides useful guidance on future CCS demonstrations in Scotland and on the scale of potential economic benefits which can be potentially achieved.

3. Carbon Capture and Storage in Scotland

CCS has an important role to play in reducing CO_2 emissions. The IEA predicts that, in 2050, worldwide CO_2 emissions from the energy sector will increase by 130% above 2005 levels as a result of increased consumption of fossil fuels[1]. The consumption of coal and natural gas for power generation is expected to increase in the coming decades as a result of the growing demand in the power generation sector in developing countries and in order to ensure worldwide security of supply. CCS is the only technology available to mitigate greenhouse gas (GHG) emissions from large scale fossil fuel usage in the power and industrial sectors. It is now expected that CCS will play a significant role, alongside other mitigation measures, in achieving the necessary emission reduction in the most cost-effective manner[2].

Scotland's CO_2 emissions amounted to 44Mt in 2006 with approximately 18 Mt emitted by Scotland's three largest power stations (Longannet: 9.6 Mt, Cockenzie: 5 Mt, Peterhead: 3.1Mt)[3]. In 2008, the three largest fossil based power stations emitted about 14Mt of CO_2 (Longannet: 6Mt, Cockenzie: 4.4 Mt, and Peterhead: 3.7Mt). The likely levels of CO_2 emissions in the electricity generation sector in the next few decades will depend on the energy mix and on the alternative trends in electricity demand. A 2009 report on CCS in Scotland indicated that under a high CO_2 output scenario, the average CO_2 emissions are expected to be

[1] IEA Energy Technology Perspective 2008
[2] CCS Technology Roadmap, 2009
[3] Scottish Centre for Carbon Storage (2009):"Opportunities for CO_2 Storage around Scotland — an integrated strategic research study"

17MtCO_2 /year between 2010 and 2050, whereas under the low CO_2 output scenario[4], for the same period, the average CO_2 emissions are expected to be 8MtCO_2/year.

CCS can play an important role in allowing Scotland to achieve its emission reduction targets while maintaining security of supply. This would require that existing and new fossil fuel power plants built in Scotland to be completely fitted with CCS between 2020 and 2030. However, for CCS to become commercially deployable in the next decade and in order to reduce the technical and commercial risks associated with it, it must first be successfully demonstrated.

CCS on fossil fuel power plants is a relatively new technology and so its early demonstration at scale is associated with many technical and financial risks. Successful demonstration of CCS on coal and gas power plants will increase confidence in the technology, will bring investment costs down and will reduce technical risks associated with applying the technology on a large scale. However, it is recognised that for any demonstration project to proceed at this stage, support from government and the wider public sector will be necessary. Several funding competitions including the UK CCS competition and the European Commission (EC) NER300 competition were set-up to support and encourage the demonstration of CCS.

The UK and Scotland are leading the way worldwide in developing plans to demonstrate CCS on fossil fuel power plants. The UK Government's CCS Strategy[5] emphasised the importance of these demonstration projects in providing direct job opportunities, developing the supply chain and skills base, building experience to enable UK businesses to pursue global CCS markets, and providing an opportunity to investigate the scope for storing CO_2 in the North Sea and Irish Sea on behalf of other countries.

The Budget 2011[6] announced that UK Government remains committed to providing public funding for up to four CCS demonstration projects, including the winner of the first UK competition. Scottish Power, with its plans to demonstrate CCS at Longannet, is currently the only remaining entrant for the UK competition. Future funding could cover CCS on gas power plants as well as other capture technologies (e.g. pre-combustion). Details of this, however, are still unclear and there are no guarantees at this stage that such funding for additional plants will be forthcoming.

The budget states that the proposed CCS Levy, which was to be raised on the sale of electricity and was to fund the three CCS demonstration projects beyond the UK competition winner, will now be dropped. The budget document states that the Government intends to fund the remaining demonstration projects out of general taxation and possibly from revenues from the proposed carbon floor price. This may, however, be further delayed and consequently causing delay in further demonstration of CCS. In order to minimise the uncertainty of financial support for CCS demonstration, it is important that the transition period from the current structure of the electricity market to the new arrangements proposed under electricity market reform (EMR)[7] is minimised. In addition, the arrangements introduced under the EMR must be tested to ensure that early CCS demonstration projects which are in operation continue to operate beyond the demonstration support period and to ensure investment in additional CCS projects.

The EC has also committed €1.05Bn for supporting CCS demonstration plants through its European Energy Programme for Recovery (EEPR)[8] with six projects throughout Europe awarded funding. Additional EC funding will be provided through the New Entrant Reserve (NER) mechanisms[9]. Each of the three proposed

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4 Scottish Centre for Carbon Storage (2009): "Opportunities for CO_2 Storage around Scotland — an integrated strategic research study".
5 Clean Coal: an industrial strategy for the development of carbon capture and storage across the UK, March 2010
6 http://cdn.hm-treasury.gov.uk/2011budget_complete.pdf
7 http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/inquiries/electricity-market-reform/
8 http://ec.europa.eu/energy/eepr/
9 The NER300 mechanism (http://www.ner300.com/) sets aside 300M allowances (€4.5Bn at a carbon price of €15) for supporting up to 8 CCS projects (maximum of three projects in the UK) and up to 34 innovative renewable energy projects in two phases of funding. The EC NER300 call was published in

CCS demonstrations in Scotland (Longannet, Peterhead and Hunterston) are seeking funding to support their plans to demonstrate CCS and so each has submitted a NER300 application to DECC on Feb 9th, 2011. If successful in obtaining EC funding, the three proposed CCS demonstrations in Scotland together would be expected to capture more than 55 Mt of CO_2 between 2020 and 2030.

Article 8 of the NER300 Commission Decision[10] states that eight CCS projects across the European Union, covering different capture and storage technologies will be funded under the NER300 competition. NER300 will provide funding for up to 50% of the relevant costs of a project. Article 8 also states that, if funding is provided to a given Member State, at least one and no more than three CCS projects will be funded within that Member State. Considering that all three CCS projects proposed in Scotland are based on the same post-combustion capture technology, the likelihood that all three UK projects are funded under NER300 is small. However, Scottish-based projects which do not get funded under NER300 are very likely to seek funding through other mechanisms such as additional funding from the UK government and Phase II of the NER300 competition. The overall environmental and economic impact on the Scottish economy from CCS demonstration will depend on the number of demonstration projects which eventually take place.

In addition to helping Scotland meet carbon reduction targets, CCS has the potential to become a significant economic sector in Scotland. Early studies on CCS in Scotland[11] concluded that Scotland and the UK in general are well placed to exploit CCS because many of the large CO_2 sources are located within a reasonable distance of offshore geological formations suitable for long-term storage. These early conclusions were also confirmed in 2009 by the "Opportunities for CO_2 Storage around Scotland" which concluded that Scotland has an extremely large CO_2 storage resource which can accommodate the industrial CO_2 emissions in Scotland for the next 200 years. The study added that there is very likely to be sufficient storage to allow import from NE England and that Scotland has the skills required to deliver a major CO_2 storage industry.

The overall vision of the Scottish Government is that Scotland should become a world leader in the deployment of CCS technology by ensuring that a number of CCS demonstration projects are developed in Scotland in the next 10 years. In the recent "Draft Electricity Generation Policy Statement 2010"[12], the Scottish Government stated that CCS should be fitted to new or existing Scottish coal power plants by 2020, to be economically and technically proven by 2020 and progressively fitted to all coal and gas thermal plants thereafter by 2030.

One of the key actions from the CCS Roadmap for Scotland[13] is that the Scottish Government will continue to support Scottish-based CCS demonstration projects through engagement with key stakeholders including the UK Government and the EC. In August 2009, the Scottish European Green Energy Centre (SEGEC)[14] was opened to gain the maximum benefit from engagement with Europe. One of the major objectives of the SEGEC is to help Scottish-based CCS demonstration projects to be in a better position to win EC funding for demonstrating CCS in Scotland.

The CCS Roadmap for Scotland outlines the advantages and strengths which make Scotland in a unique position to lead on CCS. These include:

November 2010 and bidders submitted their applications to Member States in February 2011. Member States will select projects which will then be submitted to the EC (EIB) in May 2011 and a decision on the successful applications will be made in 2012.

[10] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:290:0039:0048:en:PDF

[11] Scottish Enterprise, Carbon Capture and Storage Market Opportunities, 2005

[12] Draft Electricity Generation Policy Statement – Scotland – A Low Carbon Society, 2010

[13] Carbon Capture and Storage – A Roadmap for Scotland, A joint document by the Scottish Government and Scottish Enterprise, March 2010

[14] SEGEC: http://www.segec.org.uk/

- **Academic and research expertise:** with the establishment of the Scottish Centre for Carbon Storage (SCCS)[15] in Edinburgh, Scotland has the opportunity to demonstrate leadership in CCS. The SCCS is very active in a broad range of research areas in CO_2 capture, transport and storage and are collaborating with companies in Scotland and in the UK. Scottish companies have been recently active in testing CO_2 capture technology on a pilot scale. In 2009, a 1-MW CO_2 capture test facility utilising post-combustion capture via amine chemical absorption was installed and monitored at Longannet for seven months in 2009. Moreover, in 2009, Doosan Babcock in Renfrew launched the world's largest oxyfuel clean combustion system on a 40 MW_{th} burner[16]. In addition, Doosan Babcock is currently active in testing amine absorption.
- **Storage capacity and opportunities**: the North Sea and Irish Sea have significant storage capacity in oil and gas fields. This storage space offers a significant business opportunity to store CO_2 from European countries where storage sites are not available. Recent modelling of the captain sandstone in the Moray Firth has been undertaken which indicates potential storage for 1,200 million tonnes of CO_2[17].
- **Engineering and offshore skills and knowhow**: Scotland has strong experience in the oil and gas industry with an already-established supply chain. In addition, existing infrastructure may be used for CO_2 transport and injection into oil and gas fields.

According to the Scottish Government and Scottish Enterprise[18], CCS has the potential to create an additional 10,000 new jobs in Scotland over the next two decades. A recent report[19] by the Industrial and Power Association (IPA) concluded that CCS has the potential to create 13,000 and 20,000 jobs in Scotland by 2020 and 2030 respectively[20]. Because of its well established oil and gas industry and its synergies with CCS, Scotland is well positioned to export CCS components and services (e.g. plants construction, engineering consultancy, geological and academic expertise). The IPA study stated that the UK/Scotland has the potential to capture up to 10% of the global CCS market.

The discussion above shows that CCS can play an important role in helping Scotland meet emission reduction targets and maintain energy security while at the same time creating a significant business opportunity. The environmental and economic benefits which can be achieved from demonstrating CCS in Scotland are significant. The current study seeks to evaluate the specific benefits which can be achieved from the three proposed CCS demonstrations in Scotland and to comment on the wider long-term economic impacts.

4. Economic Impacts of CCS

Not only will the demonstration of CCS play an important role in bringing the technology to the deployment phase, but it will also lead to positive economic impacts including additional gross value added (GVA)[21] and additional employment. In the long-term, the early demonstration of CCS in Scotland will provide an opportunity to develop the necessary expertise in the supply chain and will increase the competitiveness of Scottish companies in the supply of equipment and CCS-related services which can be exported worldwide.

[15] http://www.sccs.org.uk/
[16] http://www.ccsassociation.org.uk/ccs_projects/uk_projects.html#renfrew
[17] Progressing Scotland's CO_2 Storage Opportunities (www.geos.ed.ac.uk/sccs)
[18] Carbon Capture and Storage – A Roadmap for Scotland, A joint document by the Scottish Government and Scottish Enterprise, March 2010
[19] This report was published by the IPA but was also a part of the Scottish study 'Progressing Scotland's CO_2 storage opportunities', reference 14.
[20] A. Young, R. Catterson and M. Farley, Industrial and Power Association, Carbon capture an d storage skills study, September 2010.
[21] Gross Value Added (GVA) is a measure of the contribution to the economy made by an industry. It is calculated in a number of ways but for our purposes, what we describe as direct GVA, is the total expenditure (i.e. the cost of the CCS project) less the expenditures on goods and services purchased from third parties necessary to deliver the project. Each of these expenditures on goods and services are themselves expenditures down the supply chain of the project and will appear as GVA attributable to the elements of the supply chain where value is added but not necessarily in Scotland or the UK. They are what we describe here as indirect GVA. Of this indirect GVA we have made an estimate of the share that will stay in Scotland and that which will be attributed elsewhere.

In addition, in the short-term, the construction and operation of CCS demonstrations in Scotland will lead to the creation of GVA and jobs in Scotland and in the UK since many of the services required for the construction and operation of CCS plants can currently be sourced within Scotland and in the UK.

The economic impacts from CCS demonstration result from both the construction and operational phases and are associated with the full CCS chain including the capture plant, the transport pipeline and the storage site. For the three CCS demonstrations in Scotland, economic impacts result in

- The regions where the CCS plants are constructed (i.e. Fife for Longannet, Aberdeenshire for Peterhead and Ayrshire for Hunterston): these will be mainly GVA and jobs related directly to construction activities.
- Throughout Scotland: these will be mainly related to engineering design, project management, procurement and commissioning activities throughout Scotland. In addition, employment in the construction industry in each of the regions will lead to indirect and induced effects which will spread throughout the Scottish economy. In addition, the demonstration phase will lead to the creation of consultancy and R&D jobs at Scottish Universities and research centres.
- Throughout the UK: these are GVA and jobs related to engineering design, project management, procurement and commissioning which does not occur in Scotland.

Economic impacts of the construction phase

Economic impacts result from the construction of CO_2 capture facilities, CO_2 transport pipeline and CO_2 injection facilities. Currently there are no plants which capture CO_2 from power plants or from industrial facilities in Scotland. The three CCS demonstrations in Scotland all propose to use post-combustion capture using chemical absorption with monoethanol amine as the solvent. The construction of these capture plants will go through several stages or activities which include:

- Direct activities which are related directly to construction activities such as project management, procurement and plant construction, and
- Indirect activities which are undertaken upstream such as equipment manufacturing

For each of the three CCS demonstrations, Scottish companies can have a share in each of these activity areas. Scotland, however, has strengths in engineering design, project management (direct activities related to the construction phase). Scotland does not have expertise in CO_2 chemical absorption plant and equipment manufacturing (upstream activities) where most of the world experience lies in the U.S. and in Japan. The construction of CO_2 capture plant will more likely lead to the creation of jobs in the region where the demonstration plant is built. Project management, procurement and engineering design activities are likely to create jobs throughout Scotland.

Benefits to the Scottish economy will also result from the construction of new CO_2 pipeline or from the transformation of existing gas pipeline for CO_2 transport.

- For the Longannet demonstration, the proposal is that CO_2 will be transported 300 km onshore (from Dunipace to St Fergus) and then another 100 km offshore from St Fergus to the Goldeneye gas field.
- For the Peterhead demonstration, CO_2 will be transported from the station to the St Fergus terminal and then a distance of 100 km offshore for injection in the Goldeneye gas field.
- For the Hunterston demonstration, 340 km of offshore pipeline will be constructed for CO_2 storage in the East Irish Sea.

Additional economic benefits will result from the construction of CO_2 injection facilities in the North Sea and Irish Sea. For all three CCS demonstrations, existing hydrocarbon fields will be refurbished and converted for CO_2 injection.

The potential economic impacts (GVA, job creation, etc.) which can be achieved during the construction phase will depend on (i) the required investment and resulting turnover from the construction of the CCS demonstration plants, and on (ii) the share that Scottish-based companies have in each of the activities. Some of the GVA and jobs will be directly related to the construction of the plant (direct impacts) while others will be indirect impacts resulting from effects down the supply chain (indirect impacts) throughout Scotland. The economic impacts resulting from the construction phase will be distributed over a 6-year period[22] covering project development, planning and implementation.

The resulting economic impacts (GVA and jobs) will not be evenly distributed throughout this period and will reach a maximum during construction. The GVA and jobs related to the CO_2 pipeline depends on the capital expenditure involved which, in turn, depends on whether a new CO_2 pipeline is constructed or whether an existing gas pipeline is upgraded. The current analysis focuses on the construction phase of the demonstration plants (2014 – 2020) and so the effects of upgrading the pipeline when the full power station has to be fitted with CCS (for Longannet and Peterhead) will not be considered. For Hunterston, the pipeline constructed is assumed to have the capacity to handle CO_2 from the full power plant capacity from the beginning.

Economic impacts of the operational phase

Economic impacts also result from the operation of the CO_2 capture facilities, transport pipeline and storage site. A CCS demonstration may operate for at least 10 years but operators may keep operating beyond that period and may also add additional CCS capacity even after funding ceases and as the technology becomes more technically understood and economically viable. The operation of the capture plant will require chemicals, additional fuel and maintenance which, if sourced within Scotland, will lead to the creation of GVA and jobs in Scotland. The maintenance and operation of the transport pipeline and injection/storage facilities will also lead to the creation of GVA and jobs within Scotland[23].

The potential impacts which can be achieved during the operation of the CCS plants will depend on (i) the required operational expenditure and on (ii) how much of that expenditure is spent within Scotland. Some of these impacts, such as maintenance and operating jobs (whether at the capture plant or at the injection/storage site) will be directly related to the operation of the CCS plants while others will be indirect impacts down the supply chain (e.g. additional GVA and jobs in the chemical manufacturing and coal mining industry in order to supply chemical and fuel required to operate the CCS plant).

Estimation of capital expenditure

The GVA and job creation during the construction phase will depend on the expenditure associated with:

- **The construction of the capture plant for each of the three demonstrations**
  All three proposed CCS demonstrations are expected to use post-combustion chemical absorption amine-based capture technology.

[22] A. Young, R. Catterson and M. Farley, Industrial and Power Association, Carbon capture an d storage skills study, September 2010.
[23] The operation of the storage site will require continuous monitoring and analysis of data as well as maintenance of wells and injection facilities. These activities will lead to additional GVA and jobs. In the long-term, additional economic benefits also result from (i) storage site exploration, characterisation and assessment, (ii) legal and financial activities associated with getting CO_2 storage permits, (iii) site closure and post-closure monitoring. Further details of long-term benefits are given in Section 4.

- **The construction of new or conversion of existing transport pipeline**
  Proposed CCS plants on the East coast (Longannet and Peterhead) are expected to use existing gas pipeline which will be converted for CO_2 transport. The Longannet demonstration will make use of existing onshore as well as offshore gas pipeline while the transport pipeline for the Peterhead demonstration will mostly be offshore. Hunterston, on the other hand, is proposing to construct new offshore CO_2 pipeline in the Irish Sea.
- **The refurbishment of existing injection facilities**
  All three demonstrations are expected to use existing hydrocarbon fields in both the North Sea and Irish Sea.

For the current study, the capital investment required for constructing each of the CCS demonstration plants was estimated and verified by reference to publicly-available data[24]. It should be noted that due to commercial sensitivity, plant developers were unable to provide specific data and so they have only commented on the range of figures obtained through our analysis of the costs. It is recognised that, as with other emerging technologies, estimated capital and operating costs of CCS are subject to some degree of uncertainty[25] and this, in turn, leads to some uncertainty in the estimated economic impacts. The capital and operating costs for each of the demonstrations are detailed below.

Methods are available for estimating the capital costs for CO_2 capture, transport and storage. However, these costs depend on the specific circumstances of the proposed plant and so could vary considerably from the actual costs.

CO_2 capture

Analysis[26], based on a bottom-up approach, shows that the capital expenditure required for retrofitting amine-based CO_2 capture on coal and gas power plants are as follows[27]:

- Coal power generation: £350 - 400 M
- CCGT: £180 - 220 M

The figures above include both direct and indirect costs (assuming that 50-70% of the total costs are indirect costs). Direct costs are equipment and plant costs. Indirect costs include general facilities costs, engineering and home office fees, contingency costs, interest, royalties and inventory and start-up costs. The figures assume that the CO_2 captured from the coal power plants is 2M tonnes/year (typical rate for CCS on a 300-400 MW coal power plant) and from the gas power plant about 0.8M tonnes/year. The capital cost figures above are in agreement with previous studies. According to a study by DECC[28], the total capital expenditure required for adding CO_2 capture to a 400 MW coal fired power plant is in the range of £250-350M. The recent IEA study on 'cost and performance of carbon dioxide capture from power generation[29] estimates the

[24] P.Simmonds, J. Lonsdale and D. Musco, A study to explore the potential for CCS business clusters in the UK, DECC, 2010

[25] The capital costs of CCS consist of direct costs (equipment costs) as well as indirect costs (general facilities, home office fees, contingency, owner's costs, royalties, inventory, etc.) In addition to uncertainty associated with equipment costs as a result of change in the cost of materials, there will also be greater uncertainty in indirect costs. Usually, these are estimated as a % of direct costs and this, of course, could change from one country to another.

[26] We estimated the costs of the various equipment in the CO_2 capture plant (i.e. flue gas fan, direct contact cooler, absorber, heat exchangers, regenerator, etc.) as a function of flow rate through the equipment. We used reference data on capital costs and corresponding reference flow rates to scale down the capital costs based on new flow rates, a method used frequently in chemical and process engineering applications. Our analysis estimates material flow rates through CO_2 capture equipment and estimates equipment costs from the reference costs and reference flow rates using the 0.6 power law which is used frequently in process engineering applications [i.e. new cost = reference cost * (new flow rate / reference flow rate)^0.6]. Reference data of costs and flow rates are obtained from a review of the literature (Integrated Environmental Control Modelling, IECM, by Carnegie Mellon University).

[27] These estimates depend on the specific parameters for each of the demonstrations. Some of the parameters which influence these costs include the capacity which will be fitted with CCS and, consequently the amount of CO_2 which will be captured annually, the amount of flue gas passing through the capture plant and the capture plant performance parameters. Some of these parameters are obtained from the literature published by each of the developers. The flow rates through each of the capture plant equipment is estimated based on these parameters.

[28] P.Simmonds, J. Lonsdale and D. Musco, A study to explore the potential for CCS business clusters in the UK, DECC, 2010

[29] http://www.iea.org/papers/2011/costperf_ccs_powergen.pdf

global average capital costs of adding amine capture on conventional coal power plants as 1236 $/kW (£770/kW) which translates into £220M[30] for a 300 MW coal power plant and £310M for a 400 MW plant. For purposes of the current study and in order to account for the considerable uncertainty and the changing market conditions associated with the first demonstrations, the CO_2 capture costs are doubled as shown in Table 1.

Adding CO_2 capture on gas-fired power plant of the same size is expected to be about half of the cost on coal-fired power plants because of smaller equipment size as a result of smaller CO_2 flow rates[31]. This is in agreement with the recent IEA study referenced above where capital costs for coal and gas power plants with post-combustion CO_2 capture (using amines) was estimated at 3,135 $/kW (1960 £/kW) and 1,541 $/kW (965 £/kW) respectively . Based on the results from the IEA study, the capital cost associated with amine capture on CCGT is $616/kW (390 £/kW), which for a 400 MW power plant, translates into capital costs of about £160M.

Table 1: CCS capital costs (£M) used in the current study[32]

Activity	Longannet	Peterhead	Hunterston
Capture	600	300	600
Transport	300	200	700
Storage	300	200	200
Total CCS	**1,200**	**700**	**1,500**

Notes:
(1) The capital costs of CO_2 capture on coal are approximately twice the costs on gas,
(2) The Hunterston transport costs are significantly higher than for Longannet and Peterhead because new offshore pipeline transporting CO_2 from the full power station capacity is required,
(3) The transport costs for the Peterhead demonstration cover the cost of the offshore pipeline from St Fergus which is assumed to be shared with Longannet
(4) The Longannet transport costs include the offshore pipeline from St Fergus as well as the onshore pipeline costs to St Fergus.
(5) The storage costs of the Goldeneye gas field are shared between Longannet and Peterhead. Higher cost share is assumed for Longannet because of the higher quantities of CO_2

CO_2 transport

The cost of the transport pipeline depends on whether new pipeline will be constructed or whether gas pipeline will be converted for CO_2 transport. For a 400 MW coal power plant, the study by DECC reports a broad range (£50-350M) for the capital cost of CO_2 transport reflecting the high dependency of these costs on many factors including pipeline design characteristics, terrain and whether the pipeline is onshore or offshore[33]. Transport pipeline costs offshore can be significantly higher than onshore pipeline. For Peterhead, the pipeline length required is mainly offshore and is shorter than for Longannet and so a pipeline conversion (existing offshore gas pipeline from St Fergus to the Goldeneye gas field) cost of £200M is

[30] Using a currency exchange rate of $1.6 per **£**
[31] Flue gas from gas-fired power plants has a smaller concentration of CO_2 (3-4%) in comparison to flue gas from coal-fired power generation (13-14%). This means that it will be more difficult to capture CO_2 from CCGT power plants and more energy will be required to regenerate the monoethanolamine solvent. Nevertheless, because the flow rates of CO_2 from gas power plants are smaller than from coal power plants, the required equipment is smaller in size and consequently the capital costs associated with CO_2 capture on gas-fired generation are smaller.
[32] P.Simmonds, J. Lonsdale and D. Musco, A study to explore the potential for CCS business clusters in the UK, DECC, 2010
[33] While empirical relationships are available for estimating **CO_2 transport** and injection costs, these relationships are country-dependent. As a result, the costs for CO_2 transport and injections are difficult to estimate and greatly depend on the specific circumstances of a project (e.g. whether existing gas pipeline is used or new pipeline is constructed).

assumed[34]. For Longannet, an existing 300 km onshore pipeline to St Fergus will be used. For purposes of this study, the cost incurred by Longannet for converting pipeline for CO_2 injection is assumed at £300M.

For Hunterston, the costs are expected to be significantly higher. The IEA[35] reported CO_2 transport cost curves ($/km) as a function of pipe diameter (m) for offshore and onshore pipeline. Based on these curves and based on parameters for the Hunterston demonstration, a total capital expenditure of £350M is obtained for the Hunterston offshore transport pipeline in the Irish Sea. However, this figure is based on estimates from 2008 and so it will be associated with a degree of uncertainty. For purposes of this study, this figure is doubled to account for uncertainty and changing market conditions.

CO_2 storage

For CO_2 injection facilities, the DECC study reports a range of £150-200M. For all three CCS projects, existing hydrocarbon fields will be used for CO_2 storage[36] and a base cost of £200M is assumed for each of the three demonstrations. Additional costs may be incurred by the Longannet demonstration, as a first mover, for converting the Goldeneye gas field for CO_2 injection. It should be noted that the costs of the conversion of the Goldeneye gas field for CO_2 injection could be shared between the Longannet and Peterhead demonstrations. The current study assumes that most of the costs will be incurred by Longannet and so the Longannet costs are increased by 50% to £300M.

Based on these estimates the total costs for Longannet, Peterhead and Hunterston are £1.2Bn, £0.7Bn and £1.5Bn respectively. These estimates, while higher than what is reported in the literature, are in line with what would be expected for first CCS demonstrations in the UK. These estimates of capital expenditure can then be used to estimate GVA and other economic impacts in Scotland.

Based on the figures reported in Table 1, the total expenditure required for demonstrating CCS on the three proposed plants in Scotland between 2014 and 2020 is in the range of £3.5Bn. As discussed above, since CCS is an emerging technology which has not been demonstrated on a wide scale on fossil fuel power plants, these estimates are associated with some degree of uncertainty. It should be noted that Scotland can significantly benefit from demonstrating CCS on each of the three plants. For example, while all three demonstrations propose to use the same capture technology, the performance of amine capture on CCGT offers challenges which may not be realised by demonstrating amine capture on coal power plants and so a full CCS demonstration programme should include both coal and gas power plants.

The capital costs will be distributed amongst a wide range of sectors including engineering design, project management, procurement and manufacturing, construction and commissioning. The share of each of these activity areas of the total cost for each of the CCS-chain elements (capture, transport and storage) is obtained from previous studies[37] as shown in Table 2. For example, the engineering activities for CO_2 capture make up 10% of the total costs of CO_2 capture and 15% of the total costs associated with CO_2 storage. The activities are listed in Table 2.

The gross value added and employment in Scotland as a result of the construction of CCS plants depends on the share that can be captured by Scottish companies in each of the activity areas listed above. The range of shares that can be attained by Scottish companies in each of the activity areas are based on previous studies and on consultations with experts (Table 3).

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[34] The Longannet and Peterhead CCS demonstrations will make use of existing gas pipeline while the Hunterston CCS demonstration will construct new CO_2 pipeline. Considering that the CO_2 pipeline for Hunterston is offshore and that it will be constructed to transport CO_2 from the full power plant capacity, the capital expenditure required for the Hunterston pipeline is much higher than for the two other demonstrations on the East coast.

[35] IEA (International Energy Agency), 2008c, Energy Technology Perspectives 2008, Scenarios and Strategies to 2050, Paris, 2008

[36] For Hunterston, existing injection platforms will be refurbished for CO_2 injection in the Irish Sea. The Goldeneye field in the North Sea will be converted by Shell for CO_2 injection and be used for storing CO_2 from Longannet and Peterhead.

[37] AEA 2010, IPA 2010

Table 2: Share (%) of CCS components (capture, transport, storage) in the total capital cost across range of activities

Component	Engineering	Project management	Procurement	Manufacturing	Construction	Commissioning
CO_2 capture & Compression	10%	15%	10%	40%	15%	10%
CO_2 transport	10%	10%	10%	35%	30%	5%
CO_2 storage	15%	10%	10%	40%	15%	10%

The share that Scottish companies can have in each of the three proposed CCS demonstrations may differ depending on the project and on plans by project developers. Scottish companies will have a lower share in early projects but will have a higher share in subsequent projects as these companies become more experienced. Considering CO_2 capture, while Scottish companies will have high shares in engineering, project management and construction activities, the share in manufacturing activities is expected to be lower. Higher shares are expected in CO_2 transport and storage activities in general where Scottish-based companies have significant relevant expertise in the oil and gas industry.

Table 3: Potential share (%) of Scottish-based companies in the different activity areas for CO_2 capture, transport and storage

Component	Engineering	Project management	Procurement	Manufacturing	Construction	Commissioning
CO_2 capture & Compression	50%-80%	50%-80%	5%-10%	5%-10%	50%-80%	5%-10%
CO_2 transport	70%-80%	70%-80%	70%-80%	70%-80%	70%-80%	70%-80%
CO_2 storage	80%-90%	80%-90%	80%-90%	80%-90%	80%-90%	80%-90%

** The current study assumes that the share of Scottish companies in the Longannet demonstration, which is expected to be the first CCS demonstration in Scotland, is at the lower end of the figures in the table. This share will then increase for the Peterhead and Hunterston demonstrations (higher end of figures above).*

Estimation of operating expenditure

The operation of a CCS plant requires chemicals, additional fuel and other materials which, if sourced within Scotland, can lead to increased GVA and jobs in the chemicals and coal and/or gas industries. The GVA and jobs created within Scotland depend on the share the Scottish industry will have in the manufacturing and production of chemicals and fuel. Furthermore, additional jobs will result from the maintenance of the capture plant, transport pipeline and operation of the injection and storage sites. The GVA can be estimated from the O&M expenditure (materials, fuel, maintenance costs, etc.). The estimated annual operating costs of an amine-based CCS plant (with transport and storage) are about £60M/year for gas-fired power plants and about £120M/year for coal-fired power plants[38].

[38] Estimates of CO_2 capture operating costs are based on typical consumption rates (tonne/year) of materials (chemicals, i.e. monoethanolamine, additional fuel, etc.) for a 400 MWe plant. Costs per tonne of chemicals and fuel are obtained from the literature and used with consumption rates to estimate annual operating costs. Fixed

The share that can be attained by Scottish companies in the supply chain depends on the product supplied. For example, it is expected that monoethanolamine will be imported from outside Scotland and so the share of the Scottish chemical sector in supplying this chemical may be limited. Moreover, the GVA and job creation as a result of additional fuel production will depend on the type of fuel (coal or natural gas) and whether it will be sourced within Scotland or imported.

Capture costs

Based on the capital and operating costs above, the cost of capturing CO_2 (£/tonne CO_2 captured) can be estimated. The capital and operating costs can also be used to estimate the levelised costs of CCS (£/MWh of electricity produced). Many studies have reported the costs of CCS. McKinsey in 2008[39] reported that the costs of CCS demonstration on coal power plants are in excess of 100 €/tonne CO_2 captured[40]. The study also expected these costs to reduce to below 80 €/tonne CO_2 captured for commercial CCS projects between 2020 and 2030. A recent analysis by Bloomberg estimated CCS costs per tonne CO_2 captured (Table 4). The assumptions underlying these figures are unclear.

It should be noted that the costs of CCS significantly vary from one study to another depending on the assumptions made. The broad range of figures reported for CCS costs is attributed to the fact that the technology is new and has not been applied on a large scale. As more CCS demonstrations are built, the confidence and understanding of CCS technology will increase leading to lower and more predictable costs. As with all new low-carbon technologies, the capital and the operating costs of the early plants will be greater than when the technology is more mature.

Table 4: CCS capture costs from the recent Bloomberg analysis

Project Name	Capture type	Gross capacity for CCS (MW)	Discounted cost (€/tCO_2 captured or stored)[41]
Ayrshire Power Hunterston	Supercritical coal with post-combustion capture (new plant)	400	31
Scottish Power Longannet	Supercritical coal with post-combustion capture (retrofit)	300	33
SSE Peterhead	Combined cycle gas turbine with post-combustion capture (retrofit)	385	84

Overall GVA and jobs from construction and operational phases

The CCS construction phase will generate direct impacts in the power sector where the expenditure takes place. This will trigger indirect impacts in the industries supplying inputs to the power sector industry, hence translating into additional indirect GVA and employment. Finally, the combination of direct and indirect jobs created could generate additional income distributed to households in the broader economy, hence leading to increased expenditure and induced GVA and induced jobs.

costs are assumed 2.5% of total plant costs. Operating costs of CO_2 transport and storage are, respectively, assumed 2.5% and 10% of the total capital cost (DECC 2010 study).

[39] Mckinsey & Company, Carbon Capture & Storage: Assessing the Economics, 2008.

[40] It should be noted that the cost per tonne captured (stored) is different from the cost per tonne avoided (abated). CCS imposes an energy demand which is met through additional generation (and therefore additional fossil fuel production.

[41] A currency exchange rate of $1.4/€ to convert Bloomberg figures reported in $/tonne CO_2 to €/tonne CO_2

The direct and indirect GVA from the construction of CCS projects was estimated based on the share that Scotland can achieve in several activity areas for each of the components. Some of these activity areas lead to direct impacts while others are associated with the supply chain leading to indirect impacts throughout Scotland. The percentage of the total component cost (Table 2) was estimated using the AEA report "value added to the UK from clean abatement technologies including CCS"[42]. The same report was also used to estimate the share of Scottish industry in each of the activity areas (Table 3). These figures were based on consultation with plant developers and stakeholder experts many of whom are based in Scotland. Reference was also made to the IPA study[43] for estimating potential share of the market. Direct and indirect job-years were estimated from GVA using UK National Accounts (Blue Book)[44] with staff salaries as referred to in the AEA report[45](project management: £90k, engineering: £60k, procurement: £40k, manufacturing: £60k, construction: £33k, commissioning: £60k). Job-years were converted to full time equivalent (FTE) jobs by dividing by 10.

A different approach was undertaken for estimating economic impacts from the operational phase. Direct GVA was estimated from annual operational expenditure (3.15) based on estimates of the percentage of this expenditure which could come from Scotland. Shares of Scottish companies in the various supply chain areas (e.g. chemical manufacture, fuel production) differ for each of the demonstration projects as discussed above.

Induced effects were estimated based on Type I and Type II "effects" for GVA[46] and Multipliers for employment obtained from Scottish Input-output tables as shown in Table 5. The resulting impacts during the construction and operational phases are shown in Table 6 and Table 7, respectively. Despite the low share of Scottish-based companies in manufacturing, this activity area contributes the most to GVA. This is because of the high value associated with manufacturing each of the components e.g. 35% of storage capital costs are attributed to manufacturing, 40% of total capture costs are attributed to manufacturing, and 40% of total transport costs are attributed to manufacturing. Most of the manufacturing added value is in the transport and storage part of the chain.

[42] AEA Technology, Future value of carbon abatement technologies in coal and gas power generation to UK industry, 2010.
[43] A. Young, R. Catterson and M. Farley, Industrial and Power Association, Carbon Capture and Storage skills study, September 2010.
[44] http://www.statistics.gov.uk/statbase/Product.asp?vlnk=1143
[45] AEA Technology, Future value of carbon abatement technologies in coal and gas power generation to UK industry, 2010.
[46] GVA effects are used because the available cost data is for total value of projects which includes the full range of supply chain values.

Table 5: GVA effect and employment multipliers used in estimating indirect and induced effects

Sector	GVA effect		Employment multipliers	
	Type I	Type II	Type I	Type II
Construction	0.71	0.84	1.8	2.19
Electricity production & distribution	0.58	0.64	3.26	4.15
Gas distribution	0.54	0.62	3.28	4.2
Oil & gas extraction	0.62	0.76	2.04	2.64
Chemicals	0.52	0.60	4.73	6.29
Manufacturing	0.53	0.63	1.46	1.77

Due to the experience that Scottish-based companies have gained in the oil and gas industry, from 60% to 90% of the GVA generated from transport and from 65% to 95% of the value added generated from storage are expected to be captured by Scotland. Conversely, the share of the GVA added generated from the capture infrastructure and captured by Scotland is expected to be far lower and range from 24% to 30%. Scottish companies are, however, building experience in CO_2 capture and are expected to capture more of this market in the future.

The GVA and employment effects will not be evenly distributed over the construction period and are expected to exhibit a peak point in the second half of the construction phase period. The impact on total GVA and employment levels will depend on the number of projects that are eventually implemented.

The study assumes that the share of Scottish companies in transport and storage construction activities is higher than for capture. It is also assumed that the share of Scottish-based companies increases for Peterhead and Hunterston after some experience is gained from the Longannet demonstration. Indirect impacts result from upstream activities (e.g. manufacturing) which are not directly related to the construction of the plant.

Table 6: GVA and jobs from the construction phase for the three proposed CCS projects in Scotland

Construction Phase (over a 6-year project planning and construction period, 2014 - 2020)	Longannet	Peterhead	Hunterston*	Total
Direct GVA in Scotland, £M	**454**	**296**	**662**	**1,412**
Capture	127	96	190	413
Transport	159	98	364	621
Storage	168	102	108	378
Indirect GVA in Scotland, £M	**210**	**130**	**288**	**628**
Capture	12	9	12	33
Transport	86	53	204	343
Storage	112	68	72	252
Additional induced GVA achievable in Scotland, £M	**226**	**166**	**324**	**716**
Total GVA	**890**	**592**	**1,274**	**2,756**
Direct Jobs on site, jobs	**966**	**626**	**1,448**	**3,040**
Capture	249	189	375	813
Transport	372	228	851	1,451
Storage	345	209	222	776
Additional Indirect jobs supported	**450**	**216**	**484**	**1,150**
Capture	20	15	37	72
Transport	143	88	327	558
Storage	187	113	120	420
Additional Induced jobs supported	**130**	**95**	**185**	**410**
Total jobs	**1,546**	**937**	**2,117**	**4,600**

***** *Figures for Hunterston relate to the construction of CCS elements of proposed power station only. The construction of a new Hunterston power station would provide economic impacts in its own right.*

Notes:

1. The estimated GVA depends on (i) the capital expenditure and (ii) the share of Scottish companies. The economic impacts from Hunterston are more significant than the impacts from Longannet because the analysis assumes that the share of Scottish companies in the Longannet demonstration, which is very likely to be the first mover in Scotland, is lower (lower end of figures in Table 3) than the share in the Hunterston demonstration (higher end of figures in Table 3)
2. The GVA from transport for Hunterston are more significant because of the higher anticipated expenditure due mainly to the new pipeline that would be required.
3. The GVA from storage for Longannet is highest because of the high capital expenditure involved in converting the Goldeneye gas field for CO_2 injection and storage.
4. Direct GVA and jobs refer to the impacts related directly to the construction of the capture plant. Indirect impacts are those associated with upstream activities such as equipment manufacturing.
5. Job-years are estimated from GVA using employee salary (£/year per employee). Jobs are then estimated from job-years as described above. As a result, higher GVA leads to higher jobs
6. Total GVA is the sum of direct, indirect and induced GVA. Total jobs are the sum of direct, indirect and induced jobs.
7. The figures above are total figures for a 6-year period of preparation, planning and construction of the capture plant. It is expected that a peak of expenditure and consequently GVA and jobs will be achieved in the second half of this 6-year period

Table 7: GVA and jobs from the operational phase for the three proposed CCS projects in Scotland

Operational Phase (over lifetime of project)	Longannet	Peterhead	Hunterston*	Total
Direct GVA, £M/year	**118**	**57**	**55**	**230**
Capture	79	36	18	133
Transport	4	1	17	22
Storage	35	20	20	75
Indirect GVA in Scotland, £M/year	**119**	**63**	**61**	**243**
Capture	88	40	20	148
Transport	5	1	19	25
Storage	26	22	22	70
Additional induced GVA achievable in Scotland, £M/year	**35**	**13**	**14**	**62**
Total GVA, £M/year	**272**	**133**	**130**	**535**
Direct Jobs on site, jobs	**51**	**26**	**43**	**120**
Capture	40	15	20	75
Transport	1	1	15	17
Storage	10	10	8	28
Additional Indirect jobs supported	**102**	**46**	**88**	**236**
Capture	90	34	45	169
Transport	2	2	34	38
Storage	10	10	8	28
Additional Induced jobs supported	**43**	**20**	**36**	**99**
Total jobs	**196**	**92**	**166**	**454**

***** *Figures for Hunterston relate to the construction of CCS elements of proposed power station only. The construction of a new Hunterston power station would provide economic impacts in its own right.*

Notes:
1. The operational GVA depends on (i) operational expenditure, and (ii) share of Scottish economy in the production of materials used in the operation of the capture plant.
2. Direct impacts include impacts from the production of fuel. Since for Hunterston, fuel will be imported from outside the UK[47], the GVA and consequently the jobs associated with CO_2 capture and lower than for the two other demonstrations.
3. The GVA for transport and storage are based on the capture GVA using the relevant expenditure ratio.
4. Indirect and induced impacts are estimated based on Type I and Type II multipliers for the relevant sectors.
5. Total GVA is the sum of direct, indirect and induced GVA. Total jobs are the sum of direct, indirect and induced jobs.
6. The figures above are annual figures over the lifetime of the demonstration plant. The share of the Scottish economy may change over the lifetime of the demonstration (for example, Scottish companies may increasingly capture a higher share of the monoethanolamine market) but these effects are not taken into account here.

[47] http://www.conchcampaign.org/proposal.html

5. Long-term economic opportunities for CCS in Scotland

Several studies have been undertaken on the economic benefits that the creation of a CCS industry can bring to the UK and to Scotland. There were recently two studies which evaluated the value to the UK and job creation from future deployment of CCS. The first was undertaken by AEA Technology for DECC and the second was Phase II of the Scottish study on ‘Progressing Scotland’s CO_2 storage opportunities’[48]. Both studies concluded that that there is a great potential for job creation in the UK and in Scotland. The AEA study evaluated the global market and estimated the UK share of that market for post-combustion, pre-combustion and oxyfuel capture. The IPA study estimated value to the UK and Scotland from post-combustion capture technology.

The AEA study[49] concluded that the value to the UK from global markets for new advanced coal- and gas-fired power generation plant can reach £1.5-3.0 Bn/yr by 2020 and £3.0-6.5 Bn/yr by 2030, equating to a total cumulative value of £30-70 Bn between 2020 and 2030. This has the potential to create between 70,000 – 100,000 jobs in the UK by 2030. The study also concluded that the UK has particular strengths in project management, engineering and financial & legal services, and is expected to capture a greater share of these markets, both in the UK and overseas. There is considerable uncertainty over the share that the UK might attain in manufacturing, as much of the actual manufacture is expected to be done outside the UK under licensing agreements. The AEA study also estimated that value can be achieved from consultancy services, Front End Engineering Design (FEED) studies and consultancy associated with qualifying and licensing storage sites which are likely to be performed by Scottish-based companies. In addition, it should be noted that additional GVA and jobs can also result from R&D and testing.

The Scottish study on ‘Progressing Scotland’s CO_2 storage opportunities’ concluded that the UK share of the global CCS market is potentially worth £10-14Bn/yr from around 2025 with the added value in the UK potentially worth between £5-9.5Bn/yr. This share will potentially create 27,000 jobs from 2020, approximately half of which are in Scotland. This will then increase to 70,000 in 2035, 33% of which are in Scotland. According to a report from the Industrial and Power Association(IPA)[50] (published as part of Phase II of the study), the accuracy of these estimates depends on UK/Scottish companies winning domestic and international projects and on the Government establishing a steady roll-out programme. The economic opportunities will be reduced if the roll-out programme is less rapid than forecast by the IEA[51].

Scotland has the potential to see the development of CCS as a key economic sector. Considering CO_2 capture technology, the demonstration of CCS will help Scotland gain expertise in supplying post-combustion capture. It is important to make sure that CCS is demonstrated on both coal and gas power plants in Scotland because this increases the opportunities for Scottish companies both in the UK and throughout Europe. Many CCGT power plants which received permission recently in the UK are expected to install CCS as soon as it becomes technically and economically feasible to do so and this is expected to happen between 2020 and 2030. This provides an opportunity for Scottish companies to supply post-combustion capture technology to many CCGT power plants in the UK. Additional opportunities will also arise from CCS on coal power plants. Coal generation capacity in the UK is projected to increase from around 30 GW in 2008-2009 to 32.3 GW in 2014-2015. The gas generation capacity, on the other hand, is projected to experience a faster rate of growth, increasing from around 30 GW in 2008-2009 to 42.6 GW in 2014-2015[52].

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[48] http://www.geos.ed.ac.uk/sccs/progress-to-co2-storage-scotland/
[49] AEA Technology, Future value of carbon abatement technologies in coal and gas power generation to UK industry, 2010.
[50] A. Young, R. Catterson and M. Farley, Industrial and Power Association, Carbon capture an d storage skills study, September 2010.
[51] IEA CCS Roadmap, 2009
[52] National Grid (2008): “*Seven Year Statement, May 2008 and August 2008 Update*”

Scotland has significant engineering capability in the power sector, downstream process engineering and offshore engineering. In addition, Scottish companies have a significant opportunity to offer legal and financial services, which can be up to 10% of the total CCS costs, to early demonstrators in the UK and throughout Europe.

Scottish-based companies have world leading expertise in offshore transport and storage. The early demonstration of CCS in Scotland may provide the basis and the necessary expertise for a Europe-wide CO_2 storage business[53]. In addition, the construction of offshore transport pipeline will require surveys, steel pipes and ships for laying offshore pipeline, areas in which Scottish and UK-based companies have strong capabilities. In the long-term, additional opportunities will arise for Scottish-based companies from services related to storage site exploration, screening and characterisation and monitoring.

Following the expertise gained from CCS demonstration in Scotland, Scottish-based companies will have the potential to capture some of the global CCS market. According to the IPA report referenced above, the share that can be captured by Scottish-based companies has been estimated to range from 39% to 61%, translating into an absolute GVA of around £ 2.0-3.1Bn/year (low case) or £3.7-5.8Bn/year (high case).

However, the UK GVA from global CCS market is more conservative if the range of percentages above (i.e. 39-61%) is applied to the figures reported in the AEA study conducted in 2010 to assess the UK GVA from global CCS market. This suggests that a smaller value will be captured by Scottish-based companies. Applying these percentages to the UK GVA from CCS global market (as reported by AEA) gives a total GVA for Scotland of around £0.12-0.19 billion/year in 2020 and £1.35-2.12 billion/year in 2030 (Table 8).

Table 8: UK GVA from CCS global market by 2020 and 2030

	2020 (£ billion/year)	2030 (£ billion/year)
UK GVA from new coal plants with CCS	0.22	1.76
UK GVA from CCS retrofitting to existing coal plants	0.05	0.9
UK GVA from new gas plants with CCS	0.01	1.03
UK GVA from CCS retrofitting to existing gas plants	0.03	0.68
Total UK GVA	**0.31**	**3.47**
Total Scotland GVA*	**0.12-0.19**	**1.35-2.12**

* *39-61 % of total UK GVA*

[53] Depending on the penetration and deployment of CCS in other European countries where storage sites are not available (e.g. Germany)

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